kRPC

Release

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CONTENTS

kRPC allows you to control Kerbal Space Program from scripts running outside of the game. It has client libraries for many popular languages including Python, C++, C#, Java, Lua. A Ruby client has also been implemented (by TeWu).

- Getting Started Guide
- Tutorials and Examples

The mod exposes most of KSPs API and includes support for Kerbal Alarm Clock and Infernal Robotics. This functionality is provided to client programs via a Remote Procedure Call server, using protocol buffers for serialization. The server component sets up a TCP/IP server that remote scripts can connect to. This communication could be on the local machine only, over a local network, or even over the wider internet if configured correctly. The server is also extensible. Additional remote procedures (grouped into "services") can be added to the server using the "Service API".

CHAPTER

ONE

GETTING STARTED

This short guide explains the basics for getting kRPC set up and running, and writing a basic Python script to communicate with the game.

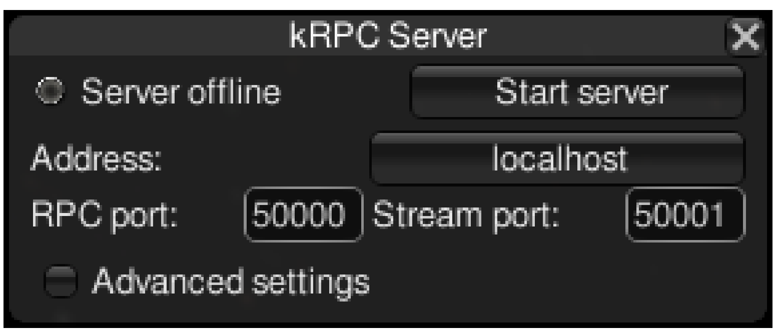
1.1 The Server Plugin

1.1.1 Installation

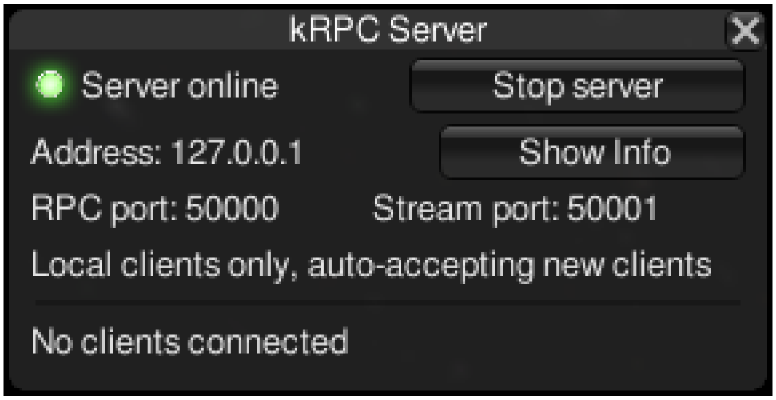
1. Download the kRPC server plugin from one of these locations:

- Github
- SpaceDock
- Curse
- Or the plugin can be obtained via CKAN

2. Extract the GameData folder from the archive into your KSP directory.
3. Start up KSP and load a save game.
4. You should be greeted by the server window:



5. Click "Start server" to, erm... start the server! If all goes well, the light should turn a happy green color:



6. You can hide the window by clicking the close button in the top right, or show/hide the window by clicking on the kRPC icon in the application launcher:

This icon will also turn green when the server is online.

1.1.2 Configuration

The server can be configured using the window displayed in-game. The configuration options are:

1. **Address**: this is the IP address that the server will listen on. To only allow connections from the local machine, select 'localhost' (the default). To allow connections over the network, either select the local IP address of your machine, or choose 'Manual' and enter the local IP address manually.
2. **RPC and Stream port numbers**: These need to be set to port numbers that are available on your machine. In most cases, they can just be left as the default.

There are also several advanced settings, which are hidden by default, but can be revealed by checking the 'Advanced settings' box:

1. **Auto-start server**: When enabled, the server will start automatically when the game loads.
2. **Auto-accept new clients**: When enabled, new client connections are automatically allowed. When disabled, a pop-up is displayed asking whether the new client connection should be allowed.

The other advanced settings control the performance of the server. For details, *see here*.

1.2 The Python Client

Note: kRPC supports both Python 2.7 and Python 3.x.

1.2.1 On Windows

1. If you don't already have python installed, download the python installer and run it: https://www.python.org/downloads/windows When running the installer, make sure that pip is installed as well.
2. Install the kRPC python module, by opening command prompt and running the following command: `C:\Python27\Scripts\pip.exe install krpc`
3. Run Python IDLE (or your favorite editor) and start coding!

1.2.2 On Linux

1. Your linux distribution likely already comes with python installed. If not, install python using your favorite package manager, or get it from here: https://www.python.org/downloads
2. You also need to install pip, either using your package manager, or from here: https://pypi.python.org/pypi/pip
3. Install the kRPC python module by running the following from a terminal: `pip install krpc`
4. Start coding!

1.3 'Hello World' Script

Run KSP and start the server with the default settings. Then execute the following python script:

```
1 import krpc
2 conn = krpc.connect(name='Hello World')
3 vessel = conn.space_center.active_vessel
4 print(vessel.name)
```

This does the following: line 1 loads the kRPC python module, line 2 opens a new connection to the server, line 3 gets the active vessel and line 4 prints out the name of the vessel. You should see something like the following:

Congratulations! You've written your first script that communicates with KSP.

1.4 Going further...

- For some more interesting examples of what you can do with kRPC, check out the tutorials.
- Client libraries are available for other languages too, including C++, C# and Lua.
- It is also easy to communicate with the server manually from any language you like – as long as it can do network I/O. See here for details.

CHAPTER

TWO

TUTORIALS AND EXAMPLES

This collection of tutorials and example scripts explain how to use the features of kRPC. They are written for the Python client, although the concepts apply to all of the client languages.

2.1 Sub-Orbital Flight

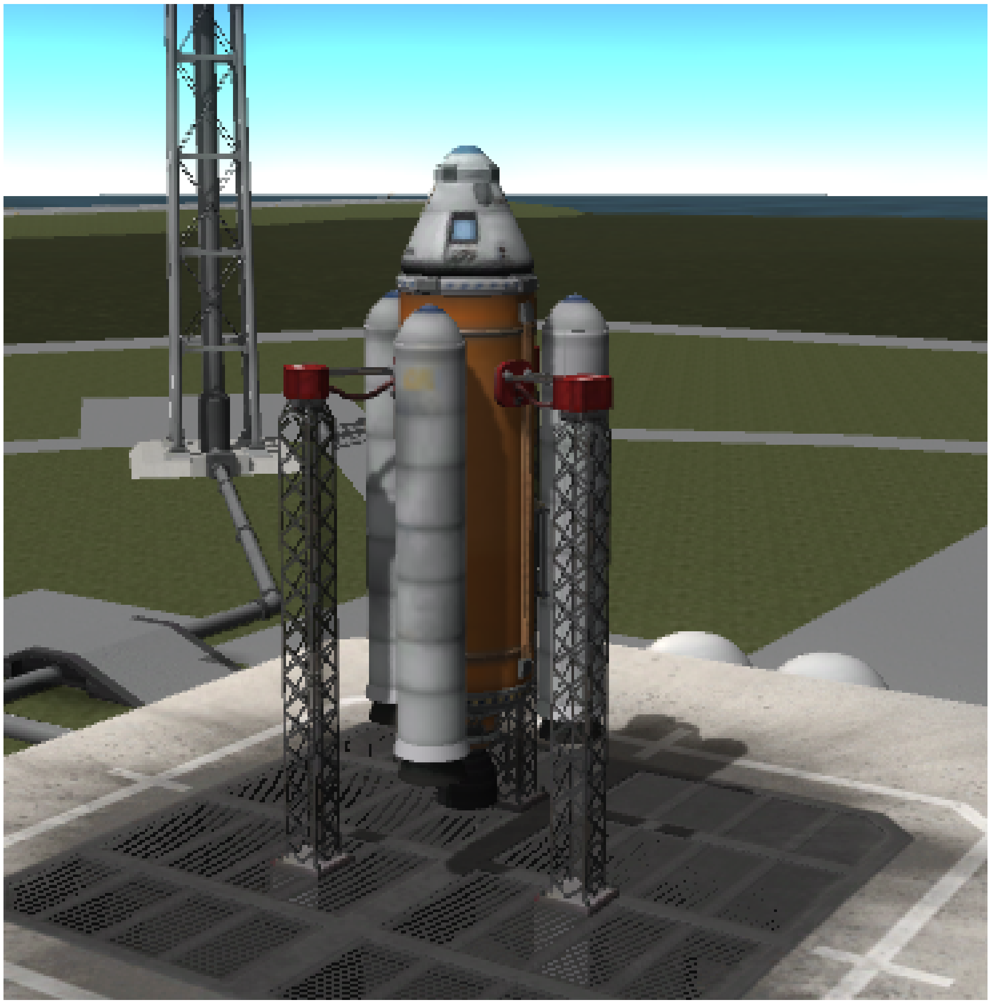
This introductory tutorial uses kRPC to send some Kerbals on a sub-orbital flight, and (hopefully) returns them safely back to Kerbin. It covers the following topics:

- Controlling a rocket (activating stages, setting the throttle)
- Using the auto pilot to point the vessel in a specific direction
- Tracking the amount of resources in the vessel
- Tracking flight and orbital data (such as altitude and apoapsis altitude)

Note: For details on how to write scripts and connect to kRPC, see the *Getting Started* guide.

2.1.1 Part One: Preparing for Launch

This tutorial uses the two stage rocket pictured below. The craft file for this rocket can be `downloaded here` and the entire python script for this tutorial `from here`



The first thing we need to do is load the python client module and open a connection to the server. We can also pass a descriptive name for our script that will appear in the server window in game:

```
import krpc
conn = krpc.connect(name='Sub-orbital flight script')
```

Next we need to get an object representing the active vessel. It's via this object that we will send instructions to the rocket:

```
vessel = conn.space_center.active_vessel
```

We then need to prepare the rocket for launch. The following code sets the throttle to maximum and instructs the auto-pilot to hold a pitch and heading of 90° (vertically upwards). It then waits for 1 second for these settings to take effect.

```
vessel.auto_pilot.target_pitch_and_heading(90,90)
vessel.auto_pilot.engage()
vessel.control.throttle = 1
import time
time.sleep(1)
```

2.1.2 Part Two: Lift-off!

We're now ready to launch by activating the first stage (equivalent to pressing the space bar):

```
print('Launch!')
vessel.control.activate_next_stage()
```

The rocket has a solid fuel stage that will quickly run out, and will need to be jettisoned. We can monitor the amount of solid fuel in the rocket using a while loop that repeatedly checks how much solid fuel there is left in the rocket. When the loop exits, we will activate the next stage to jettison the boosters:

```
while vessel.resources.amount('SolidFuel') > 0.1:
    time.sleep(1)
print('Booster separation')
vessel.control.activate_next_stage()
```

In this bit of code, `vessel.resources` returns a *Resources* object that is used to get information about the resources in the rocket.

2.1.3 Part Three: Reaching Apoapsis

Next we will execute a gravity turn when the rocket reaches a sufficiently high altitude. The following loop repeatedly checks the altitude and exits when the rocket reaches 10km:

```
while vessel.flight().mean_altitude < 10000:
   time.sleep(1)
```

In this bit of code, calling `vessel.flight()` returns a *Flight* object that is used to get all sorts of information about the rocket, such as the direction it is pointing in and its velocity.

Now we need to angle the rocket over to a pitch of 60° and maintain a heading of 90° (west). To do this, we simply reconfigure the auto-pilot:

```
print('Gravity turn')
vessel.auto_pilot.target_pitch_and_heading(60,90)
```

Now we wait until the apoapsis reaches 100km, then reduce the throttle to zero, jettison the launch stage and turn off the auto-pilot:

```
while vessel.orbit.apoapsis_altitude < 100000:
   time.sleep(1)
print('Launch stage separation')
vessel.control.throttle = 0
time.sleep(1)
vessel.control.activate_next_stage()
vessel.auto_pilot.disengage()
```

In this bit of code, `vessel.orbit` returns an *Orbit* object that contains all the information about the orbit of the rocket.

2.1.4 Part Four: Returning Safely to Kerbin

Our Kerbals are now heading on a sub-orbital trajectory and are on a collision course with the surface. All that remains to do is wait until they fall to 1km altitude above the surface, and then deploy the parachutes. If you like, you can use time acceleration to skip ahead to just before this happens - the script will continue to work.

```
while vessel.flight().surface_altitude > 1000:
    time.sleep(1)
vessel.control.activate_next_stage()
```

The parachutes should have now been deployed. The next bit of code will repeatedly print out the altitude of the capsule until its speed reaches zero – which will happen when it lands:

```
while vessel.flight(vessel.orbit.body.reference_frame).vertical_speed < -0.1:
    print('Altitude = %.1f meters' % vessel.flight().surface_altitude)
    time.sleep(1)
print('Landed!')
```

This bit of code uses the `vessel.flight()` function, as before, but this time it is passed a *`ReferenceFrame`* parameter. We want to get the vertical speed of the capsule relative to the surface of Kerbin, so the values returned by the flight object need to be relative to the surface of Kerbin. We therefore pass `vessel.orbit.body.reference_frame` to `vessel.flight()` as this reference frame has its origin at the center of Kerbin and it rotates with the planet. For more information, check out the tutorial on *Reference Frames*.

Your Kerbals should now have safely landed back on the surface.

2.2 Reference Frames

2.2.1 Introduction

All of the positions, directions, velocities and rotations in kRPC are relative to something, and *reference frames* define what that something is.

A reference frame specifies:

- The position of the origin at `(0,0,0)`,
- the direction of the coordinate axes `x`, `y`, and `z`,
- the linear velocity of the origin (if the reference frame moves)
- and the angular velocity of the coordinate axes (the speed and direction of rotation of the axes).

Note: KSP and kRPC use a left handed coordinate system.

Origin Position and Axis Orientation

The following gives some examples of the position of the origin and the orientation of the coordinate axes for various reference frames.

Celestial Body Reference Frame

The reference frame obtained by calling *CelestialBody.reference_frame* for Kerbin has the following properties:

- The origin is at the center of Kerbin,
- the y-axis points from the center of Kerbin to the north pole,
- the x-axis points from the center of Kerbin to the intersection of the prime meridian and equator (the surface position at 0° longitude, 0° latitude),
- the z-axis points from the center of Kerbin to the equator at 90°E longitude,
- and the axes rotate with the planet, i.e. the reference frame has the same rotational/angular velocity as Kerbin.

This means that the reference frame is *fixed* relative to Kerbin – it moves with the center of the planet, and also rotates with the planet. Therefore, positions in this reference frame are relative to the center of the planet. Consider the following code prints out the position of the active vessel in Kerbin's reference frame:

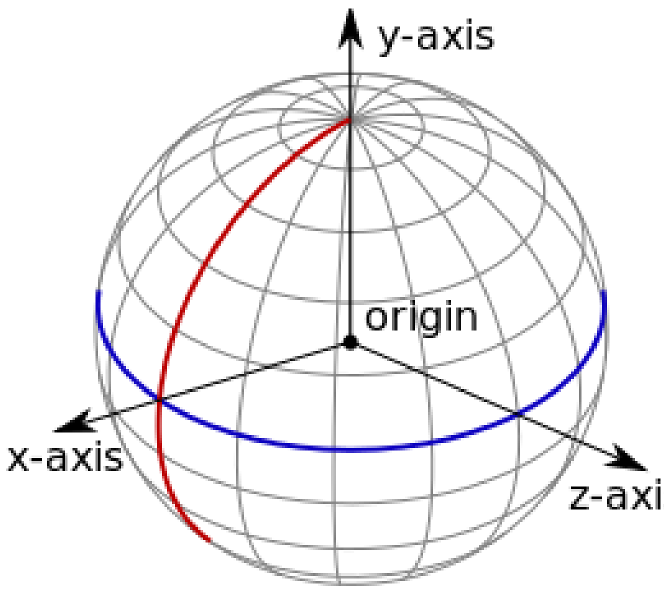


Fig. 2.1: The reference frame for a celestial body, such as Kerbin. The equator is shown in blue, and the prime meridian in red. The black arrows show the coordinate axes, and the origin is at the center of the planet.

```
import krpc
conn = krpc.connect()
vessel = conn.space_center.active_vessel
print(vessel.position(vessel.orbit.body.reference_frame))
```

For a vessel sat on the launchpad, the magnitude of this position vector will be roughly 600,000 meters (equal to the radius of Kerbin). The position vector will also not change over time, because the vessel is sat on the surface of Kerbin and the reference frame also rotates with Kerbin.

Vessel Orbital Reference Frame

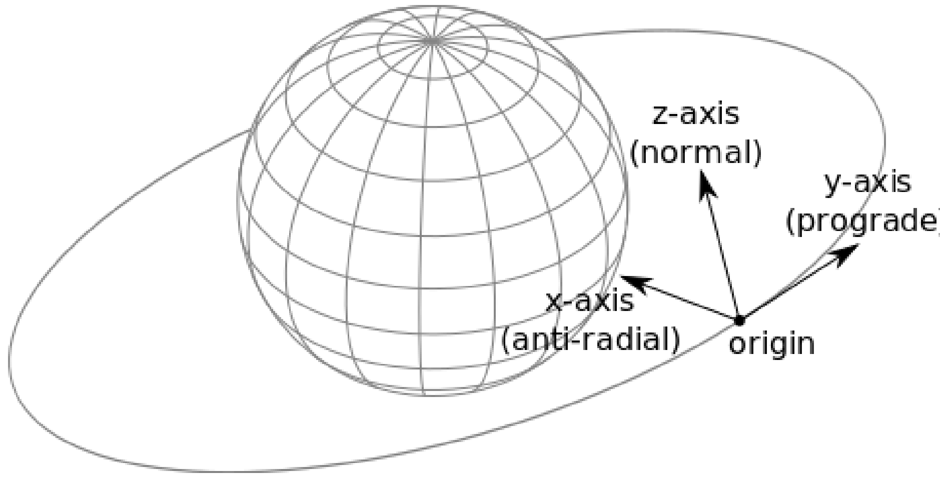


Fig. 2.2: The orbital reference frame for a vessel.

Another example is the orbital reference frame for a vessel, obtained by calling `Vessel.orbital_reference_frame`. This is fixed to the vessel (the origin moves with the vessel) and it is orientated so that the axes point in the orbital prograde/normal/radial directions.

- The origin is at the center of mass of the vessel,
- the y-axis points in the prograde direction of the vessels orbit,
- the x-axis points in the anti-radial direction of the vessels orbit,
- the z-axis points in the normal direction of the vessels orbit,
- and the axes rotate to match any changes to the prograde/normal/radial directions, for example when the prograde direction changes as the vessel continues on its orbit.

Vessel Surface Reference Frame

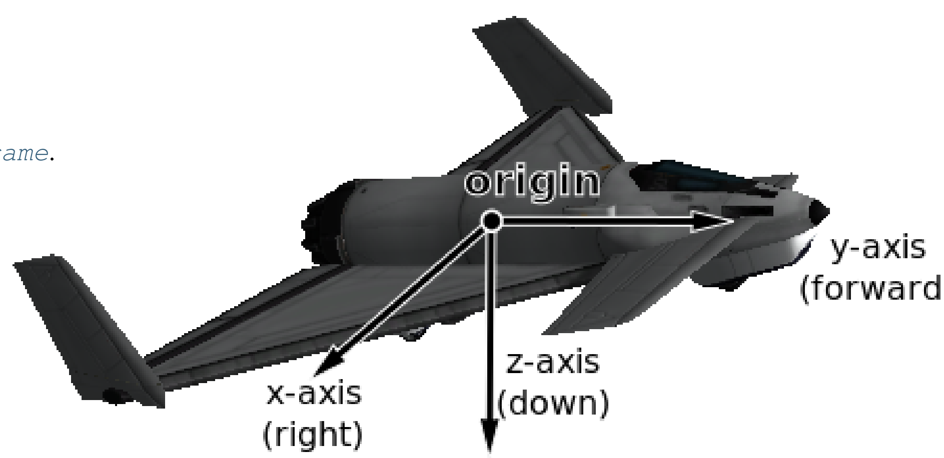


Fig. 2.3: The reference frame for an aircraft.

Another example is `Vessel.reference_frame`. As with the previous example, it is fixed to the vessel (the origin moves with the vessel), however the orientation of the coordinate axes is different. They track the orientation of the vessel:

- The origin is at the center of mass of the vessel,
- the y-axis points in the same direction that the vessel is pointing,

- the x-axis points out of the right side of the vessel,
- the z-axis points downwards out of the bottom of the vessel,
- and the axes rotate with any changes to the direction of the vessel.

Linear Velocity and Angular Velocity

Reference frames move and rotate relative to one another. For example, the reference frames discussed previously all have their origin position fixed to some object (such as a vessel or a planet). This means that they move and rotate to track the object, and so have a linear and angular velocity associated with them.

For example, the reference frame obtained by calling *CelestialBody.reference_frame* for Kerbin is fixed relative to Kerbin. This means the angular velocity of the reference frame is identical to Kerbin's angular velocity, and the linear velocity of the reference frame matches the current orbital velocity of Kerbin.

2.2.2 Available Reference Frames

kRPC provides the following reference frames:

- *Vessel.reference_frame*
- *Vessel.orbital_reference_frame*
- *Vessel.surface_reference_frame*
- *Vessel.surface_velocity_reference_frame*
- *CelestialBody.reference_frame*
- *CelestialBody.non_rotating_reference_frame*
- *CelestialBody.orbital_reference_frame*
- *Node.reference_frame*
- *Node.orbital_reference_frame*
- *Part.reference_frame*
- *DockingPort.reference_frame*

2.2.3 Converting Between Reference Frames

kRPC provides a utility methods to convert positions, directions, rotations and velocities between the different reference frames:

- *SpaceCenter.transform_position()*
- *SpaceCenter.transform_direction()*
- *SpaceCenter.transform_rotation()*

- *SpaceCenter.transform_velocity()*

2.2.4 Visual Debugging

References frames can be confusing, and choosing the correct one is a challenge in itself. To aid debugging, kRPC provides some methods with which you can draw direction vectors in-game.

SpaceCenter.draw_direction() will draw a direction vector, starting from the center of the active vessel. For example, the following code draws the direction of the current vessels velocity relative to the surface:

```
import krpc
conn = krpc.connect(name='Visual Debugging')
vessel = conn.space_center.active_vessel

ref_frame = vessel.orbit.body.reference_frame
velocity = vessel.flight(ref_frame).velocity
conn.space_center.draw_direction(velocity, ref_frame, (1,0,0))

while True:
    pass
```

Note: The client must remain connected, otherwise kRPC will stop drawing the directions, hence the while loop at the end of this example.

2.2.5 Examples

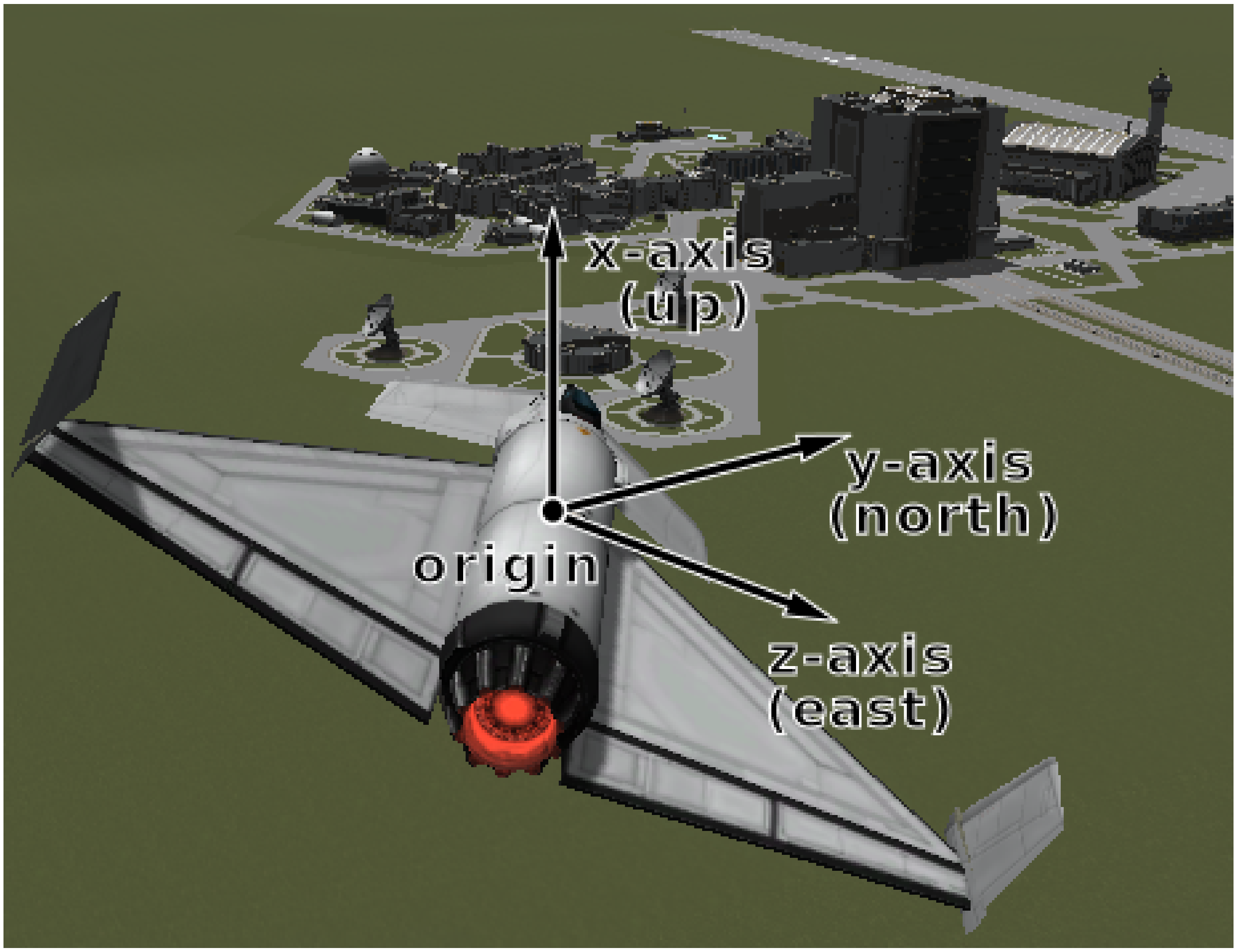
The following examples demonstrate various uses of reference frames.

Navball directions

This example demonstrates how to make the vessel point in various directions on the navball:

```
import krpc
conn = krpc.connect(name='Navball directions')
vessel = conn.space_center.active_vessel
ap = vessel.auto_pilot
ap.reference_frame = vessel.surface_reference_frame
ap.engage()

# Point the vessel north on the navball, with a pitch of 0 degrees
ap.target_direction = (0,1,0)
ap.wait()

# Point the vessel vertically upwards on the navball
ap.target_direction = (1,0,0)
ap.wait()

# Point the vessel west (heading of 270 degrees), with a pitch of 0 degrees
ap.target_direction = (0,0,-1)
ap.wait()

ap.disengage()
```

The code uses the vessel's surface reference frame (*Vessel.surface_reference_frame*), pictured below:



Line 9 instructs the auto-pilot to point in direction `(0,1,0)` (i.e. along the y-axis) in the vessel's surface reference frame. The y-axis of the reference frame points in the north direction, as required.

Line 13 instructs the auto-pilot to point in direction `(1,0,0)` (along the x-axis) in the vessel's surface reference frame. This x-axis of the reference frame points upwards (away from the planet) as required.

Line 17 instructs the auto-pilot to point in direction `(0,0,-1)` (along the negative z axis). The z-axis of the reference frame points east, so the requested direction points west – as required.

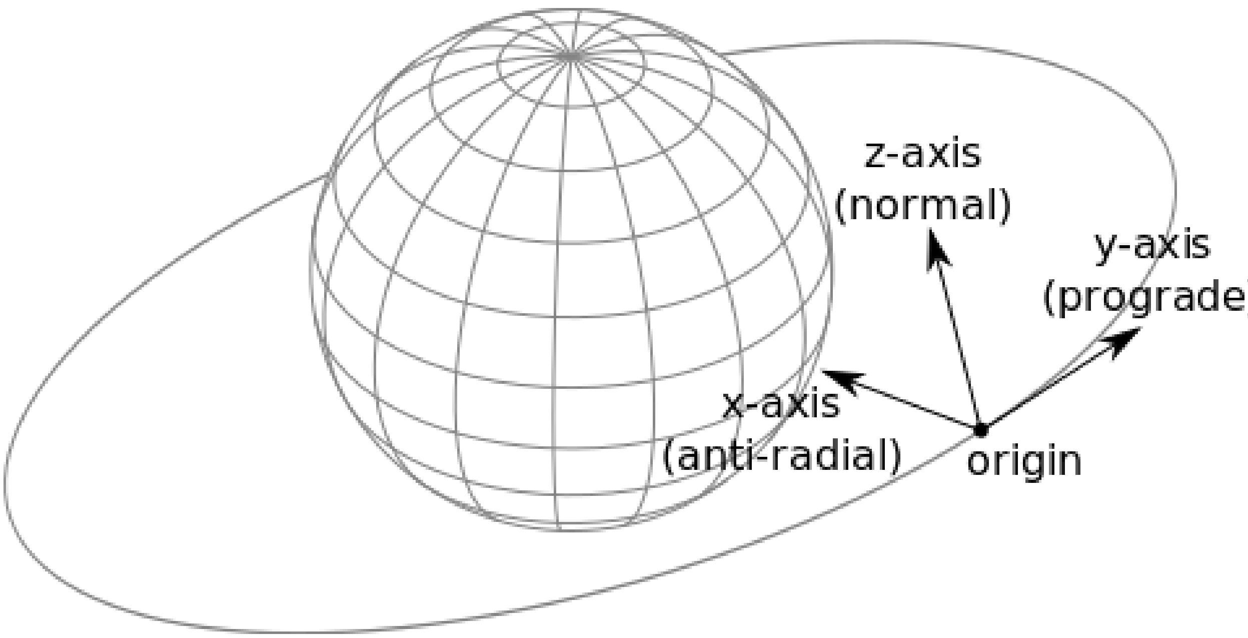
Orbital directions

This example demonstrates how to make the vessel point in the various orbital directions, as seen on the navball when it is in 'orbit' mode. It uses *Vessel.orbital_reference_frame*.

```python
import krpc
conn = krpc.connect(name='Orbital directions')
vessel = conn.space_center.active_vessel
ap = vessel.auto_pilot
ap.reference_frame = vessel.orbital_reference_frame
ap.engage()

# Point the vessel in the prograde direction
ap.target_direction = (0,1,0)
```

```
ap.wait()

# Point the vessel in the orbit normal direction
ap.target_direction = (0,0,1)
ap.wait()

# Point the vessel in the orbit radial direction
ap.target_direction = (-1,0,0)
ap.wait()

ap.disengage()
```

This code uses the vessel's orbital reference frame, pictured below:

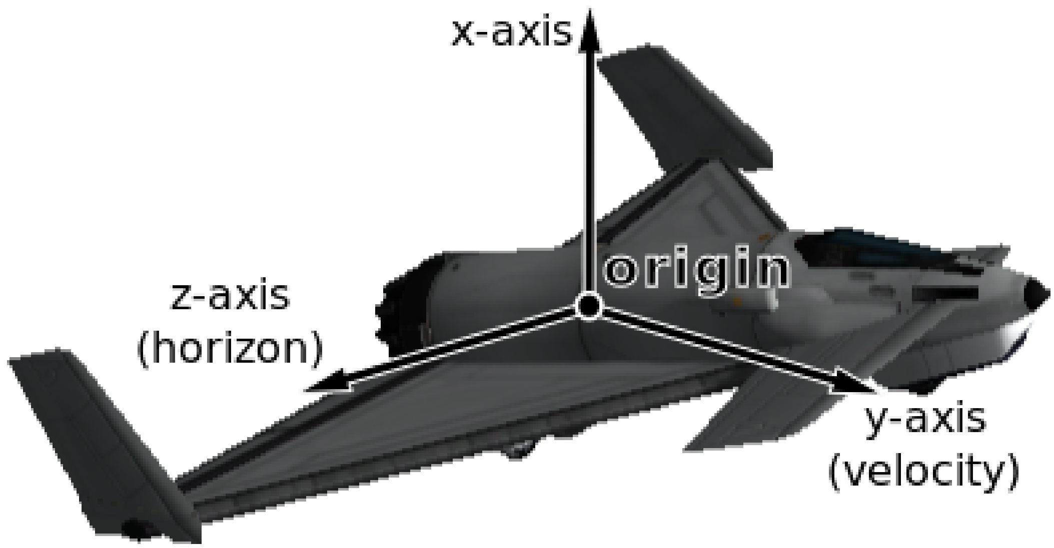


Surface 'prograde'

This example demonstrates how to point the vessel in the 'prograde' direction on the navball, when in 'surface' mode. This is the direction of the vessels velocity relative to the surface:

```
import krpc
conn = krpc.connect(name='Surface prograde')
vessel = conn.space_center.active_vessel
ap = vessel.auto_pilot

ap.reference_frame = vessel.surface_velocity_reference_frame
ap.target_direction = (0,1,0)
ap.engage()
ap.wait()
ap.disengage()
```

This code uses the *Vessel.surface_velocity_reference_frame*, pictured below:



Orbital speed

To compute the orbital speed of a vessel, you need to get the velocity relative to the planet's *non-rotating* reference frame (*CelestialBody.non_rotating_reference_frame*). This reference frame is fixed relative to the body, but does not rotate:

```
import krpc, time
conn = krpc.connect(name='Orbital speed')
vessel = conn.space_center.active_vessel

while True:

    velocity = vessel.flight(vessel.orbit.body.non_rotating_reference_frame).velocity
    print('Orbital velocity = (%.1f, %.1f, %.1f)' % velocity)

    speed = vessel.flight(vessel.orbit.body.non_rotating_reference_frame).speed
    print('Orbital speed = %.1f m/s' % speed)

    time.sleep(1)
```

Surface speed

To compute the speed of a vessel relative to the surface of a planet/moon, you need to get the velocity relative to the planets reference frame (*CelestialBody.reference_frame*). This reference frame rotates with the body, therefore the rotational velocity of the body is taken into account when computing the velocity of the vessel:

```
import krpc, time
conn = krpc.connect(name='Surface speed')
vessel = conn.space_center.active_vessel

while True:

    velocity = vessel.flight(vessel.orbit.body.reference_frame).velocity
    print('Surface velocity = (%.1f, %.1f, %.1f)' % velocity)

    speed = vessel.flight(vessel.orbit.body.reference_frame).speed
```

```
    print('Surface speed = %.1f m/s' % speed)

    time.sleep(1)
```

Angle of attack

This example computes the angle between the direction the vessel is pointing in, and the direction that the vessel is moving in (relative to the surface):

```
1  import krpc, math, time
2  conn = krpc.connect(name='Angle of attack')
3  vessel = conn.space_center.active_vessel
4
5  while True:
6
7      d = vessel.direction(vessel.orbit.body.reference_frame)
8      v = vessel.velocity(vessel.orbit.body.reference_frame)
9
10     # Compute the dot product of d and v
11     dotprod = d[0]*v[0] + d[1]*v[1] + d[2]*v[2]
12
13     # Compute the magnitude of v
14     vmag = math.sqrt(v[0]**2 + v[1]**2 + v[2]**2)
15     # Note: don't need to magnitude of d as it is a unit vector
16
17     # Compute the angle between the vectors
18     if dotprod == 0:
19         angle = 0
20     else:
21         angle = abs(math.acos (dotprod / vmag) * (180. / math.pi))
22
23     print('Angle of attack = %.1f' % angle)
24
25     time.sleep(1)
```

Note that the orientation of the reference frame used to get the direction and velocity vectors (on lines 7 and 8) does not matter, as the angle between two vectors is the same regardless of the orientation of the axes. However, if we were to use a reference frame that moves with the vessel, line 8 would return `(0,0,0)`. We therefore need a reference frame that is not fixed relative to the vessel. *`CelestialBody.reference_frame`* fits these requirements.

2.3 Launch into Orbit

This tutorial launches a two-stage rocket into a 150km circular orbit. The craft file for the rocket can be `downloaded here` and the entire python script `from here`.

The following code connects to the server, gets the active vessel, sets up a bunch streams to get flight telemetry then prepares the rocket for launch.

```
import krpc, time, math

turn_start_altitude = 250
turn_end_altitude = 45000
target_altitude = 150000

conn = krpc.connect(name='Launch into orbit')
```

```
vessel = conn.space_center.active_vessel

# Set up streams for telemetry
ut = conn.add_stream(getattr, conn.space_center, 'ut')
altitude = conn.add_stream(getattr, vessel.flight(), 'mean_altitude')
apoapsis = conn.add_stream(getattr, vessel.orbit, 'apoapsis_altitude')
periapsis = conn.add_stream(getattr, vessel.orbit, 'periapsis_altitude')
eccentricity = conn.add_stream(getattr, vessel.orbit, 'eccentricity')
stage_2_resources = vessel.resources_in_decouple_stage(stage=2, cumulative=False)
stage_3_resources = vessel.resources_in_decouple_stage(stage=3, cumulative=False)
srb_fuel = conn.add_stream(stage_3_resources.amount, 'SolidFuel')
launcher_fuel = conn.add_stream(stage_2_resources.amount, 'LiquidFuel')

# Pre-launch setup
vessel.control.sas = False
vessel.control.rcs = False
vessel.control.throttle = 1

# Countdown...
print('3...'); time.sleep(1)
print('2...'); time.sleep(1)
print('1...'); time.sleep(1)
print('Launch!')
```

The next part of the program launches the rocket. The main loop continuously updates the auto-pilot heading to gradually pitch the rocket towards the horizon. It also monitors the amount of solid fuel remaining in the boosters, separating them when they run dry. The loop exits when the rockets apoapsis is close to the target apoapsis.

```
# Activate the first stage
vessel.control.activate_next_stage()
vessel.auto_pilot.engage()
vessel.auto_pilot.target_pitch_and_heading(90, 90)

# Main ascent loop
srbs_separated = False
turn_angle = 0
while True:

    # Gravity turn
    if altitude() > turn_start_altitude and altitude() < turn_end_altitude:
        frac = (altitude() - turn_start_altitude) / (turn_end_altitude - turn_start_altitude)
        new_turn_angle = frac * 90
        if abs(new_turn_angle - turn_angle) > 0.5:
            turn_angle = new_turn_angle
            vessel.auto_pilot.target_pitch_and_heading(90-turn_angle, 90)

    # Separate SRBs when finished
    if not srbs_separated:
        if srb_fuel() < 0.1:
            vessel.control.activate_next_stage()
            srbs_separated = True
            print('SRBs separated')

    # Decrease throttle when approaching target apoapsis
    if apoapsis() > target_altitude*0.9:
        print('Approaching target apoapsis')
        break
```

Next, the program fine tunes the apoapsis, using 10% thrust, then waits until the rocket has left Kerbin's atmosphere.

```
# Disable engines when target apoapsis is reached
vessel.control.throttle = 0.25
while apoapsis() < target_altitude:
    pass
print('Target apoapsis reached')
vessel.control.throttle = 0

# Wait until out of atmosphere
print('Coasting out of atmosphere')
while altitude() < 70500:
    pass
```

It is now time to plan the circularization burn. First, we calculate the delta-v required to circularize the orbit using the vis-viva equation. We then calculate the burn time needed to achieve this delta-v, using the Tsiolkovsky rocket equation.

```
# Plan circularization burn (using vis-viva equation)
print('Planning circularization burn')
mu = vessel.orbit.body.gravitational_parameter
r = vessel.orbit.apoapsis
a1 = vessel.orbit.semi_major_axis
a2 = r
v1 = math.sqrt(mu*((2./r)-(1./a1)))
v2 = math.sqrt(mu*((2./r)-(1./a2)))
delta_v = v2 - v1
node = vessel.control.add_node(ut() + vessel.orbit.time_to_apoapsis, prograde=delta_v)

# Calculate burn time (using rocket equation)
F = vessel.available_thrust
Isp = vessel.specific_impulse * 9.82
m0 = vessel.mass
m1 = m0 / math.exp(delta_v/Isp)
flow_rate = F / Isp
burn_time = (m0 - m1) / flow_rate
```

Next, we need to rotate the craft and wait until the circularization burn. We orientate the ship along the y-axis of the maneuver node's reference frame (i.e. in the direction of the burn) then time warp to 5 seconds before the burn.

```
# Orientate ship
print('Orientating ship for circularization burn')
vessel.auto_pilot.reference_frame = node.reference_frame
vessel.auto_pilot.target_direction = (0,1,0)
vessel.auto_pilot.wait()

# Wait until burn
print('Waiting until circularization burn')
burn_ut = ut() + vessel.orbit.time_to_apoapsis - (burn_time/2.)
lead_time = 5
conn.space_center.warp_to(burn_ut - lead_time)
```

This next part executes the burn. It sets maximum throttle, then throttles down to 5% approximately a tenth of a second before the predicted end of the burn. It then monitors the remaining delta-v until it flips around to point retrograde (at which point the node has been executed).

```
# Execute burn
print('Ready to execute burn')
time_to_apoapsis = conn.add_stream(getattr, vessel.orbit, 'time_to_apoapsis')
while time_to_apoapsis() - (burn_time/2.) > 0:
    pass
```

```
print('Executing burn')
vessel.control.throttle = 1
time.sleep(burn_time - 0.1)
print('Fine tuning')
vessel.control.throttle = 0.05
remaining_burn = conn.add_stream(node.remaining_burn_vector, node.reference_frame)
while remaining_burn()[1] > 0:
    pass
vessel.control.throttle = 0
node.remove()

print('Launch complete')
```

The rocket should now be in a circular 150km orbit above Kerbin.

2.4 Pitch, Heading and Roll

The following example calculates the pitch, heading and rolls angles of the active vessel once per second:

```
import krpc, math, time
conn = krpc.connect(name='Pitch/Heading/Roll')
vessel = conn.space_center.active_vessel

def cross_product(x, y):
    return (x[1]*y[2] - x[2]*y[1], x[2]*y[0] - x[0]*y[2], x[0]*y[1] - x[1]*y[0])

def dot_product(x, y):
    return x[0]*y[0] + x[1]*y[1] + x[2]*y[2]

def magnitude(x):
    return math.sqrt(x[0]**2 + x[1]**2 + x[2]**2)

def angle_between_vectors(x, y):
    """ Compute the angle between vector x and y """
    dp = dot_product(x, y)
    if dp == 0:
        return 0
    xm = magnitude(x)
    ym = magnitude(y)
    return math.acos(dp / (xm*ym)) * (180. / math.pi)

def angle_between_vector_and_plane(x, n):
    """ Compute the angle between a vector x and plane with normal vector n """
    dp = dot_product(x,n)
    if dp == 0:
        return 0
    xm = magnitude(x)
    nm = magnitude(n)
    return math.asin(dp / (xm*nm)) * (180. / math.pi)

while True:

    vessel_direction = vessel.direction(vessel.surface_reference_frame)

    # Get the direction of the vessel in the horizon plane
    horizon_direction = (0, vessel_direction[1], vessel_direction[2])
```

```
    # Compute the pitch - the angle between the vessels direction and the direction in the horizon p
    pitch = angle_between_vectors(vessel_direction, horizon_direction)
    if vessel_direction[0] < 0:
        pitch = -pitch

    # Compute the heading - the angle between north and the direction in the horizon plane
    north = (0,1,0)
    heading = angle_between_vectors(north, horizon_direction)
    if horizon_direction[2] < 0:
        heading = 360 - heading

    # Compute the roll
    # Compute the plane running through the vessels direction and the upwards direction
    up = (1,0,0)
    plane_normal = cross_product(vessel_direction, up)
    # Compute the upwards direction of the vessel
    vessel_up = conn.space_center.transform_direction(
        (0,0,-1), vessel.reference_frame, vessel.surface_reference_frame)
    # Compute the angle between the upwards direction of the vessel and the plane
    roll = angle_between_vector_and_plane(vessel_up, plane_normal)
    # Adjust so that the angle is between -180 and 180 and
    # rolling right is +ve and left is -ve
    if vessel_up[0] > 0:
        roll *= -1
    elif roll < 0:
        roll += 180
    else:
        roll -= 180

    print('pitch = % 5.1f, heading = % 5.1f, roll = % 5.1f' % (pitch, heading, roll))

    time.sleep(1)
```

2.5 Interacting with Parts

The following examples demonstrate use of the *Parts* functionality to achieve various tasks. More details on specific topics can also be found in the API documentation:

- *Trees of Parts*
- *Attachment Modes*
- *Fuel Lines*
- *Staging*

2.5.1 Deploying all Parachutes

Sometimes things go horribly wrong. The following script does its best to save your Kerbals by deploying all the parachutes:

```
import krpc
conn = krpc.connect()
vessel = conn.space_center.active_vessel
```

```
for parachute in vessel.parts.parachutes:
    parachute.deploy()
```

2.5.2 'Control From Here' for Docking Ports

The following example will find a standard sized Clamp-O-Tron docking port, and control the vessel from it:

```
import krpc
conn = krpc.connect()
vessel = conn.space_center.active_vessel

ports = vessel.parts.docking_ports
port = list(filter(lambda p: p.part.title == 'Clamp-O-Tron Docking Port', ports))[0]
part = port.part
vessel.parts.controlling = part
```

2.5.3 Combined Specific Impulse

The following script calculates the combined specific impulse of all currently active and fueled engines on a rocket. See here for a description of the maths: http://wiki.kerbalspaceprogram.com/wiki/Specific_impulse#Multiple_engines

```
import krpc
conn = krpc.connect()
vessel = conn.space_center.active_vessel

active_engines = filter(lambda e: e.active and e.has_fuel, vessel.parts.engines)

print('Active engines:')
for engine in active_engines:
    print('    %s in stage %d' % (engine.part.title, engine.part.stage))

thrust = sum(engine.thrust for engine in active_engines)
fuel_consumption = sum(engine.thrust / engine.specific_impulse for engine in active_engines)
isp = thrust / fuel_consumption

print('Combined vaccuum Isp = %d seconds' % isp)
```

2.6 Docking Guidance

The following script outputs docking guidance information. It waits until the vessel is being controlled from a docking port, and a docking port is set as the current target. It then prints out information about speeds and distances relative to the docking axis.

It uses numpy to do linear algebra on the vectors returned by kRPC – for example computing the dot product or length of a vector – and uses curses for terminal output.

```
import krpc, curses, time, sys
import numpy as np
import numpy.linalg as la

# Set up curses
stdscr = curses.initscr()
curses.nocbreak()
```

```
stdscr.keypad(1)
curses.noecho()

try:

    # Connect to kRPC
    conn = krpc.connect(name='Docking Guidance')
    vessel = conn.space_center.active_vessel
    current = None
    target = None

    while True:

        stdscr.clear()
        stdscr.addstr(0,0,'-- Docking Guidance --')

        current = conn.space_center.active_vessel.parts.controlling.docking_port
        target = conn.space_center.target_docking_port

        if current is None:
            stdscr.addstr(2,0,'Awaiting control from docking port...')

        elif target is None:
            stdscr.addstr(2,0,'Awaiting target docking port...')

        else:
            # Get positions, distances, velocities and speeds relative to the target docking port
            current_position = current.position(target.reference_frame)
            velocity = current.part.velocity(target.reference_frame)
            displacement = np.array(current_position)
            distance = la.norm(displacement)
            speed = la.norm(np.array(velocity))

            # Get speeds and distances relative to the docking axis
            # (the direction the target docking port is facing in)

            # Axial = along the docking axis
            axial_displacement = np.copy(displacement)
            axial_displacement[0] = 0
            axial_displacement[2] = 0
            axial_distance = axial_displacement[1]
            axial_velocity = np.copy(velocity)
            axial_velocity[0] = 0
            axial_velocity[2] = 0
            axial_speed = axial_velocity[1]
            if axial_distance > 0:
                axial_speed *= -1

            # Radial = perpendicular to the docking axis
            radial_displacement = np.copy(displacement)
            radial_displacement[1] = 0
            radial_distance = la.norm(radial_displacement)
            radial_velocity = np.copy(velocity)
            radial_velocity[1] = 0
            radial_speed = la.norm(radial_velocity)
            if np.dot(radial_velocity, radial_displacement) > 0:
                radial_speed *= -1
```

```
            # Get the docking port state
            if current.state == conn.space_center.DockingPortState.ready:
                state = 'Ready to dock'
            elif current.state == conn.space_center.DockingPortState.docked:
                state = 'Docked'
            elif current.state == conn.space_center.DockingPortState.docking:
                state = 'Docking...'
            else:
                state = 'Unknown'

            # Output information
            stdscr.addstr(2,0,'Current ship: {:30}'.format(current.part.vessel.name[:30]))
            stdscr.addstr(3,0,'Current port: {:30}'.format(current.part.title[:30]))
            stdscr.addstr(5,0,'Target ship:  {:30}'.format(target.part.vessel.name[:30]))
            stdscr.addstr(6,0,'Target port:  {:30}'.format(target.part.title[:30]))
            stdscr.addstr(8,0,'Status: {:10}'.format(state))
            stdscr.addstr(10, 0, '           +--------------------------+')
            stdscr.addstr(11, 0, '           |  Distance  |  Speed       |')
            stdscr.addstr(12, 0, '+----------+------------+--------------+')
            stdscr.addstr(13, 0, '|          |  {:>+6.2f} m  |  {:>+6.2f} m/s  |'.format(distance, spe
            stdscr.addstr(14, 0, '|   Axial |  {:>+6.2f} m  |  {:>+6.2f} m/s  |'.format(axial_distanc
            stdscr.addstr(15, 0, '|  Radial |  {:>+6.2f} m  |  {:>+6.2f} m/s  |'.format(radial_distar
            stdscr.addstr(16, 0, '+----------+------------+--------------+')

        stdscr.refresh()
        time.sleep(0.25)

finally:
    # Shutdown curses
    curses.nocbreak()
    stdscr.keypad(0)
    curses.echo()
    curses.endwin()
```

CHAPTER

THREE

C#

3.1 C# Client

The `KRPC.Client.dll` library provides functionality to interact with a kRPC server from C#.

3.1.1 Installing the Client

`KRPC.Client.dll` is available on NuGet. You also need to get `Google.Protobuf.dll`, which is also available on NuGet.

Note: The copy of `Google.Protobuf.dll` in the GameData folder shipped with kRPC should be *avoided*. It is a modified version to work within KSP. See here for more details.

3.1.2 Connecting to the Server

To connect to a server, create a `KRPC.Client.Connection` object. For example to connect to a server running on the local machine:

```
using KRPC.Client.Services.KRPC;

class Program
{
    public static void Main ()
    {
        var connection = new KRPC.Client.Connection (name : "Example");
        System.Console.WriteLine (connection.KRPC ().GetStatus ().Version);
    }
}
```

The class constructor also accepts arguments that specify what address and port numbers to connect to. For example:

```
using KRPC.Client.Services.KRPC;

class Program
{
    public static void Main ()
    {
        var connection = new KRPC.Client.Connection (name : "Example", address: "my.domain.name", rpc
        System.Console.WriteLine (connection.KRPC ().GetStatus ().Version);
```

```
    }
}
```

3.1.3 Interacting with the Server

Interaction with the server is performed via a connection object. Functionality for services are defined in the namespaces `KRPC.Client.Services.*`.

Before a service can be used it must first be instantiated. The following example connects to the server, instantiates the SpaceCenter service, and outputs the name of the active vessel:

```
using KRPC.Client.Services.SpaceCenter;

class Program
{
    public static void Main ()
    {
        var connection = new KRPC.Client.Connection (name : "Vessel Name");
        var sc = connection.SpaceCenter ();
        var vessel = sc.ActiveVessel;
        System.Console.WriteLine (vessel.Name);
    }
}
```

3.1.4 Streaming Data from the Server

A stream repeatedly executes a function on the server, with a fixed set of argument values. It provides a more efficient way of repeatedly getting the result of calling function on the server, without having to invoke it directly – which incurs communication overheads.

For example, consider the following loop that continuously prints out the position of the active vessel. This loop incurs significant communication overheads, as the *`Vessel.Position`* method is called repeatedly.

```
var vessel = connection.SpaceCenter().ActiveVessel;
var refframe = vessel.Orbit.Body.ReferenceFrame;
while (True)
    Console.Out.WriteLine(vessel.Position(refframe));
```

The following code achieves the same thing, but is far more efficient. It makes a single call to `Connection.AddStream` to create the stream, which avoids the communication overhead in the previous example.

```
var vessel = connection.SpaceCenter().ActiveVessel;
var refframe = vessel.Orbit.Body.ReferenceFrame;
var position = conn.AddStream(() => vessel.Position(refframe));
while (True)
    Console.Out.WriteLine(position.Get());
```

Streams are created by calling `Connection.AddStream` and passing it a lambda expression. It returns an instance of the `KRPC.Client.Stream` class from which the latest value can be obtained by calling `KRPC.Client.Stream.Get`.

The lambda expression passed to `Connection.AddStream` must take zero arguments and be either a method call expression or a parameter call expression.

3.2 SpaceCenter API

3.2.1 SpaceCenter

class SpaceCenter

Provides functionality to interact with Kerbal Space Program. This includes controlling the active vessel, managing its resources, planning maneuver nodes and auto-piloting.

Vessel **ActiveVessel** { **get; set;** }
The currently active vessel.

IList<*Vessel*> **Vessels** { **get;** }
A list of all the vessels in the game.

IDictionary<string, *CelestialBody*> **Bodies** { **get;** }
A dictionary of all celestial bodies (planets, moons, etc.) in the game, keyed by the name of the body.

CelestialBody **TargetBody** { **get; set;** }
The currently targeted celestial body.

Vessel **TargetVessel** { **get; set;** }
The currently targeted vessel.

DockingPort **TargetDockingPort** { **get; set;** }
The currently targeted docking port.

void **ClearTarget** ()
Clears the current target.

void **LaunchVesselFromVAB** (string *name*)
Launch a new vessel from the VAB onto the launchpad.

Parameters

- **name** – Name of the vessel's craft file.

void **LaunchVesselFromSPH** (string *name*)
Launch a new vessel from the SPH onto the runway.

Parameters

- **name** – Name of the vessel's craft file.

double **UT** { **get;** }
The current universal time in seconds.

float **G** { **get;** }
The value of the gravitational constant G in $N(m/kg)^2$.

WarpMode **WarpMode** { **get;** }
The current time warp mode. Returns `WarpMode.None` if time warp is not active, `WarpMode.Rails` if regular "on-rails" time warp is active, or `WarpMode.Physics` if physical time warp is active.

float **WarpRate** { **get;** }
The current warp rate. This is the rate at which time is passing for either on-rails or physical time warp. For example, a value of 10 means time is passing 10x faster than normal. Returns 1 if time warp is not active.

float **WarpFactor** { **get;** }
The current warp factor. This is the index of the rate at which time is passing for either regular "on-rails" or physical time warp. Returns 0 if time warp is not active. When in on-rails time warp, this is equal to `RailsWarpFactor`, and in physics time warp, this is equal to `PhysicsWarpFactor`.

int **RailsWarpFactor** { **get; set;** }
The time warp rate, using regular "on-rails" time warp. A value between 0 and 7 inclusive. 0 means no time warp. Returns 0 if physical time warp is active. If requested time warp factor cannot be set, it will be set to the next lowest possible value. For example, if the vessel is too close to a planet. See the KSP wiki for details.

int **PhysicsWarpFactor** { **get; set;** }
The physical time warp rate. A value between 0 and 3 inclusive. 0 means no time warp. Returns 0 if regular "on-rails" time warp is active.

bool **CanRailsWarpAt** (int *factor = 1*)
Returns `true` if regular "on-rails" time warp can be used, at the specified warp *factor*. The maximum time warp rate is limited by various things, including how close the active vessel is to a planet. See the KSP wiki for details.

Parameters

- **factor** – The warp factor to check.

int **MaximumRailsWarpFactor** { **get;** }
The current maximum regular "on-rails" warp factor that can be set. A value between 0 and 7 inclusive. See the KSP wiki for details.

void **WarpTo** (double *UT*, float *maxRailsRate = 100000.0*, float *maxPhysicsRate = 2.0*)
Uses time acceleration to warp forward to a time in the future, specified by universal time *UT*. This call blocks until the desired time is reached. Uses regular "on-rails" or physical time warp as appropriate. For example, physical time warp is used when the active vessel is traveling through an atmosphere. When using regular "on-rails" time warp, the warp rate is limited by *maxRailsRate*, and when using physical time warp, the warp rate is limited by *maxPhysicsRate*.

Parameters

- **UT** – The universal time to warp to, in seconds.
- **maxRailsRate** – The maximum warp rate in regular "on-rails" time warp.
- **maxPhysicsRate** – The maximum warp rate in physical time warp.

Returns When the time warp is complete.

Tuple<double, double, double> **TransformPosition** (Tuple<double, double, double> *position*, *ReferenceFrame from*, *ReferenceFrame to*)
Converts a position vector from one reference frame to another.

Parameters

- **position** – Position vector in reference frame *from*.
- **from** – The reference frame that the position vector is in.
- **to** – The reference frame to covert the position vector to.

Returns The corresponding position vector in reference frame *to*.

Tuple<double, double, double> **TransformDirection** (Tuple<double, double, double> *direction*, *ReferenceFrame from*, *ReferenceFrame to*)
Converts a direction vector from one reference frame to another.

Parameters

- **direction** – Direction vector in reference frame *from*.
- **from** – The reference frame that the direction vector is in.
- **to** – The reference frame to covert the direction vector to.

Returns The corresponding direction vector in reference frame *to*.

Tuple<double, double, double, double> **TransformRotation** (Tuple<double, double, double, double> *rotation*, *ReferenceFrame from*, *ReferenceFrame to*)

Converts a rotation from one reference frame to another.

Parameters

- **rotation** – Rotation in reference frame *from*.
- **from** – The reference frame that the rotation is in.
- **to** – The corresponding rotation in reference frame *to*.

Returns The corresponding rotation in reference frame *to*.

Tuple<double, double, double> **TransformVelocity** (Tuple<double, double, double> *position*, Tuple<double, double, double> *velocity*, *ReferenceFrame from*, *ReferenceFrame to*)

Converts a velocity vector (acting at the specified position vector) from one reference frame to another. The position vector is required to take the relative angular velocity of the reference frames into account.

Parameters

- **position** – Position vector in reference frame *from*.
- **velocity** – Velocity vector in reference frame *from*.
- **from** – The reference frame that the position and velocity vectors are in.
- **to** – The reference frame to covert the velocity vector to.

Returns The corresponding velocity in reference frame *to*.

bool **FARAvailable** { **get;** }

Whether Ferram Aerospace Research is installed.

bool **RemoteTechAvailable** { **get;** }

Whether RemoteTech is installed.

void **DrawDirection** (Tuple<double, double, double> *direction*, *ReferenceFrame referenceFrame*, Tuple<double, double, double> *color*, float *length = 10.0*)

Draw a direction vector on the active vessel.

Parameters

- **direction** – Direction to draw the line in.
- **referenceFrame** – Reference frame that the direction is in.
- **color** – The color to use for the line, as an RGB color.
- **length** – The length of the line. Defaults to 10.

void **DrawLine** (Tuple<double, double, double> *start*, Tuple<double, double, double> *end*, *ReferenceFrame referenceFrame*, Tuple<double, double, double> *color*)

Draw a line.

Parameters

- **start** – Position of the start of the line.
- **end** – Position of the end of the line.
- **referenceFrame** – Reference frame that the position are in.
- **color** – The color to use for the line, as an RGB color.

void **ClearDrawing** ()
Remove all directions and lines currently being drawn.

enum WarpMode
Returned by `WarpMode`

Rails
Time warp is active, and in regular "on-rails" mode.

Physics
Time warp is active, and in physical time warp mode.

None
Time warp is not active.

3.2.2 Vessel

class Vessel
These objects are used to interact with vessels in KSP. This includes getting orbital and flight data, manipulating control inputs and managing resources.

string **Name** { **get; set;** }
The name of the vessel.

VesselType **Type** { **get; set;** }
The type of the vessel.

VesselSituation **Situation** { **get;** }
The situation the vessel is in.

double **MET** { **get;** }
The mission elapsed time in seconds.

Flight **Flight** (*ReferenceFrame referenceFrame = None*)
Returns a `Flight` object that can be used to get flight telemetry for the vessel, in the specified reference frame.

Parameters

- **referenceFrame** – Reference frame. Defaults to the vessel's surface reference frame (`Vessel.SurfaceReferenceFrame`).

Vessel **Target** { **get; set;** }
The target vessel. `null` if there is no target. When setting the target, the target cannot be the current vessel.

Orbit **Orbit** { **get;** }
The current orbit of the vessel.

Control **Control** { **get;** }
Returns a `Control` object that can be used to manipulate the vessel's control inputs. For example, its pitch/yaw/roll controls, RCS and thrust.

AutoPilot **AutoPilot** { **get;** }
An `AutoPilot` object, that can be used to perform simple auto-piloting of the vessel.

Resources **Resources** { **get;** }
A `Resources` object, that can used to get information about resources stored in the vessel.

Resources **ResourcesInDecoupleStage** (int *stage*, bool *cumulative = True*)
Returns a `Resources` object, that can used to get information about resources stored in a given *stage*.

Parameters

- **stage** – Get resources for parts that are decoupled in this stage.
- **cumulative** – When `false`, returns the resources for parts decoupled in just the given stage. When `true` returns the resources decoupled in the given stage and all subsequent stages combined.

Note: For details on stage numbering, see the discussion on *Staging*.

Parts **`Parts`** { **get;** }
A *`Parts`* object, that can used to interact with the parts that make up this vessel.

Comms **`Comms`** { **get;** }
A *`Comms`* object, that can used to interact with RemoteTech for this vessel.

Note: Requires RemoteTech to be installed.

float **`Mass`** { **get;** }
The total mass of the vessel, including resources, in kg.

float **`DryMass`** { **get;** }
The total mass of the vessel, excluding resources, in kg.

float **`Thrust`** { **get;** }
The total thrust currently being produced by the vessel's engines, in Newtons. This is computed by summing *`Engine.Thrust`* for every engine in the vessel.

float **`AvailableThrust`** { **get;** }
Gets the total available thrust that can be produced by the vessel's active engines, in Newtons. This is computed by summing *`Engine.AvailableThrust`* for every active engine in the vessel.

float **`MaxThrust`** { **get;** }
The total maximum thrust that can be produced by the vessel's active engines, in Newtons. This is computed by summing *`Engine.MaxThrust`* for every active engine.

float **`MaxVacuumThrust`** { **get;** }
The total maximum thrust that can be produced by the vessel's active engines when the vessel is in a vacuum, in Newtons. This is computed by summing *`Engine.MaxVacuumThrust`* for every active engine.

float **`SpecificImpulse`** { **get;** }
The combined specific impulse of all active engines, in seconds. This is computed using the formula described here.

float **`VacuumSpecificImpulse`** { **get;** }
The combined vacuum specific impulse of all active engines, in seconds. This is computed using the formula described here.

float **`KerbinSeaLevelSpecificImpulse`** { **get;** }
The combined specific impulse of all active engines at sea level on Kerbin, in seconds. This is computed using the formula described here.

ReferenceFrame **`ReferenceFrame`** { **get;** }
The reference frame that is fixed relative to the vessel, and orientated with the vessel.

- The origin is at the center of mass of the vessel.
- The axes rotate with the vessel.

- The x-axis points out to the right of the vessel.
- The y-axis points in the forward direction of the vessel.
- The z-axis points out of the bottom off the vessel.

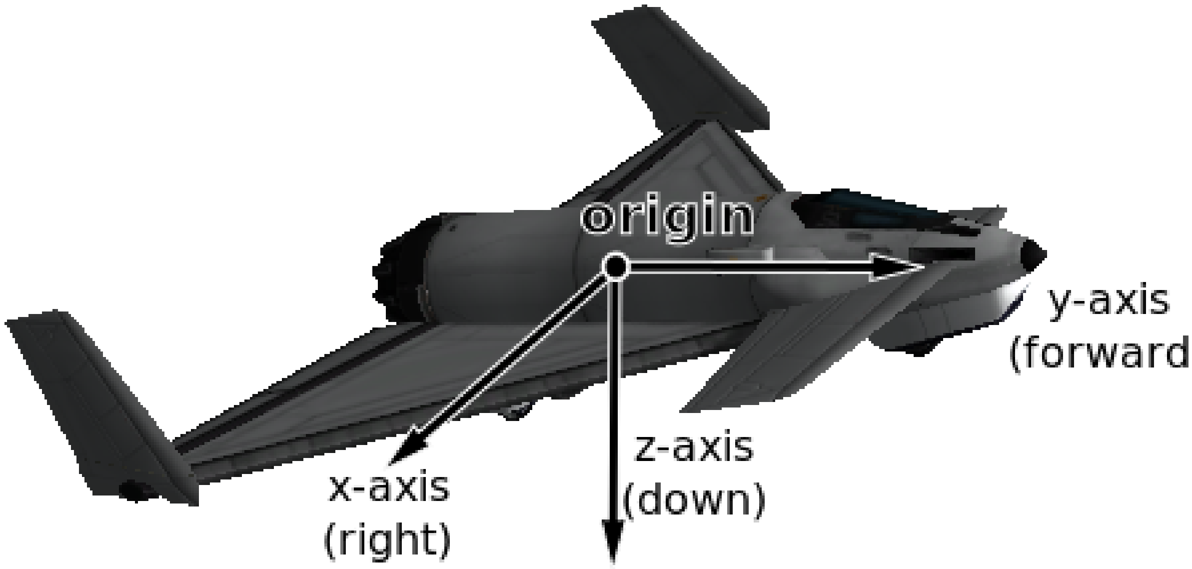


Fig. 3.1: Vessel reference frame origin and axes for the Aeris 3A aircraft

ReferenceFrame **OrbitalReferenceFrame** { **get;** }

The reference frame that is fixed relative to the vessel, and orientated with the vessels orbital prograde/normal/radial directions.

- The origin is at the center of mass of the vessel.
- The axes rotate with the orbital prograde/normal/radial directions.
- The x-axis points in the orbital anti-radial direction.
- The y-axis points in the orbital prograde direction.
- The z-axis points in the orbital normal direction.

Note: Be careful not to confuse this with 'orbit' mode on the navball.

ReferenceFrame **SurfaceReferenceFrame** { **get;** }

The reference frame that is fixed relative to the vessel, and orientated with the surface of the body being orbited.

- The origin is at the center of mass of the vessel.
- The axes rotate with the north and up directions on the surface of the body.
- The x-axis points in the zenith direction (upwards, normal to the body being orbited, from the center of the body towards the center of mass of the vessel).
- The y-axis points northwards towards the astronomical horizon (north, and tangential to the surface of the body – the direction in which a compass would point when on the surface).
- The z-axis points eastwards towards the astronomical horizon (east, and tangential to the surface of the body – east on a compass when on the surface).

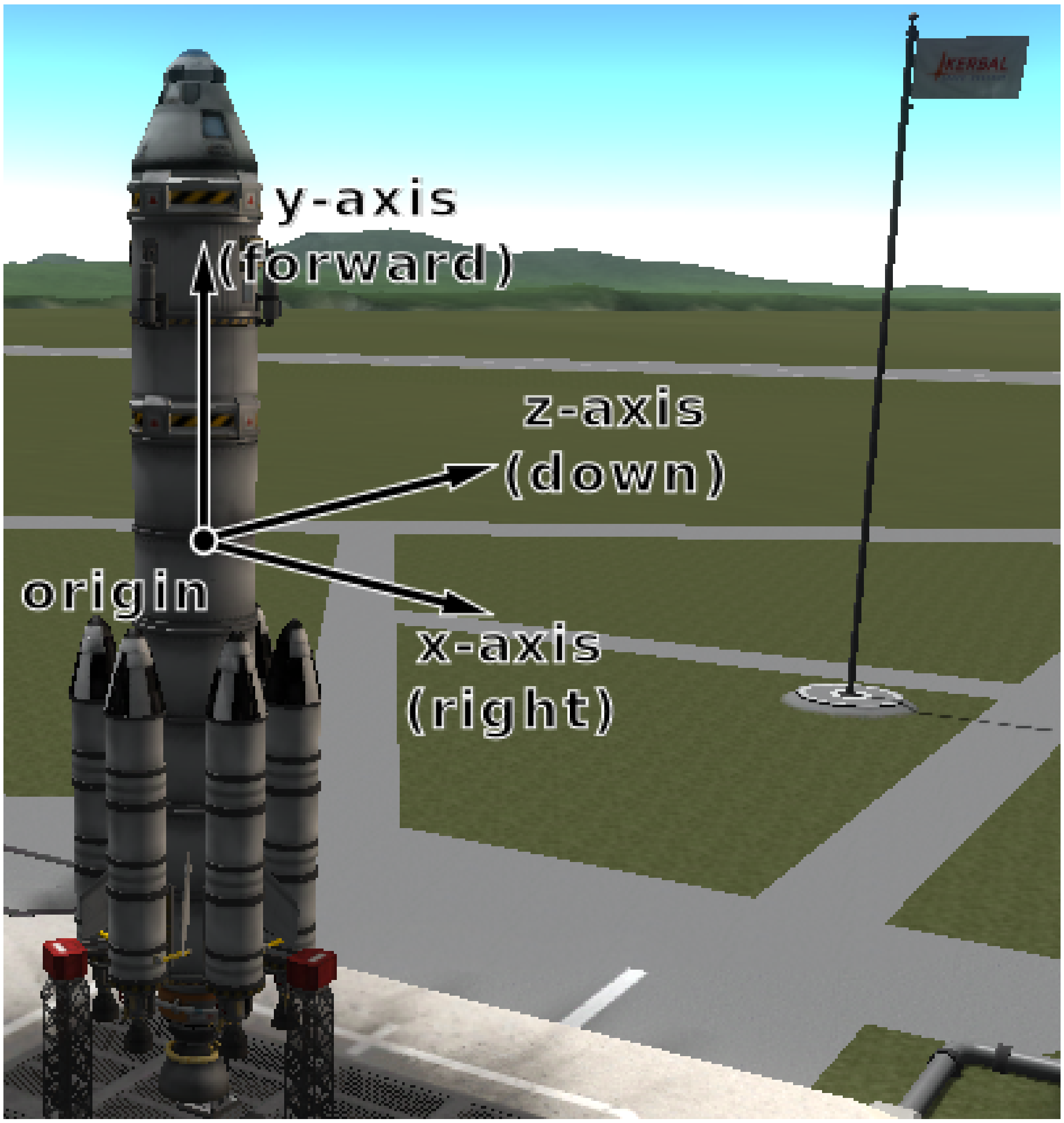


Fig. 3.2: Vessel reference frame origin and axes for the Kerbal-X rocket

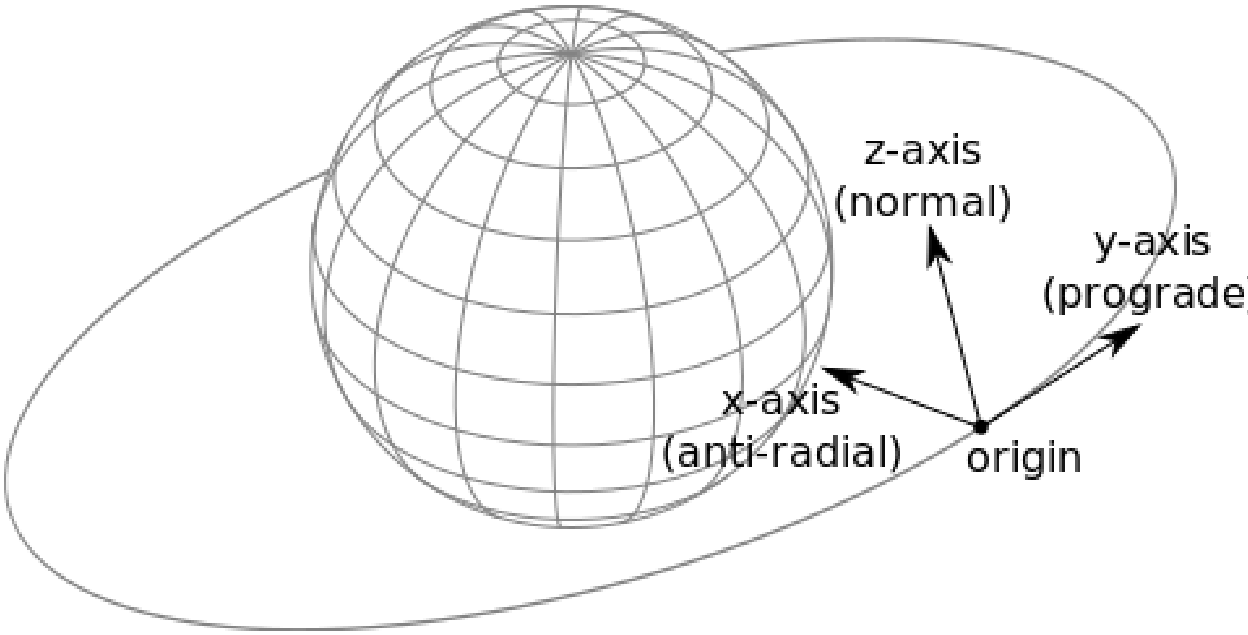


Fig. 3.3: Vessel orbital reference frame origin and axes

Note: Be careful not to confuse this with 'surface' mode on the navball.

ReferenceFrame **SurfaceVelocityReferenceFrame** { **get;** }

The reference frame that is fixed relative to the vessel, and orientated with the velocity vector of the vessel relative to the surface of the body being orbited.

- The origin is at the center of mass of the vessel.
- The axes rotate with the vessel's velocity vector.
- The y-axis points in the direction of the vessel's velocity vector, relative to the surface of the body being orbited.
- The z-axis is in the plane of the astronomical horizon.
- The x-axis is orthogonal to the other two axes.

Tuple<double, double, double> **Position** (*ReferenceFrame referenceFrame*)

Returns the position vector of the center of mass of the vessel in the given reference frame.

Parameters

Tuple<double, double, double> **Velocity** (*ReferenceFrame referenceFrame*)

Returns the velocity vector of the center of mass of the vessel in the given reference frame.

Parameters

Tuple<double, double, double, double> **Rotation** (*ReferenceFrame referenceFrame*)

Returns the rotation of the center of mass of the vessel in the given reference frame.

Parameters

Tuple<double, double, double> **Direction** (*ReferenceFrame referenceFrame*)

Returns the direction in which the vessel is pointing, as a unit vector, in the given reference frame.

Parameters

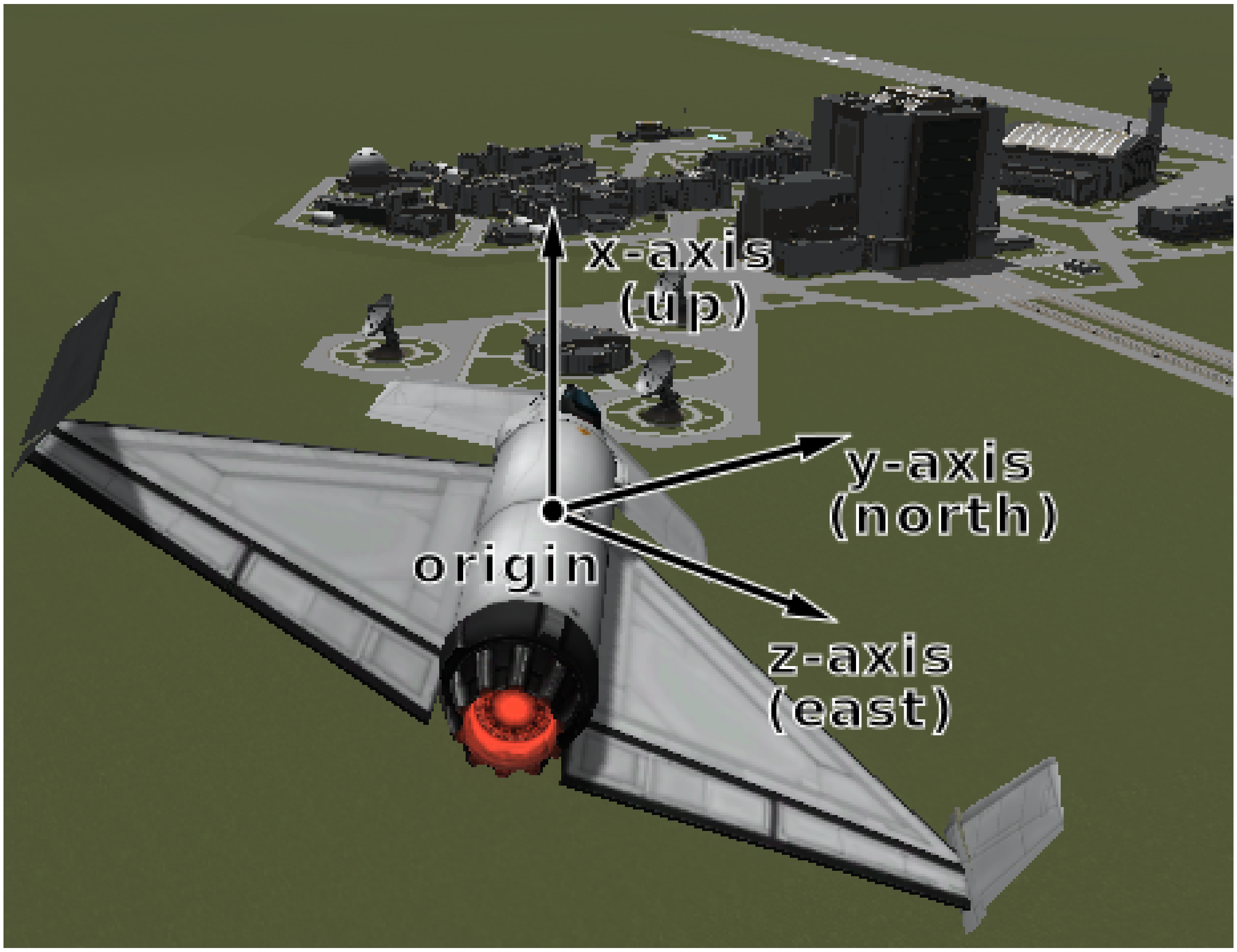


Fig. 3.4: Vessel surface reference frame origin and axes

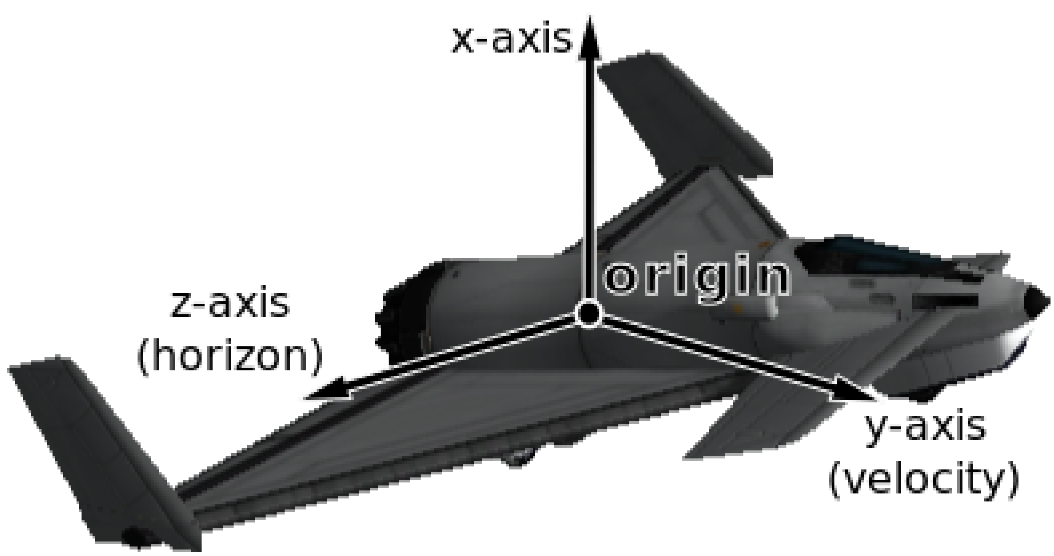


Fig. 3.5: Vessel surface velocity reference frame origin and axes

Tuple<double, double, double> **AngularVelocity** (*ReferenceFrame referenceFrame*)
Returns the angular velocity of the vessel in the given reference frame. The magnitude of the returned vector is the rotational speed in radians per second, and the direction of the vector indicates the axis of rotation (using the right hand rule).

Parameters

enum VesselType
See *Vessel.Type*.

Ship
Ship.

Station
Station.

Lander
Lander.

Probe
Probe.

Rover
Rover.

Base
Base.

Debris
Debris.

enum VesselSituation
See *Vessel.Situation*.

Docked
Vessel is docked to another.

Escaping
Escaping.

Flying
Vessel is flying through an atmosphere.

Landed
Vessel is landed on the surface of a body.

Orbiting
Vessel is orbiting a body.

PreLaunch
Vessel is awaiting launch.

Splashed
Vessel has splashed down in an ocean.

SubOrbital
Vessel is on a sub-orbital trajectory.

3.2.3 CelestialBody

class CelestialBody
Represents a celestial body (such as a planet or moon).

string **Name** { **get;** }
The name of the body.

IList<*CelestialBody*> **Satellites** { **get;** }
A list of celestial bodies that are in orbit around this celestial body.

Orbit **Orbit** { **get;** }
The orbit of the body.

float **Mass** { **get;** }
The mass of the body, in kilograms.

float **GravitationalParameter** { **get;** }
The standard gravitational parameter of the body in m^3s^{-2}.

float **SurfaceGravity** { **get;** }
The acceleration due to gravity at sea level (mean altitude) on the body, in m/s^2.

float **RotationalPeriod** { **get;** }
The sidereal rotational period of the body, in seconds.

float **RotationalSpeed** { **get;** }
The rotational speed of the body, in radians per second.

float **EquatorialRadius** { **get;** }
The equatorial radius of the body, in meters.

double **SurfaceHeight** (double *latitude*, double *longitude*)
The height of the surface relative to mean sea level at the given position, in meters. When over water this is equal to 0.

Parameters

- **latitude** – Latitude in degrees
- **longitude** – Longitude in degrees

double **BedrockHeight** (double *latitude*, double *longitude*)
The height of the surface relative to mean sea level at the given position, in meters. When over water, this is the height of the sea-bed and is therefore a negative value.

Parameters

- **latitude** – Latitude in degrees
- **longitude** – Longitude in degrees

Tuple<double, double, double> **MSLPosition** (double *latitude*, double *longitude*, *ReferenceFrame* *referenceFrame*)
The position at mean sea level at the given latitude and longitude, in the given reference frame.

Parameters

- **latitude** – Latitude in degrees
- **longitude** – Longitude in degrees
- **referenceFrame** – Reference frame for the returned position vector

Tuple<double, double, double> **SurfacePosition** (double *latitude*, double *longitude*, *ReferenceFrame* *referenceFrame*)
The position of the surface at the given latitude and longitude, in the given reference frame. When over water, this is the position of the surface of the water.

Parameters

- **latitude** – Latitude in degrees
- **longitude** – Longitude in degrees
- **referenceFrame** – Reference frame for the returned position vector

Tuple<double, double, double> **BedrockPosition** (double *latitude*, double *longitude*, *ReferenceFrame referenceFrame*)

The position of the surface at the given latitude and longitude, in the given reference frame. When over water, this is the position at the bottom of the sea-bed.

Parameters

- **latitude** – Latitude in degrees
- **longitude** – Longitude in degrees
- **referenceFrame** – Reference frame for the returned position vector

float **SphereOfInfluence** { **get;** }

The radius of the sphere of influence of the body, in meters.

bool **HasAtmosphere** { **get;** }

`true` if the body has an atmosphere.

float **AtmosphereDepth** { **get;** }

The depth of the atmosphere, in meters.

bool **HasAtmosphericOxygen** { **get;** }

`true` if there is oxygen in the atmosphere, required for air-breathing engines.

ReferenceFrame **ReferenceFrame** { **get;** }

The reference frame that is fixed relative to the celestial body.

- The origin is at the center of the body.
- The axes rotate with the body.
- The x-axis points from the center of the body towards the intersection of the prime meridian and equator (the position at 0° longitude, 0° latitude).
- The y-axis points from the center of the body towards the north pole.
- The z-axis points from the center of the body towards the equator at 90°E longitude.

ReferenceFrame **NonRotatingReferenceFrame** { **get;** }

The reference frame that is fixed relative to this celestial body, and orientated in a fixed direction (it does not rotate with the body).

- The origin is at the center of the body.
- The axes do not rotate.
- The x-axis points in an arbitrary direction through the equator.
- The y-axis points from the center of the body towards the north pole.
- The z-axis points in an arbitrary direction through the equator.

ReferenceFrame **OrbitalReferenceFrame** { **get;** }

Gets the reference frame that is fixed relative to this celestial body, but orientated with the body's orbital prograde/normal/radial directions.

- The origin is at the center of the body.
- The axes rotate with the orbital prograde/normal/radial directions.
- The x-axis points in the orbital anti-radial direction.

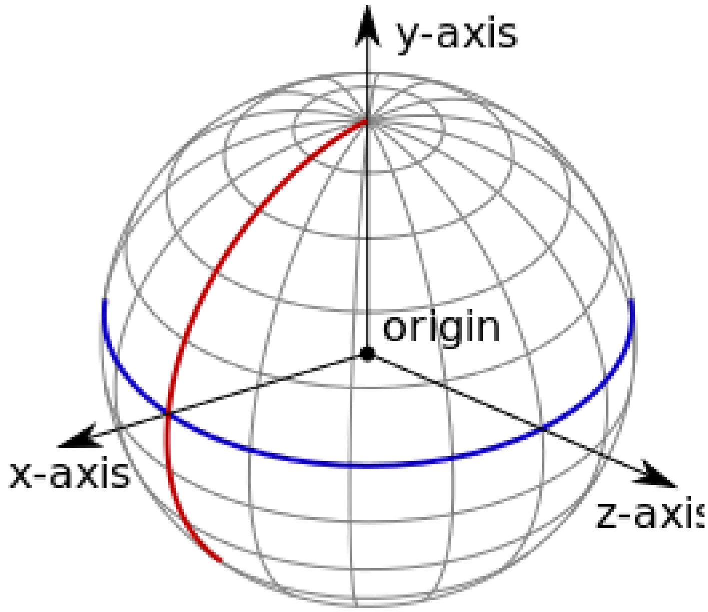


Fig. 3.6: Celestial body reference frame origin and axes. The equator is shown in blue, and the prime meridian in red.

- The y-axis points in the orbital prograde direction.
- The z-axis points in the orbital normal direction.

Tuple<double, double, double> **Position** (*ReferenceFrame referenceFrame*)
Returns the position vector of the center of the body in the specified reference frame.

Parameters

Tuple<double, double, double> **Velocity** (*ReferenceFrame referenceFrame*)
Returns the velocity vector of the body in the specified reference frame.

Parameters

Tuple<double, double, double, double> **Rotation** (*ReferenceFrame referenceFrame*)
Returns the rotation of the body in the specified reference frame.

Parameters

Tuple<double, double, double> **Direction** (*ReferenceFrame referenceFrame*)
Returns the direction in which the north pole of the celestial body is pointing, as a unit vector, in the specified reference frame.

Parameters

Tuple<double, double, double> **AngularVelocity** (*ReferenceFrame referenceFrame*)
Returns the angular velocity of the body in the specified reference frame. The magnitude of the vector is the rotational speed of the body, in radians per second, and the direction of the vector indicates the axis of rotation, using the right-hand rule.

Parameters

3.2.4 Flight

class Flight
Used to get flight telemetry for a vessel, by calling `Vessel.Flight`. All of the information returned by this

class is given in the reference frame passed to that method.

Note: To get orbital information, such as the apoapsis or inclination, see `Orbit`.

---

float **GForce** { **get;** }
The current G force acting on the vessel in m/s^2.

double **MeanAltitude** { **get;** }
The altitude above sea level, in meters.

double **SurfaceAltitude** { **get;** }
The altitude above the surface of the body or sea level, whichever is closer, in meters.

double **BedrockAltitude** { **get;** }
The altitude above the surface of the body, in meters. When over water, this is the altitude above the sea floor.

double **Elevation** { **get;** }
The elevation of the terrain under the vessel, in meters. This is the height of the terrain above sea level, and is negative when the vessel is over the sea.

double **Latitude** { **get;** }
The latitude of the vessel for the body being orbited, in degrees.

double **Longitude** { **get;** }
The longitude of the vessel for the body being orbited, in degrees.

Tuple<double, double, double> **Velocity** { **get;** }
The velocity vector of the vessel. The magnitude of the vector is the speed of the vessel in meters per second. The direction of the vector is the direction of the vessels motion.

double **Speed** { **get;** }
The speed of the vessel in meters per second.

double **HorizontalSpeed** { **get;** }
The horizontal speed of the vessel in meters per second.

double **VerticalSpeed** { **get;** }
The vertical speed of the vessel in meters per second.

Tuple<double, double, double> **CenterOfMass** { **get;** }
The position of the center of mass of the vessel.

Tuple<double, double, double, double> **Rotation** { **get;** }
The rotation of the vessel.

Tuple<double, double, double> **Direction** { **get;** }
The direction vector that the vessel is pointing in.

float **Pitch** { **get;** }
The pitch angle of the vessel relative to the horizon, in degrees. A value between -90° and +90°.

float **Heading** { **get;** }
The heading angle of the vessel relative to north, in degrees. A value between 0° and 360°.

float **Roll** { **get;** }
The roll angle of the vessel relative to the horizon, in degrees. A value between -180° and +180°.

Tuple<double, double, double> **Prograde** { **get;** }
The unit direction vector pointing in the prograde direction.

Tuple<double, double, double> **Retrograde** { **get;** }
The unit direction vector pointing in the retrograde direction.

Tuple<double, double, double> **Normal** { **get;** }
The unit direction vector pointing in the normal direction.

Tuple<double, double, double> **AntiNormal** { **get;** }
The unit direction vector pointing in the anti-normal direction.

Tuple<double, double, double> **Radial** { **get;** }
The unit direction vector pointing in the radial direction.

Tuple<double, double, double> **AntiRadial** { **get;** }
The unit direction vector pointing in the anti-radial direction.

float **AtmosphereDensity** { **get;** }
The current density of the atmosphere around the vessel, in kg/m^3.

float **DynamicPressure** { **get;** }
The dynamic pressure acting on the vessel, in Pascals. This is a measure of the strength of the aerodynamic forces. It is equal to $\frac{1}{2}$.air density.velocity^2. It is commonly denoted as Q.

Note: Calculated using KSPs stock aerodynamic model, or Ferram Aerospace Research if it is installed.

float **StaticPressure** { **get;** }
The static atmospheric pressure acting on the vessel, in Pascals.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

Tuple<double, double, double> **AerodynamicForce** { **get;** }
The total aerodynamic forces acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

Tuple<double, double, double> **Lift** { **get;** }
The aerodynamic lift currently acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

Tuple<double, double, double> **Drag** { **get;** }
The aerodynamic drag currently acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

float **SpeedOfSound** { **get;** }
The speed of sound, in the atmosphere around the vessel, in m/s.

Note: Not available when Ferram Aerospace Research is installed.

float **Mach** { **get;** }
The speed of the vessel, in multiples of the speed of sound.

Note: Not available when Ferram Aerospace Research is installed.

float **EquivalentAirSpeed** { **get;** }
The equivalent air speed of the vessel, in m/s.

Note: Not available when Ferram Aerospace Research is installed.

float **TerminalVelocity** { **get;** }
An estimate of the current terminal velocity of the vessel, in m/s. This is the speed at which the drag forces cancel out the force of gravity.

Note: Calculated using KSPs stock aerodynamic model, or Ferram Aerospace Research if it is installed.

float **AngleOfAttack** { **get;** }
Gets the pitch angle between the orientation of the vessel and its velocity vector, in degrees.

float **SideslipAngle** { **get;** }
Gets the yaw angle between the orientation of the vessel and its velocity vector, in degrees.

float **TotalAirTemperature** { **get;** }
The total air temperature of the atmosphere around the vessel, in Kelvin. This temperature includes the *Flight.StaticAirTemperature* and the vessel's kinetic energy.

float **StaticAirTemperature** { **get;** }
The static (ambient) temperature of the atmosphere around the vessel, in Kelvin.

float **StallFraction** { **get;** }
Gets the current amount of stall, between 0 and 1. A value greater than 0.005 indicates a minor stall and a value greater than 0.5 indicates a large-scale stall.

Note: Requires Ferram Aerospace Research.

float **DragCoefficient** { **get;** }
Gets the coefficient of drag. This is the amount of drag produced by the vessel. It depends on air speed, air density and wing area.

Note: Requires Ferram Aerospace Research.

float **LiftCoefficient** { **get;** }
Gets the coefficient of lift. This is the amount of lift produced by the vessel, and depends on air speed, air density and wing area.

Note: Requires Ferram Aerospace Research.

float **BallisticCoefficient** { **get;** }
Gets the ballistic coefficient.

Note: Requires Ferram Aerospace Research.

float **ThrustSpecificFuelConsumption** { **get;** }
Gets the thrust specific fuel consumption for the jet engines on the vessel. This is a measure of the efficiency of the engines, with a lower value indicating a more efficient vessel. This value is the number of Newtons of fuel that are burned, per hour, to product one newton of thrust.

Note: Requires Ferram Aerospace Research.

3.2.5 Orbit

class Orbit
Describes an orbit. For example, the orbit of a vessel, obtained by calling `Vessel.Orbit`, or a celestial body, obtained by calling `CelestialBody.Orbit`.

CelestialBody **Body** { **get;** }
The celestial body (e.g. planet or moon) around which the object is orbiting.

double **Apoapsis** { **get;** }
Gets the apoapsis of the orbit, in meters, from the center of mass of the body being orbited.

Note: For the apoapsis altitude reported on the in-game map view, use `Orbit.ApoapsisAltitude`.

double **Periapsis** { **get;** }
The periapsis of the orbit, in meters, from the center of mass of the body being orbited.

Note: For the periapsis altitude reported on the in-game map view, use `Orbit.PeriapsisAltitude`.

double **ApoapsisAltitude** { **get;** }
The apoapsis of the orbit, in meters, above the sea level of the body being orbited.

Note: This is equal to `Orbit.Apoapsis` minus the equatorial radius of the body.

double **PeriapsisAltitude** { **get;** }
The periapsis of the orbit, in meters, above the sea level of the body being orbited.

Note: This is equal to `Orbit.Periapsis` minus the equatorial radius of the body.

double **SemiMajorAxis** { **get;** }
The semi-major axis of the orbit, in meters.

double **SemiMinorAxis** { **get;** }
The semi-minor axis of the orbit, in meters.

double **Radius** { **get;** }
The current radius of the orbit, in meters. This is the distance between the center of mass of the object in orbit, and the center of mass of the body around which it is orbiting.

Note: This value will change over time if the orbit is elliptical.

double **Speed** { **get;** }
The current orbital speed of the object in meters per second.

Note: This value will change over time if the orbit is elliptical.

double **Period** { **get;** }
The orbital period, in seconds.

double **TimeToApoapsis** { **get;** }
The time until the object reaches apoapsis, in seconds.

double **TimeToPeriapsis** { **get;** }
The time until the object reaches periapsis, in seconds.

double **Eccentricity** { **get;** }
The eccentricity of the orbit.

double **Inclination** { **get;** }
The inclination of the orbit, in radians.

double **LongitudeOfAscendingNode** { **get;** }
The longitude of the ascending node, in radians.

double **ArgumentOfPeriapsis** { **get;** }
The argument of periapsis, in radians.

double **MeanAnomalyAtEpoch** { **get;** }
The mean anomaly at epoch.

double **Epoch** { **get;** }
The time since the epoch (the point at which the mean anomaly at epoch was measured, in seconds.

double **MeanAnomaly** { **get;** }
The mean anomaly.

double **EccentricAnomaly** { **get;** }
The eccentric anomaly.

static Tuple<double, double, double> **ReferencePlaneNormal** (*ReferenceFrame referenceFrame*)
The unit direction vector that is normal to the orbits reference plane, in the given reference frame. The reference plane is the plane from which the orbits inclination is measured.

Parameters

static Tuple<double, double, double> **ReferencePlaneDirection** (*ReferenceFrame referenceFrame*)
The unit direction vector from which the orbits longitude of ascending node is measured, in the given reference frame.

Parameters

double **TimeToSOIChange** { **get;** }

The time until the object changes sphere of influence, in seconds. Returns `NaN` if the object is not going to change sphere of influence.

Orbit **NextOrbit** { **get;** }

If the object is going to change sphere of influence in the future, returns the new orbit after the change. Otherwise returns `null`.

3.2.6 Control

class Control

Used to manipulate the controls of a vessel. This includes adjusting the throttle, enabling/disabling systems such as SAS and RCS, or altering the direction in which the vessel is pointing.

Note: Control inputs (such as pitch, yaw and roll) are zeroed when all clients that have set one or more of these inputs are no longer connected.

bool **SAS** { **get; set;** }

The state of SAS.

Note: Equivalent to *AutoPilot.SAS*

SASMode **SASMode** { **get; set;** }

The current *SASMode*. These modes are equivalent to the mode buttons to the left of the navball that appear when SAS is enabled.

Note: Equivalent to *AutoPilot.SASMode*

SpeedMode **SpeedMode** { **get; set;** }

The current *SpeedMode* of the navball. This is the mode displayed next to the speed at the top of the navball.

bool **RCS** { **get; set;** }

The state of RCS.

bool **Gear** { **get; set;** }

The state of the landing gear/legs.

bool **Lights** { **get; set;** }

The state of the lights.

bool **Brakes** { **get; set;** }

The state of the wheel brakes.

bool **Abort** { **get; set;** }

The state of the abort action group.

float **Throttle** { **get; set;** }

The state of the throttle. A value between 0 and 1.

float **Pitch** { **get; set;** }

The state of the pitch control. A value between -1 and 1. Equivalent to the w and s keys.

float **Yaw** { **get; set;** }

The state of the yaw control. A value between -1 and 1. Equivalent to the a and d keys.

float **Roll** { **get; set;** }
The state of the roll control. A value between -1 and 1. Equivalent to the q and e keys.

float **Forward** { **get; set;** }
The state of the forward translational control. A value between -1 and 1. Equivalent to the h and n keys.

float **Up** { **get; set;** }
The state of the up translational control. A value between -1 and 1. Equivalent to the i and k keys.

float **Right** { **get; set;** }
The state of the right translational control. A value between -1 and 1. Equivalent to the j and l keys.

float **WheelThrottle** { **get; set;** }
The state of the wheel throttle. A value between -1 and 1. A value of 1 rotates the wheels forwards, a value of -1 rotates the wheels backwards.

float **WheelSteering** { **get; set;** }
The state of the wheel steering. A value between -1 and 1. A value of 1 steers to the left, and a value of -1 steers to the right.

int **CurrentStage** { **get;** }
The current stage of the vessel. Corresponds to the stage number in the in-game UI.

IList<*Vessel*> **ActivateNextStage** ()
Activates the next stage. Equivalent to pressing the space bar in-game.

Returns A list of vessel objects that are jettisoned from the active vessel.

bool **GetActionGroup** (uint *group*)
Returns `true` if the given action group is enabled.

Parameters

- **group** – A number between 0 and 9 inclusive.

void **SetActionGroup** (uint *group*, bool *state*)
Sets the state of the given action group (a value between 0 and 9 inclusive).

Parameters

- **group** – A number between 0 and 9 inclusive.

void **ToggleActionGroup** (uint *group*)
Toggles the state of the given action group.

Parameters

- **group** – A number between 0 and 9 inclusive.

Node **AddNode** (double *UT*, float *prograde = 0.0*, float *normal = 0.0*, float *radial = 0.0*)
Creates a maneuver node at the given universal time, and returns a `Node` object that can be used to modify it. Optionally sets the magnitude of the delta-v for the maneuver node in the prograde, normal and radial directions.

Parameters

- **UT** – Universal time of the maneuver node.
- **prograde** – Delta-v in the prograde direction.
- **normal** – Delta-v in the normal direction.
- **radial** – Delta-v in the radial direction.

IList<*Node*> **Nodes** { **get;** }
Returns a list of all existing maneuver nodes, ordered by time from first to last.

void **RemoveNodes** ()

Remove all maneuver nodes.

enum SASMode

The behavior of the SAS auto-pilot. See *AutoPilot.SASMode*.

StabilityAssist

Stability assist mode. Dampen out any rotation.

Maneuver

Point in the burn direction of the next maneuver node.

Prograde

Point in the prograde direction.

Retrograde

Point in the retrograde direction.

Normal

Point in the orbit normal direction.

AntiNormal

Point in the orbit anti-normal direction.

Radial

Point in the orbit radial direction.

AntiRadial

Point in the orbit anti-radial direction.

Target

Point in the direction of the current target.

AntiTarget

Point away from the current target.

enum SpeedMode

See *Control.SpeedMode*.

Orbit

Speed is relative to the vessel's orbit.

Surface

Speed is relative to the surface of the body being orbited.

Target

Speed is relative to the current target.

3.2.7 Parts

The following classes allow interaction with a vessels individual parts.

Parts

class Parts

Instances of this class are used to interact with the parts of a vessel. An instance can be obtained by calling `Vessel.Parts`.

IList<*Part*> **All** { **get;** }

A list of all of the vessels parts.

Part **Root** { **get;** }

The vessels root part.

Note: See the discussion on *Trees of Parts*.

Part **Controlling** { **get; set;** }

The part from which the vessel is controlled.

IList<*Part*> **WithName** (string *name*)

A list of parts whose `Part.Name` is *name*.

Parameters

IList<*Part*> **WithTitle** (string *title*)

A list of all parts whose `Part.Title` is *title*.

Parameters

IList<*Part*> **WithModule** (string *moduleName*)

A list of all parts that contain a `Module` whose `Module.Name` is *moduleName*.

Parameters

IList<*Part*> **InStage** (int *stage*)
A list of all parts that are activated in the given *stage*.

Parameters

Note: See the discussion on *Staging*.

IList<*Part*> **InDecoupleStage** (int *stage*)
A list of all parts that are decoupled in the given *stage*.

Parameters

Note: See the discussion on *Staging*.

IList<*Module*> **ModulesWithName** (string *moduleName*)
A list of modules (combined across all parts in the vessel) whose `Module.Name` is *moduleName*.

Parameters

IList<*Decoupler*> **Decouplers** { **get;** }
A list of all decouplers in the vessel.

IList<*DockingPort*> **DockingPorts** { **get;** }
A list of all docking ports in the vessel.

DockingPort **DockingPortWithName** (string *name*)
The first docking port in the vessel with the given port name, as returned by `DockingPort.Name`. Returns `null` if there are no such docking ports.

Parameters

IList<*Engine*> **Engines** { **get;** }
A list of all engines in the vessel.

IList<*LandingGear*> **LandingGear** { **get;** }
A list of all landing gear attached to the vessel.

IList<*LandingLeg*> **LandingLegs** { **get;** }
A list of all landing legs attached to the vessel.

IList<*LaunchClamp*> **LaunchClamps** { **get;** }
A list of all launch clamps attached to the vessel.

IList<*Light*> **Lights** { **get;** }
A list of all lights in the vessel.

IList<*Parachute*> **Parachutes** { **get;** }
A list of all parachutes in the vessel.

IList<*Radiator*> **Radiators** { **get;** }
A list of all radiators in the vessel.

IList<*ResourceConverter*> **ResourceConverters** { **get;** }
A list of all resource converters in the vessel.

IList<*ResourceHarvester*> **ResourceHarvesters** { **get;** }
A list of all resource harvesters in the vessel.

IList<*ReactionWheel*> **ReactionWheels** { **get;** }
A list of all reaction wheels in the vessel.

IList<*Sensor*> **Sensors** { **get;** }
: A list of all sensors in the vessel.

IList<*SolarPanel*> **SolarPanels** { **get;** }
: A list of all solar panels in the vessel.

Part

class Part

Instances of this class represents a part. A vessel is made of multiple parts. Instances can be obtained by various methods in `Parts`.

string **Name** { **get;** }
: Internal name of the part, as used in part cfg files. For example "Mark1-2Pod".

string **Title** { **get;** }
: Title of the part, as shown when the part is right clicked in-game. For example "Mk1-2 Command Pod".

double **Cost** { **get;** }
: The cost of the part, in units of funds.

Vessel **Vessel** { **get;** }
: The vessel that contains this part.

Part **Parent** { **get;** }
: The parts parent. Returns `null` if the part does not have a parent. This, in combination with `Part.Children`, can be used to traverse the vessels parts tree.

Note: See the discussion on *Trees of Parts*.

IList<*Part*> **Children** { **get;** }
: The parts children. Returns an empty list if the part has no children. This, in combination with `Part.Parent`, can be used to traverse the vessels parts tree.

Note: See the discussion on *Trees of Parts*.

bool **AxiallyAttached** { **get;** }
: Whether the part is axially attached to its parent, i.e. on the top or bottom of its parent. If the part has no parent, returns `false`.

Note: See the discussion on *Attachment Modes*.

bool **RadiallyAttached** { **get;** }
: Whether the part is radially attached to its parent, i.e. on the side of its parent. If the part has no parent, returns `false`.

Note: See the discussion on *Attachment Modes*.

int **Stage** { **get;** }
: The stage in which this part will be activated. Returns -1 if the part is not activated by staging.

Note: See the discussion on *Staging*.

int **DecoupleStage** { **get;** }
The stage in which this part will be decoupled. Returns -1 if the part is never decoupled from the vessel.

Note: See the discussion on *Staging*.

bool **Massless** { **get;** }
Whether the part is massless.

double **Mass** { **get;** }
The current mass of the part, including resources it contains, in kilograms. Returns zero if the part is massless.

double **DryMass** { **get;** }
The mass of the part, not including any resources it contains, in kilograms. Returns zero if the part is massless.

double **ImpactTolerance** { **get;** }
The impact tolerance of the part, in meters per second.

double **Temperature** { **get;** }
Temperature of the part, in Kelvin.

double **SkinTemperature** { **get;** }
Temperature of the skin of the part, in Kelvin.

double **MaxTemperature** { **get;** }
Maximum temperature that the part can survive, in Kelvin.

double **MaxSkinTemperature** { **get;** }
Maximum temperature that the skin of the part can survive, in Kelvin.

double **ExternalTemperature** { **get;** }
Temperature of the atmosphere/vacuum surrounding the part, in Kelvin. This does not include heating from direct sunlight.

double **ThermalMass** { **get;** }
How much it takes to heat up the part.

double **ThermalSkinMass** { **get;** }
How much it takes to heat up the part's skin.

double **ThermalResourceMass** { **get;** }
How much it takes to heat up resources in the part.

double **ThermalConductionFlux** { **get;** }
The speed that heat is conducting into or out of the part through contact with other parts. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **ThermalConvectionFlux** { **get;** }
The speed that heat is convecting into or out of the part from the surrounding atmosphere. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **ThermalRadiationFlux** { **get;** }
The speed that heat is radiating into or out of the part from the surrounding vacuum. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **ThermalInternalFlux** { **get;** }
The speed that heat is generated by the part. For example, engines generate heat by burning fuel. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **ThermalSkinToInternalFlux** { **get;** }
The speed that heat is conducting between the part's skin and its internals.

Resources **Resources** { **get;** }
A `Resources` object for the part.

bool **Crossfeed** { **get;** }
Whether this part is crossfeed capable.

bool **IsFuelLine** { **get;** }
Whether this part is a fuel line.

IList<*Part*> **FuelLinesFrom** { **get;** }
The parts that are connected to this part via fuel lines, where the direction of the fuel line is into this part.

Note: See the discussion on *Fuel Lines*.

IList<*Part*> **FuelLinesTo** { **get;** }
The parts that are connected to this part via fuel lines, where the direction of the fuel line is out of this part.

Note: See the discussion on *Fuel Lines*.

IList<*Module*> **Modules** { **get;** }
The modules for this part.

Decoupler **Decoupler** { **get;** }
A `Decoupler` if the part is a decoupler, otherwise `null`.

DockingPort **DockingPort** { **get;** }
A `DockingPort` if the part is a docking port, otherwise `null`.

Engine **Engine** { **get;** }
An `Engine` if the part is an engine, otherwise `null`.

LandingGear **LandingGear** { **get;** }
A `LandingGear` if the part is a landing gear , otherwise `null`.

LandingLeg **LandingLeg** { **get;** }
A `LandingLeg` if the part is a landing leg, otherwise `null`.

LaunchClamp **LaunchClamp** { **get;** }
A `LaunchClamp` if the part is a launch clamp, otherwise `null`.

Light **Light** { **get;** }
A `Light` if the part is a light, otherwise `null`.

Parachute **Parachute** { **get;** }
A `Parachute` if the part is a parachute, otherwise `null`.

Radiator **Radiator** { **get;** }
A `Radiator` if the part is a radiator, otherwise `null`.

ReactionWheel **ReactionWheel** { **get;** }
A `ReactionWheel` if the part is a reaction wheel, otherwise `null`.

ResourceConverter **ResourceConverter** { **get;** }
A `ResourceConverter` if the part is a resource converter, otherwise `null`.

ResourceHarvester **ResourceHarvester** { **get;** }
A `ResourceHarvester` if the part is a resource harvester, otherwise `null`.

Sensor **Sensor** { **get;** }
A `Sensor` if the part is a sensor, otherwise `null`.

SolarPanel **SolarPanel** { **get;** }
A `SolarPanel` if the part is a solar panel, otherwise `null`.

Tuple<double, double, double> **Position** (*ReferenceFrame referenceFrame*)
The position of the part in the given reference frame.

Parameters

Tuple<double, double, double> **Direction** (*ReferenceFrame referenceFrame*)
The direction of the part in the given reference frame.

Parameters

Tuple<double, double, double> **Velocity** (*ReferenceFrame referenceFrame*)
The velocity of the part in the given reference frame.

Parameters

Tuple<double, double, double, double> **Rotation** (*ReferenceFrame referenceFrame*)
The rotation of the part in the given reference frame.

Parameters

ReferenceFrame **ReferenceFrame** { **get;** }
The reference frame that is fixed relative to this part.

- The origin is at the position of the part.
- The axes rotate with the part.
- The x, y and z axis directions depend on the design of the part.

Note: For docking port parts, this reference frame is not necessarily equivalent to the reference frame for the docking port, returned by `DockingPort.ReferenceFrame`.

Module

class Module
In KSP, each part has zero or more PartModules associated with it. Each one contains some of the functionality of the part. For example, an engine has a "ModuleEngines" PartModule that contains all the functionality of an engine. This class allows you to interact with KSPs PartModules, and any PartModules that have been added by other mods.

string **Name** { **get;** }
Name of the PartModule. For example, "ModuleEngines".

Part **Part** { **get;** }
The part that contains this module.

IDictionary<string, string> **Fields** { **get;** }
The modules field names and their associated values, as a dictionary. These are the values visible in the right-click menu of the part.

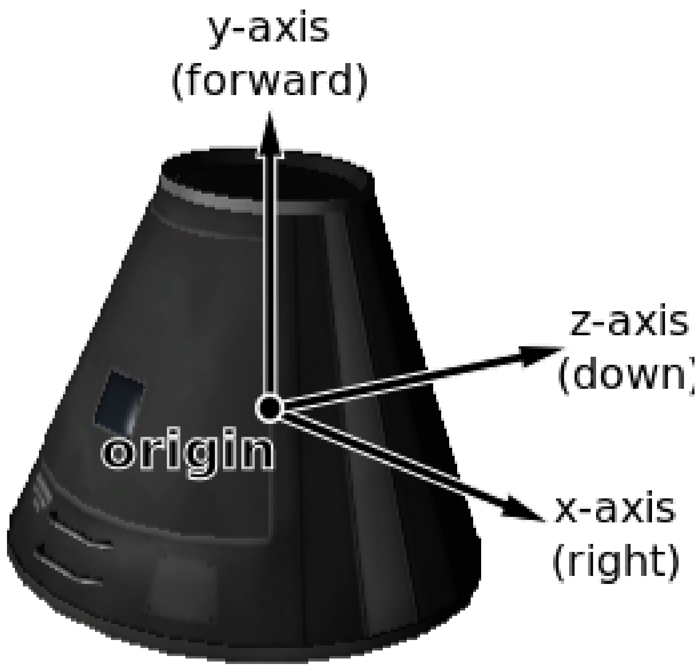


Fig. 3.7: Mk1 Command Pod reference frame origin and axes

bool **HasField** (string *name*)

Returns `true` if the module has a field with the given name.

Parameters

- **name** – Name of the field.

string **GetField** (string *name*)

Returns the value of a field.

Parameters

- **name** – Name of the field.

IList<string> **Events** { **get;** }

A list of the names of all of the modules events. Events are the clickable buttons visible in the right-click menu of the part.

bool **HasEvent** (string *name*)

`true` if the module has an event with the given name.

Parameters

void **TriggerEvent** (string *name*)

Trigger the named event. Equivalent to clicking the button in the right-click menu of the part.

Parameters

IList<string> **Actions** { **get;** }

A list of all the names of the modules actions. These are the parts actions that can be assigned to action groups in the in-game editor.

bool **HasAction** (string *name*)

`true` if the part has an action with the given name.

Parameters

void **SetAction** (string *name*, bool *value* = *True*)
Set the value of an action with the given name.

Parameters

Specific Types of Part

The following classes provide functionality for specific types of part.

Decoupler

class Decoupler
Obtained by calling `Part.Decoupler`

Part **Part** { **get;** }
The part object for this decoupler.

void **Decouple** ()
Fires the decoupler. Has no effect if the decoupler has already fired.

bool **Decoupled** { **get;** }
Whether the decoupler has fired.

float **Impulse** { **get;** }
The impulse that the decoupler imparts when it is fired, in Newton seconds.

Docking Port

class DockingPort
Obtained by calling `Part.DockingPort`

Part **Part** { **get;** }
The part object for this docking port.

string **Name** { **get; set;** }
The port name of the docking port. This is the name of the port that can be set in the right click menu, when the Docking Port Alignment Indicator mod is installed. If this mod is not installed, returns the title of the part (`Part.Title`).

DockingPortState **State** { **get;** }
The current state of the docking port.

Part **DockedPart** { **get;** }
The part that this docking port is docked to. Returns `null` if this docking port is not docked to anything.

Vessel **Undock** ()
Undocks the docking port and returns the vessel that was undocked from. After undocking, the active vessel may change (`ActiveVessel`). This method can be called for either docking port in a docked pair - both calls will have the same effect. Returns `null` if the docking port is not docked to anything.

float **ReengageDistance** { **get;** }
The distance a docking port must move away when it undocks before it becomes ready to dock with another port, in meters.

bool **HasShield** { **get;** }
Whether the docking port has a shield.

bool **Shielded** { **get; set;** }
The state of the docking ports shield, if it has one. Returns `true` if the docking port has a shield, and the shield is closed. Otherwise returns `false`. When set to `true`, the shield is closed, and when set to `false` the shield is opened. If the docking port does not have a shield, setting this attribute has no effect.

Tuple<double, double, double> **Position** (*ReferenceFrame referenceFrame*)
The position of the docking port in the given reference frame.

Parameters

Tuple<double, double, double> **Direction** (*ReferenceFrame referenceFrame*)
The direction that docking port points in, in the given reference frame.

Parameters

Tuple<double, double, double, double> **Rotation** (*ReferenceFrame referenceFrame*)
The rotation of the docking port, in the given reference frame.

Parameters

ReferenceFrame **ReferenceFrame** { **get;** }
The reference frame that is fixed relative to this docking port, and oriented with the port.

- The origin is at the position of the docking port.
- The axes rotate with the docking port.
- The x-axis points out to the right side of the docking port.
- The y-axis points in the direction the docking port is facing.
- The z-axis points out of the bottom off the docking port.

Note: This reference frame is not necessarily equivalent to the reference frame for the part, returned by `Part.ReferenceFrame`.

enum DockingPortState
See `DockingPort.State`.

Ready
The docking port is ready to dock to another docking port.

Docked
The docking port is docked to another docking port, or docked to another part (from the VAB/SPH).

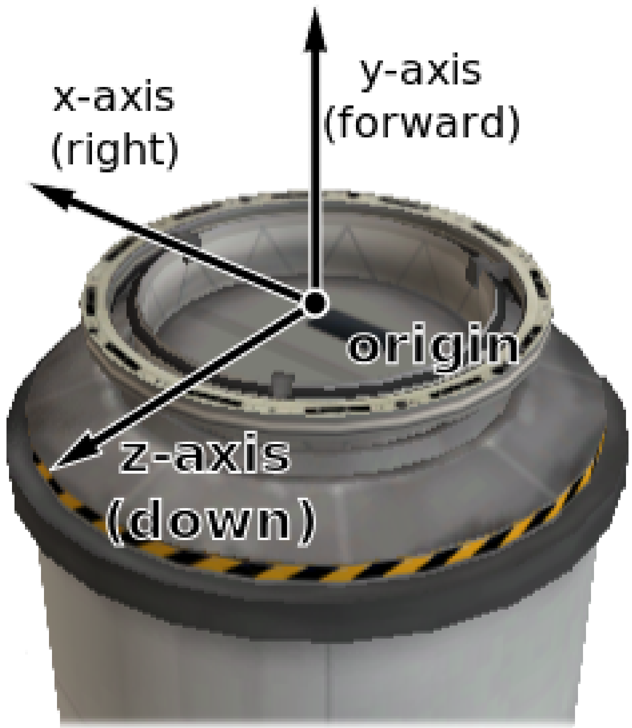


Fig. 3.8: Docking port reference frame origin and axes

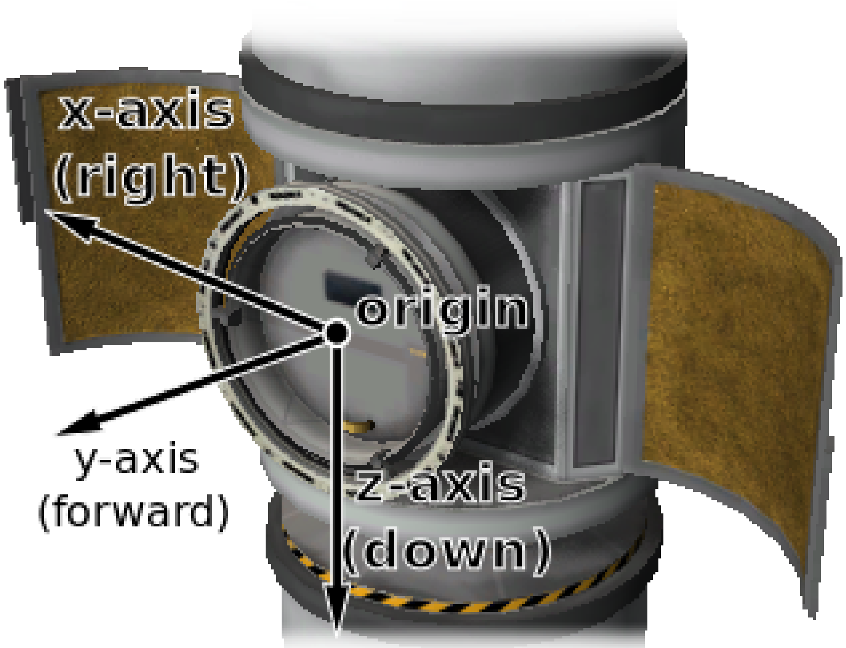


Fig. 3.9: Inline docking port reference frame origin and axes

Docking
The docking port is very close to another docking port, but has not docked. It is using magnetic force to acquire a solid dock.

Undocking
The docking port has just been undocked from another docking port, and is disabled until it moves away by a sufficient distance (`DockingPort.ReengageDistance`).

Shielded
The docking port has a shield, and the shield is closed.

Moving
The docking ports shield is currently opening/closing.

Engine

class Engine
Obtained by calling `Part.Engine`.

Part **Part** { **get;** }
The part object for this engine.

bool **Active** { **get; set;** }
Whether the engine is active. Setting this attribute may have no effect, depending on `Engine.CanShutdown` and `Engine.CanRestart`.

float **Thrust** { **get;** }
The current amount of thrust being produced by the engine, in Newtons. Returns zero if the engine is not active or if it has no fuel.

float **AvailableThrust** { **get;** }
The maximum available amount of thrust that can be produced by the engine, in Newtons. This takes `Engine.ThrustLimit` into account, and is the amount of thrust produced by the engine when activated and the main throttle is set to 100%. Returns zero if the engine does not have any fuel.

float **MaxThrust** { **get;** }
Gets the maximum amount of thrust that can be produced by the engine, in Newtons. This is the amount of thrust produced by the engine when activated, `Engine.ThrustLimit` is set to 100% and the main vessel's throttle is set to 100%.

float **MaxVacuumThrust** { **get;** }
The maximum amount of thrust that can be produced by the engine in a vacuum, in Newtons. This is the amount of thrust produced by the engine when activated, `Engine.ThrustLimit` is set to 100%, the main vessel's throttle is set to 100% and the engine is in a vacuum.

float **ThrustLimit** { **get; set;** }
The thrust limiter of the engine. A value between 0 and 1. Setting this attribute may have no effect, for example the thrust limit for a solid rocket booster cannot be changed in flight.

float **SpecificImpulse** { **get;** }
The current specific impulse of the engine, in seconds. Returns zero if the engine is not active.

float **VacuumSpecificImpulse** { **get;** }
The vacuum specific impulse of the engine, in seconds.

float **KerbinSeaLevelSpecificImpulse** { **get;** }
The specific impulse of the engine at sea level on Kerbin, in seconds.

IList<string> **Propellants** { **get;** }
The names of resources that the engine consumes.

IDictionary<string, float> **PropellantRatios** { **get;** }
: The ratios of resources that the engine consumes. A dictionary mapping resource names to the ratios at which they are consumed by the engine.

bool **HasFuel** { **get;** }
: Whether the engine has run out of fuel (or flamed out).

float **Throttle** { **get;** }
: The current throttle setting for the engine. A value between 0 and 1. This is not necessarily the same as the vessel's main throttle setting, as some engines take time to adjust their throttle (such as jet engines).

bool **ThrottleLocked** { **get;** }
: Whether the `Control.Throttle` affects the engine. For example, this is `true` for liquid fueled rockets, and `false` for solid rocket boosters.

bool **CanRestart** { **get;** }
: Whether the engine can be restarted once shutdown. If the engine cannot be shutdown, returns `false`. For example, this is `true` for liquid fueled rockets and `false` for solid rocket boosters.

bool **CanShutdown** { **get;** }
: Gets whether the engine can be shutdown once activated. For example, this is `true` for liquid fueled rockets and `false` for solid rocket boosters.

bool **Gimballed** { **get;** }
: Whether the engine nozzle is gimballed, i.e. can provide a turning force.

float **GimbalRange** { **get;** }
: The range over which the gimbal can move, in degrees.

bool **GimbalLocked** { **get; set;** }
: Whether the engines gimbal is locked in place. Setting this attribute has no effect if the engine is not gimballed.

float **GimbalLimit** { **get; set;** }
: The gimbal limiter of the engine. A value between 0 and 1. Returns 0 if the gimbal is locked or the engine is not gimballed. Setting this attribute has no effect if the engine is not gimballed.

Landing Gear

class LandingGear
: Obtained by calling `Part.LandingGear`.

Part **Part** { **get;** }
: The part object for this landing gear.

LandingGearState **State** { **get;** }
: Gets the current state of the landing gear.

bool **Deployed** { **get; set;** }
: Whether the landing gear is deployed.

enum LandingGearState
: See `LandingGear.State`.

Deployed
: Landing gear is fully deployed.

Retracted
: Landing gear is fully retracted.

Deploying
Landing gear is being deployed.

Retracting
Landing gear is being retracted.

Landing Leg

class LandingLeg
Obtained by calling *Part.LandingLeg*.

Part **Part** { **get;** }
The part object for this landing leg.

LandingLegState **State** { **get;** }
The current state of the landing leg.

bool **Deployed** { **get; set;** }
Whether the landing leg is deployed.

enum LandingLegState
See *LandingLeg.State*.

Deployed
Landing leg is fully deployed.

Retracted
Landing leg is fully retracted.

Deploying
Landing leg is being deployed.

Retracting
Landing leg is being retracted.

Broken
Landing leg is broken.

Repairing
Landing leg is being repaired.

Launch Clamp

class LaunchClamp
Obtained by calling *Part.LaunchClamp*.

Part **Part** { **get;** }
The part object for this launch clamp.

void **Release** ()
Releases the docking clamp. Has no effect if the clamp has already been released.

Light

class Light
Obtained by calling *Part.Light*.

Part **Part** { **get;** }
The part object for this light.

bool **Active** { **get; set;** }
Whether the light is switched on.

float **PowerUsage** { **get;** }
The current power usage, in units of charge per second.

Parachute

class Parachute
Obtained by calling `Part.Parachute`.

Part **Part** { **get;** }
The part object for this parachute.

void **Deploy** ()
Deploys the parachute. This has no effect if the parachute has already been deployed.

bool **Deployed** { **get;** }
Whether the parachute has been deployed.

ParachuteState **State** { **get;** }
The current state of the parachute.

float **DeployAltitude** { **get; set;** }
The altitude at which the parachute will full deploy, in meters.

float **DeployMinPressure** { **get; set;** }
The minimum pressure at which the parachute will semi-deploy, in atmospheres.

enum ParachuteState
See `Parachute.State`.

Stowed
The parachute is safely tucked away inside its housing.

Active
The parachute is still stowed, but ready to semi-deploy.

SemiDeployed
The parachute has been deployed and is providing some drag, but is not fully deployed yet.

Deployed
The parachute is fully deployed.

Cut
The parachute has been cut.

Radiator

class Radiator
Obtained by calling `Part.Radiator`.

Part **Part** { **get;** }
The part object for this radiator.

bool **Deployed** { **get; set;** }
Whether the radiator is extended.

RadiatorState **State** { **get;** }
The current state of the radiator.

enum RadiatorState
RadiatorState

Extended
Radiator is fully extended.

Retracted
Radiator is fully retracted.

Extending
Radiator is being extended.

Retracting
Radiator is being retracted.

Broken
Radiator is being broken.

Resource Converter

class ResourceConverter
Obtained by calling *Part.ResourceConverter*.

Part **Part** { **get;** }
The part object for this converter.

int **Count** { **get;** }
The number of converters in the part.

string **Name** (int *index*)
The name of the specified converter.

Parameters

- **index** – Index of the converter.

bool **Active** (int *index*)
True if the specified converter is active.

Parameters

- **index** – Index of the converter.

void **Start** (int *index*)
Start the specified converter.

Parameters

- **index** – Index of the converter.

void **Stop** (int *index*)
Stop the specified converter.

Parameters

- **index** – Index of the converter.

ResourceConverterState **State** (int *index*)
The state of the specified converter.

Parameters

- **index** – Index of the converter.

string **StatusInfo** (int *index*)
Status information for the specified converter. This is the full status message shown in the in-game UI.

Parameters

- **index** – Index of the converter.

IList<string> **Inputs** (int *index*)
List of the names of resources consumed by the specified converter.

Parameters

- **index** – Index of the converter.

IList<string> **Outputs** (int *index*)
List of the names of resources produced by the specified converter.

Parameters

- **index** – Index of the converter.

enum ResourceConverterState
See *ResourceConverter.State*.

Running
Converter is running.

Idle
Converter is idle.

MissingResource
Converter is missing a required resource.

StorageFull
No available storage for output resource.

Capacity
At preset resource capacity.

Unknown
Unknown state. Possible with modified resource converters. In this case, check *ResourceConverter.StatusInfo* for more information.

Resource Harvester

class ResourceHarvester
Obtained by calling *Part.ResourceHarvester*.

Part **Part** { **get;** }
The part object for this harvester.

ResourceHarvesterState **State** { **get;** }
The state of the harvester.

bool **Deployed** { **get; set;** }
Whether the harvester is deployed.

bool **Active** { **get; set;** }
Whether the harvester is actively drilling.

float **ExtractionRate** { **get;** }
The rate at which the drill is extracting ore, in units per second.

float **ThermalEfficiency** { **get;** }
The thermal efficiency of the drill, as a percentage of its maximum.

float **CoreTemperature** { **get;** }
The core temperature of the drill, in Kelvin.

float **OptimumCoreTemperature** { **get;** }
The core temperature at which the drill will operate with peak efficiency, in Kelvin.

Reaction Wheel

class ReactionWheel
Obtained by calling *Part.ReactionWheel*.

Part **Part** { **get;** }
The part object for this reaction wheel.

bool **Active** { **get; set;** }
Whether the reaction wheel is active.

bool **Broken** { **get;** }
Whether the reaction wheel is broken.

float **PitchTorque** { **get;** }
The torque in the pitch axis, in Newton meters.

float **YawTorque** { **get;** }
The torque in the yaw axis, in Newton meters.

float **RollTorque** { **get;** }
The torque in the roll axis, in Newton meters.

Sensor

class Sensor
Obtained by calling *Part.Sensor*.

Part **Part** { **get;** }
The part object for this sensor.

bool **Active** { **get; set;** }
Whether the sensor is active.

string **Value** { **get;** }
The current value of the sensor.

float **PowerUsage** { **get;** }
The current power usage of the sensor, in units of charge per second.

Solar Panel

class SolarPanel
Obtained by calling *Part.SolarPanel*.

Part **Part** { **get;** }
The part object for this solar panel.

bool **Deployed** { **get; set;** }
Whether the solar panel is extended.

SolarPanelState **State** { **get;** }
The current state of the solar panel.

float **EnergyFlow** { **get;** }
The current amount of energy being generated by the solar panel, in units of charge per second.

float **SunExposure** { **get;** }
The current amount of sunlight that is incident on the solar panel, as a percentage. A value between 0 and 1.

enum SolarPanelState
See `SolarPanel.State`.

Extended
Solar panel is fully extended.

Retracted
Solar panel is fully retracted.

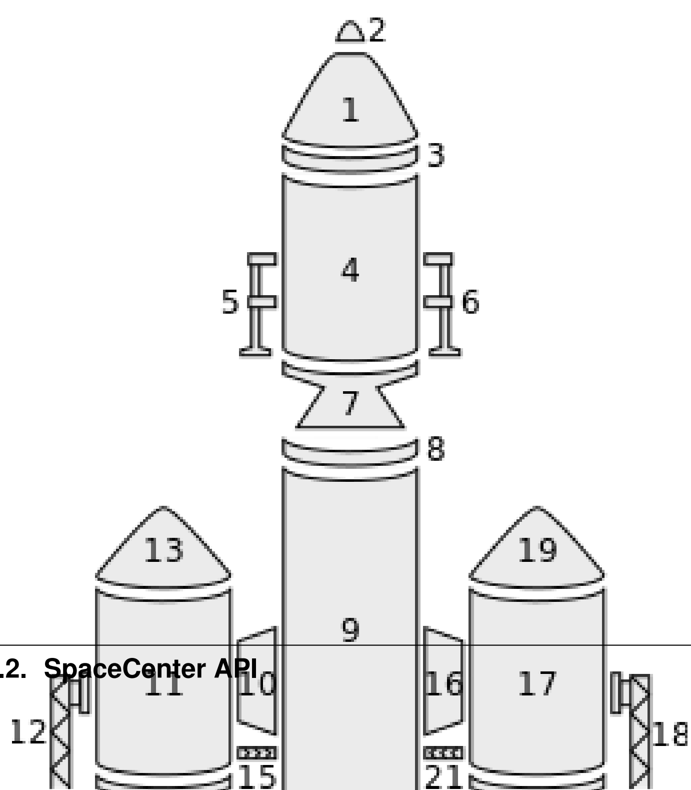
Extending
Solar panel is being extended.

Retracting
Solar panel is being retracted.

Broken
Solar panel is broken.

Trees of Parts

Vessels in KSP are comprised of a number of parts, connected to one another in a *tree* structure. An example vessel is shown in Figure 1, and the corresponding tree of parts in Figure 2. The craft file for this example can also be `downloaded here`.



Traversing the Tree

The tree of parts can be traversed using the attributes `SpaceCenter.Parts.Root`, `SpaceCenter.Part.Parent` and `SpaceCenter.Part.Children`.

The root of the tree is the same as the vessels *root part* (part number 1 in the example above) and can be obtained by calling `SpaceCenter.Parts.Root`. A parts children can be obtained by calling `SpaceCenter.Part.Children`. If the part does not have any children, `SpaceCenter.Part.Children` returns an empty list. A parts parent can be obtained by calling `SpaceCenter.Part.Parent`.

If the part does not have a parent (as is the case for the root part), `SpaceCenter.Part.Parent` returns `null`.

The following C# example uses these attributes to perform a depth-first traversal over all of the parts in a vessel:

```
using KRPC.Client;
using KRPC.Client.Services.SpaceCenter;
using System;
using System.Collections.Generic;
using System.Net;

class AttachmentModes
{
    public static void Main ()
    {
        var connection = new KRPC.Client.Connect
        var vessel = connection.SpaceCenter ().A
        var root = vessel.Parts.Root;
        var stack = new Stack<KRPC.Client.Tuple<
        stack.Push (new KRPC.Client.Tuple<Part,i
        while (stack.Count > 0) {
            var item = stack.Pop ();
            Part part = item.Item1;
            int depth = item.Item2;
            Console.WriteLine (new String (' ',
            foreach (var child in part.Children)
                stack.Push (new KRPC.Client.Tupl
        }
    }
}
```

When this code is execute using the craft file for the example vessel pictured above, the following is printed out:

```
Command Pod Mk1
 TR-18A Stack Decoupler
  FL-T400 Fuel Tank
   LV-909 Liquid Fuel Engine
    TR-18A Stack Decoupler
     FL-T800 Fuel Tank
      LV-909 Liquid Fuel Engine
      TT-70 Radial Decoupler
       FL-T400 Fuel Tank
        TT18-A Launch Stability Enhancer
        FTX-2 External Fuel Duct
        LV-909 Liquid Fuel Engine
        Aerodynamic Nose Cone
      TT-70 Radial Decoupler
       FL-T400 Fuel Tank
        TT18-A Launch Stability Enhancer
        FTX-2 External Fuel Duct
        LV-909 Liquid Fuel Engine
        Aerodynamic Nose Cone
   LT-1 Landing Struts
```

```
                LT-1 Landing Struts
              Mk16 Parachute
```

Attachment Modes

Parts can be attached to other parts either *radially* (on the side of the parent part) or *axially* (on the end of the parent part, to form a stack).

For example, in the vessel pictured above, the parachute (part 2) is *axially* connected to its parent (the command pod – part 1), and the landing leg (part 5) is *radially* connected to its parent (the fuel tank – part 4).

The root part of a vessel (for example the command pod – part 1) does not have a parent part, so does not have an attachment mode. However, the part is consider to be *axially* attached to nothing.

The following C# example does a depth-first traversal as before, but also prints out the attachment mode used by the part:

```
using KRPC.Client;
using KRPC.Client.Services.SpaceCenter;
using System;
using System.Collections.Generic;
using System.Net;

class AttachmentModes
{
    public static void Main ()
    {
        var connection = new KRPC.Client.Connection ();
        var vessel = connection.SpaceCenter ().ActiveVessel;
        var root = vessel.Parts.Root;
        var stack = new Stack<KRPC.Client.Tuple<Part,int>> ();
        stack.Push (new KRPC.Client.Tuple<Part,int> (root, 0));
        while (stack.Count > 0) {
            var item = stack.Pop ();
            Part part = item.Item1;
            int depth = item.Item2;
            string attachMode = (part.AxiallyAttached ? "axial" : "radial");
            Console.WriteLine (new String (' ', depth) + part.Title + " - " + attachMode);
            foreach (var child in part.Children)
                stack.Push (new KRPC.Client.Tuple<Part,int> (child, depth + 1));
        }
    }
}
```

When this code is execute using the craft file for the example vessel pictured above, the following is printed out:

```
Command Pod Mk1 - axial
 TR-18A Stack Decoupler - axial
```

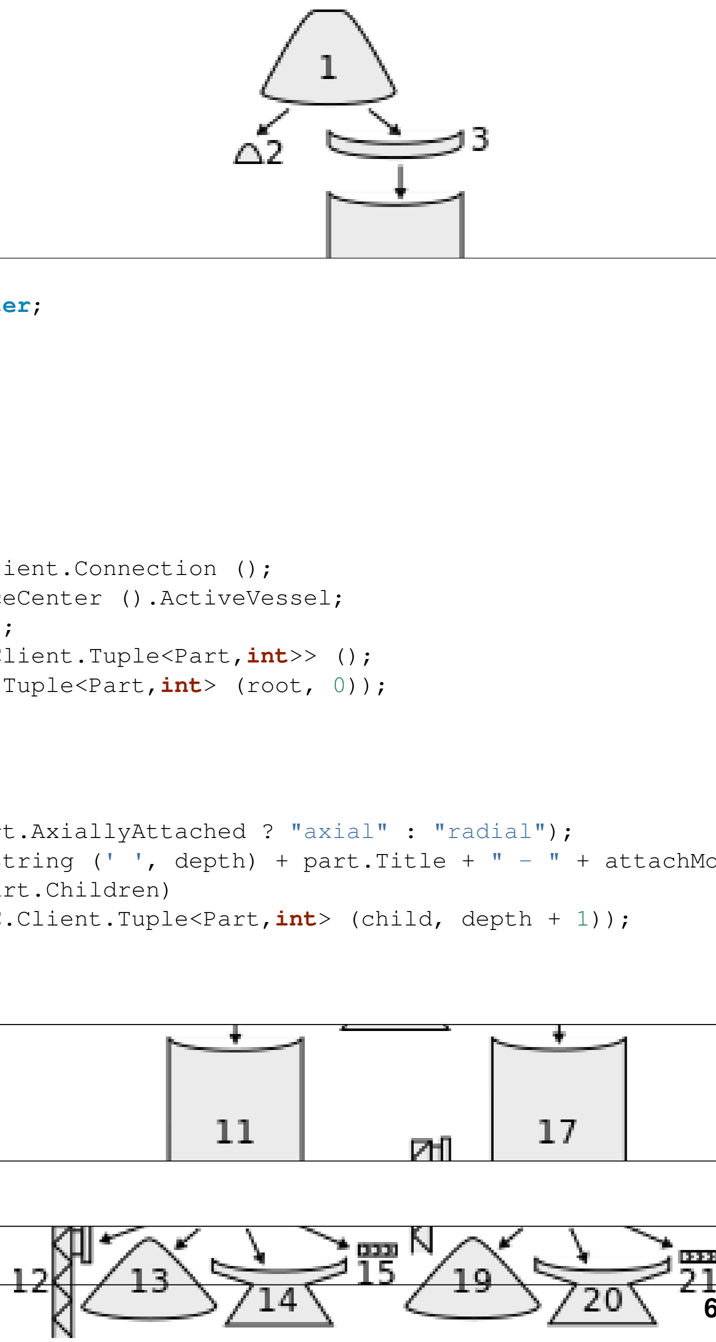


Fig. 3.11: **Figure 2** – Tree of parts for the vessel in Figure 1. Arrows point from the parent part to the child part.

```
  FL-T400 Fuel Tank - axial
   LV-909 Liquid Fuel Engine - axial
    TR-18A Stack Decoupler - axial
     FL-T800 Fuel Tank - axial
      LV-909 Liquid Fuel Engine - axial
      TT-70 Radial Decoupler - radial
       FL-T400 Fuel Tank - radial
        TT18-A Launch Stability Enhancer - radial
        FTX-2 External Fuel Duct - radial
        LV-909 Liquid Fuel Engine - axial
        Aerodynamic Nose Cone - axial
      TT-70 Radial Decoupler - radial
       FL-T400 Fuel Tank - radial
        TT18-A Launch Stability Enhancer - radial
        FTX-2 External Fuel Duct - radial
        LV-909 Liquid Fuel Engine - axial
        Aerodynamic Nose Cone - axial
   LT-1 Landing Struts - radial
   LT-1 Landing Struts - radial
 Mk16 Parachute - axial
```

Fuel Lines

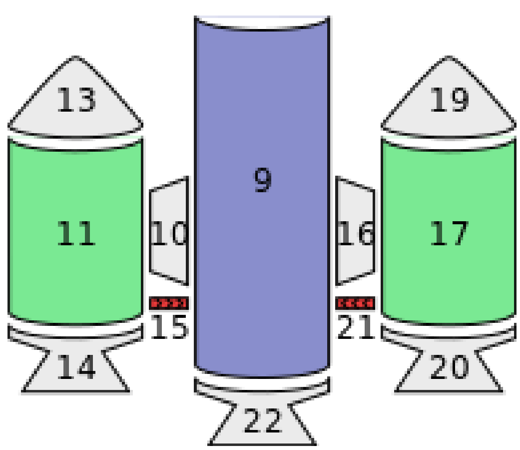
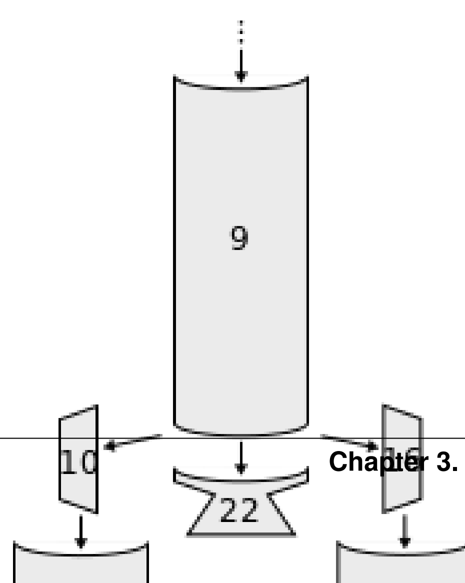


Fig. 3.12: **Figure 5** – Fuel lines from the example in Figure 1. Fuel flows from the parts highlighted in green, into the part highlighted in blue.

Fuel lines are considered parts, and are included in the parts tree (for example, as pictured in Figure 4). However, the parts tree does not contain information about which parts fuel lines connect to. The parent part of a fuel line is the part from which it will take fuel (as shown in Figure 4) however the part that it will send fuel to is not represented in the parts tree.

Figure 5 shows the fuel lines from the example vessel pictured earlier. Fuel line part 15 (in red) takes fuel from a fuel tank (part 11 – in green) and feeds it into another fuel tank (part 9 – in blue). The fuel line is therefore a child of part 11, but its connection to part 9 is not represented in the tree.

The attributes `SpaceCenter.Part.FuelLinesFrom` and



`SpaceCenter.Part.FuelLinesTo` can be used to discover these connections. In the example in Figure 5, when `SpaceCenter.Part.FuelLinesTo` is called on fuel tank part 11, it will return a list of parts containing just fuel tank part 9 (the blue part). When `SpaceCenter.Part.FuelLinesFrom` is called on fuel tank part 9, it will return a list containing fuel tank parts 11 and 17 (the parts colored green).

Staging

Each part has two staging numbers associated with it: the stage in which the part is *activated* and the stage in which the part is *decoupled*. These values can be obtained using `SpaceCenter.Part.Stage` and `SpaceCenter.Part.DecoupleStage` respectively. For parts that are not activated by staging, `SpaceCenter.Part.Stage` returns -1. For parts that are never decoupled, `SpaceCenter.Part.DecoupleStage` returns a value of -1.

Figure 6 shows an example staging sequence for a vessel. Figure 7 shows the stages in which each part of the vessel will be *activated*. Figure 8 shows the stages in which each part of the vessel will be *decoupled*.

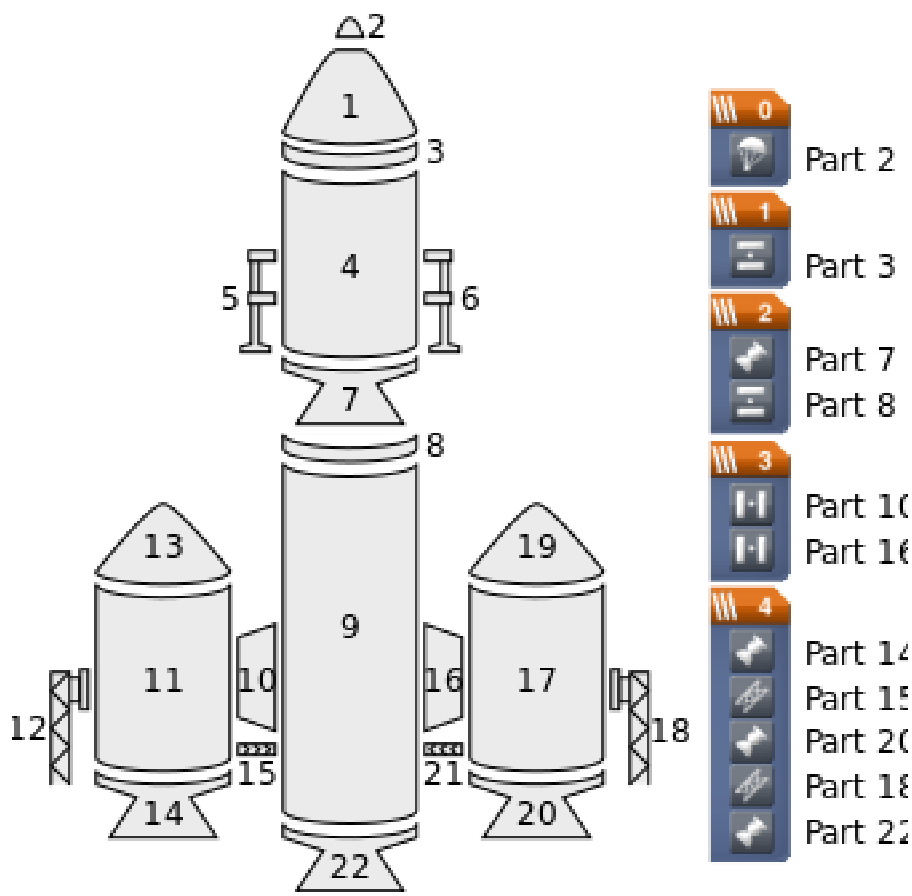


Fig. 3.14: **Figure 6** – Example vessel from Figure 1 with a staging sequence.

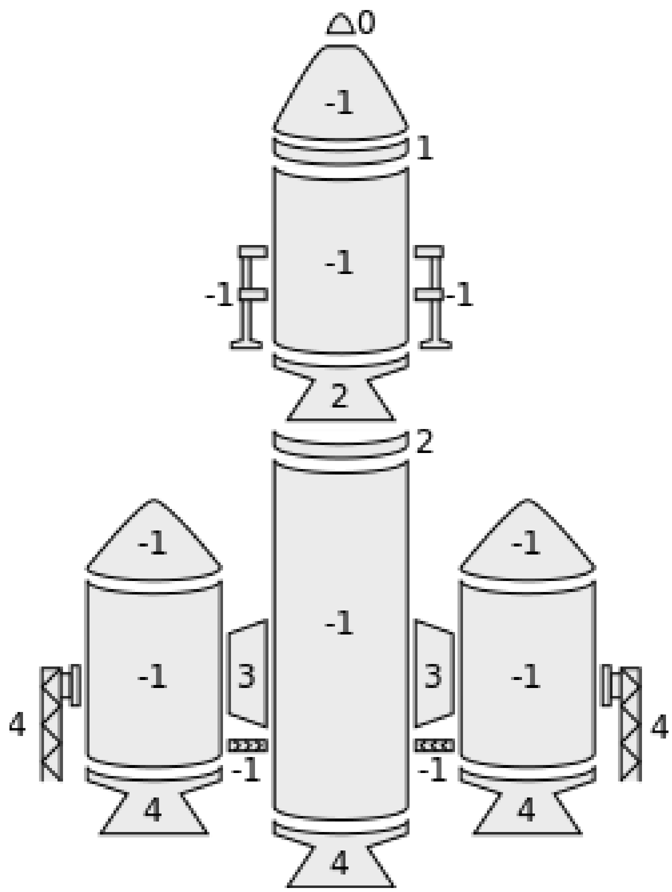
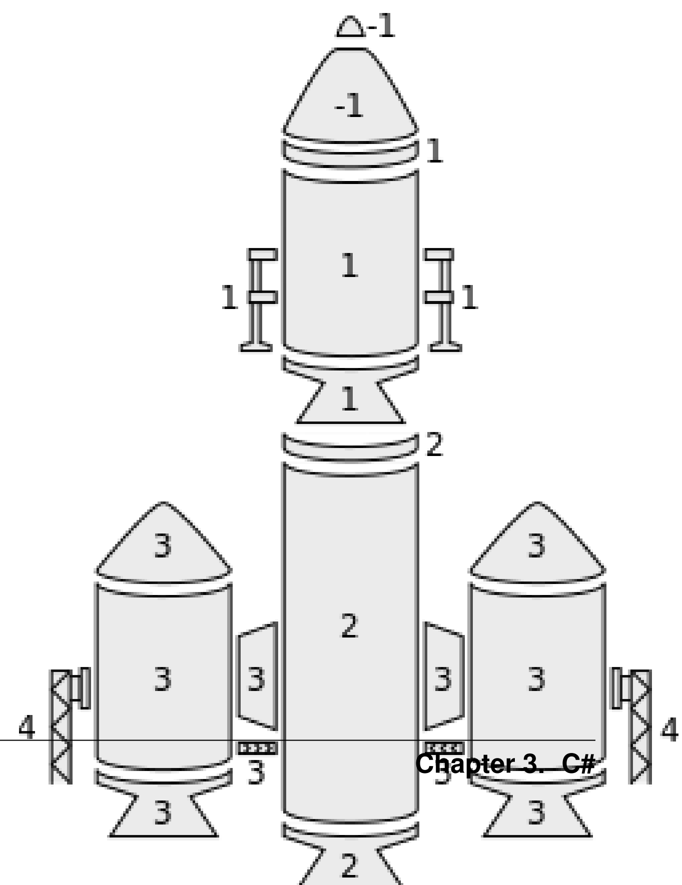


Fig. 3.15: **Figure 7** – The stage in which each part is *activated*.

3.2.8 Resources



class Resources

Created by calling `Vessel.Resources`, `Vessel.ResourcesInDecoupleStage` or `Part.Resources`.

IList<string> **Names** { **get;** }

A list of resource names that can be stored.

bool **HasResource** (string *name*)

Check whether the named resource can be stored.

Parameters

- **name** – The name of the resource.

float **Max** (string *name*)

Returns the amount of a resource that can be stored.

Parameters

- **name** – The name of the resource.

float **Amount** (string *name*)

Returns the amount of a resource that is currently stored.

Parameters

- **name** – The name of the resource.

static float **Density** (string *name*)
Returns the density of a resource, in kg/l.

Parameters

- **name** – The name of the resource.

static ResourceFlowMode **FlowMode** (string *name*)
Returns the flow mode of a resource.

Parameters

- **name** – The name of the resource.

enum ResourceFlowMode
See `Resources.FlowMode`.

Vessel
The resource flows to any part in the vessel. For example, electric charge.

Stage
The resource flows from parts in the first stage, followed by the second, and so on. For example, mono-propellant.

Adjacent
The resource flows between adjacent parts within the vessel. For example, liquid fuel or oxidizer.

None
The resource does not flow. For example, solid fuel.

3.2.9 Node

class Node
Represents a maneuver node. Can be created using `Control.AddNode`.

float **Prograde** { **get; set;** }
The magnitude of the maneuver nodes delta-v in the prograde direction, in meters per second.

float **Normal** { **get; set;** }
The magnitude of the maneuver nodes delta-v in the normal direction, in meters per second.

float **Radial** { **get; set;** }
The magnitude of the maneuver nodes delta-v in the radial direction, in meters per second.

float **DeltaV** { **get; set;** }
The delta-v of the maneuver node, in meters per second.

Note: Does not change when executing the maneuver node. See `Node.RemainingDeltaV`.

---

float **RemainingDeltaV** { **get;** }

Gets the remaining delta-v of the maneuver node, in meters per second. Changes as the node is executed. This is equivalent to the delta-v reported in-game.

Tuple<double, double, double> **BurnVector** (*ReferenceFrame referenceFrame = None*)

Returns a vector whose direction the direction of the maneuver node burn, and whose magnitude is the delta-v of the burn in m/s.

Parameters

Note: Does not change when executing the maneuver node. See `Node.RemainingBurnVector`.

Tuple<double, double, double> **RemainingBurnVector** (*ReferenceFrame referenceFrame = None*)

Returns a vector whose direction the direction of the maneuver node burn, and whose magnitude is the delta-v of the burn in m/s. The direction and magnitude change as the burn is executed.

Parameters

double **UT** { **get; set;** }

The universal time at which the maneuver will occur, in seconds.

double **TimeTo** { **get;** }

The time until the maneuver node will be encountered, in seconds.

Orbit **Orbit** { **get;** }

The orbit that results from executing the maneuver node.

void **Remove** ()

Removes the maneuver node.

ReferenceFrame **ReferenceFrame** { **get;** }

Gets the reference frame that is fixed relative to the maneuver node's burn.

- The origin is at the position of the maneuver node.
- The y-axis points in the direction of the burn.
- The x-axis and z-axis point in arbitrary but fixed directions.

ReferenceFrame **OrbitalReferenceFrame** { **get;** }

Gets the reference frame that is fixed relative to the maneuver node, and orientated with the orbital prograde/normal/radial directions of the original orbit at the maneuver node's position.

- The origin is at the position of the maneuver node.
- The x-axis points in the orbital anti-radial direction of the original orbit, at the position of the maneuver node.
- The y-axis points in the orbital prograde direction of the original orbit, at the position of the maneuver node.
- The z-axis points in the orbital normal direction of the original orbit, at the position of the maneuver node.

Tuple<double, double, double> **Position** (*ReferenceFrame referenceFrame*)
Returns the position vector of the maneuver node in the given reference frame.

Parameters

Tuple<double, double, double> **Direction** (*ReferenceFrame referenceFrame*)
Returns the unit direction vector of the maneuver nodes burn in the given reference frame.

Parameters

3.2.10 Comms

class Comms
Used to interact with RemoteTech. Created using a call to `Vessel.Comms`.

Note: This class requires RemoteTech to be installed.

bool **HasLocalControl** { **get;** }
Whether the vessel can be controlled locally.

bool **HasFlightComputer** { **get;** }
Whether the vessel has a RemoteTech flight computer on board.

bool **HasConnection** { **get;** }
Whether the vessel can receive commands from the KSC or a command station.

bool **HasConnectionToGroundStation** { **get;** }
Whether the vessel can transmit science data to a ground station.

double **SignalDelay** { **get;** }
The signal delay when sending commands to the vessel, in seconds.

double **SignalDelayToGroundStation** { **get;** }
The signal delay between the vessel and the closest ground station, in seconds.

double **SignalDelayToVessel** (*Vessel other*)
Returns the signal delay between the current vessel and another vessel, in seconds.

Parameters

3.2.11 ReferenceFrame

class ReferenceFrame
Represents a reference frame for positions, rotations and velocities. Contains:

- The position of the origin.
- The directions of the x, y and z axes.
- The linear velocity of the frame.
- The angular velocity of the frame.

Note: This class does not contain any properties or methods. It is only used as a parameter to other functions.

3.2.12 AutoPilot

class AutoPilot
Provides basic auto-piloting utilities for a vessel. Created by calling `Vessel.AutoPilot`.

void **Engage** ()
Engage the auto-pilot.

void **Disengage** ()
Disengage the auto-pilot.

void **Wait** ()
Blocks until the vessel is pointing in the target direction (if set) and has the target roll (if set).

float **Error** { **get;** }
The error, in degrees, between the direction the ship has been asked to point in and the direction it is pointing in. Returns zero if the auto-pilot has not been engaged, SAS is not enabled, SAS is in stability assist mode, or no target direction is set.

float **RollError** { **get;** }
The error, in degrees, between the roll the ship has been asked to be in and the actual roll. Returns zero if the auto-pilot has not been engaged or no target roll is set.

ReferenceFrame **ReferenceFrame** { **get; set;** }
The reference frame for the target direction (`AutoPilot.TargetDirection`).

Tuple<double, double, double> **TargetDirection** { **get; set;** }
The target direction. `null` if no target direction is set.

void **TargetPitchAndHeading** (float *pitch*, float *heading*)
Set (*AutoPilot.TargetDirection*) from a pitch and heading angle.

Parameters

- **pitch** – Target pitch angle, in degrees between -90° and +90°.
- **heading** – Target heading angle, in degrees between 0° and 360°.

float **TargetRoll** { **get; set;** }
The target roll, in degrees. `NaN` if no target roll is set.

bool **SAS** { **get; set;** }
The state of SAS.

Note: Equivalent to *Control.SAS*

SASMode **SASMode** { **get; set;** }
The current *SASMode*. These modes are equivalent to the mode buttons to the left of the navball that appear when SAS is enabled.

Note: Equivalent to *Control.SASMode*

float **RotationSpeedMultiplier** { **get; set;** }
Target rotation speed multiplier. Defaults to 1.

float **MaxRotationSpeed** { **get; set;** }
Maximum target rotation speed. Defaults to 1.

float **RollSpeedMultiplier** { **get; set;** }
Target roll speed multiplier. Defaults to 1.

float **MaxRollSpeed** { **get; set;** }
Maximum target roll speed. Defaults to 1.

void **SetPIDParameters** (float *Kp = 1.0*, float *Ki = 0.0*, float *Kd = 0.0*)
Sets the gains for the rotation rate PID controller.

Parameters

- **Kp** – Proportional gain.
- **Ki** – Integral gain.
- **Kd** – Derivative gain.

3.2.13 Geometry Types

class Vector3

3-dimensional vectors are represented as a 3-tuple.
For example:

```
using KRPC.Client;
using KRPC.Client.Services.SpaceCenter;
using System;
using System.Net;

class VectorExample
{
    public static void Main ()
    {
        var connection = new KRPC.Client.Connection ();
        var vessel = connection.SpaceCenter ().ActiveVessel;
        KRPC.Client.Tuple<double,double,double> v = vessel.Flight ().Prograde;
        Console.WriteLine (v.Item1 + "," + v.Item2 + "," + v.Item3);
    }
}
```

class Quaternion

Quaternions (rotations in 3-dimensional space) are encoded as a 4-tuple containing the x, y, z and w components. For example:

```
using KRPC.Client;
using KRPC.Client.Services.SpaceCenter;
using System;
using System.Net;

class QuaternionExample
{
    public static void Main ()
    {
        var connection = new KRPC.Client.Connection ();
        var vessel = connection.SpaceCenter ().ActiveVessel;
        KRPC.Client.Tuple<double,double,double,double> q = vessel.Flight ().Rotation;
        Console.WriteLine (q.Item1 + "," + q.Item2 + "," + q.Item3 + "," + q.Item4);
    }
}
```

3.3 InfernalRobotics API

Provides RPCs to interact with the InfernalRobotics mod. Provides the following classes:

3.3.1 InfernalRobotics

class InfernalRobotics

This service provides functionality to interact with the InfernalRobotics mod.

IList<*ControlGroup*> **ServoGroups** { **get;** }
A list of all the servo groups in the active vessel.

ControlGroup **ServoGroupWithName** (string *name*)
Returns the servo group with the given *name* or `null` if none exists. If multiple servo groups have the same name, only one of them is returned.

Parameters

- **name** – Name of servo group to find.

Servo **ServoWithName** (string *name*)
Returns the servo with the given *name*, from all servo groups, or `null` if none exists. If multiple servos have the same name, only one of them is returned.

Parameters

- **name** – Name of the servo to find.

3.3.2 ControlGroup

class ControlGroup
A group of servos, obtained by calling `ServoGroups` or `ServoGroupWithName`. Represents the "Servo Groups" in the InfernalRobotics UI.

string **Name** { **get; set;** }
The name of the group.

string **ForwardKey** { **get; set;** }
The key assigned to be the "forward" key for the group.

string **ReverseKey** { **get; set;** }
The key assigned to be the "reverse" key for the group.

float **Speed** { **get; set;** }
The speed multiplier for the group.

bool **Expanded** { **get; set;** }
Whether the group is expanded in the InfernalRobotics UI.

IList<*Servo*> **Servos** { **get;** }
The servos that are in the group.

Servo **ServoWithName** (string *name*)
Returns the servo with the given *name* from this group, or `null` if none exists.

Parameters

- **name** – Name of servo to find.

void **MoveRight** ()
Moves all of the servos in the group to the right.

void **MoveLeft** ()
Moves all of the servos in the group to the left.

void **MoveCenter** ()
Moves all of the servos in the group to the center.

void **MoveNextPreset** ()
Moves all of the servos in the group to the next preset.

void **MovePrevPreset** ()
Moves all of the servos in the group to the previous preset.

void **Stop** ()
Stops the servos in the group.

3.3.3 Servo

class Servo
Represents a servo. Obtained using *ControlGroup.Servos*, *ControlGroup.ServoWithName* or `ServoWithName`.

string **Name** { **get; set;** }
The name of the servo.

bool **Highlight** { **set;** }
Whether the servo should be highlighted in-game.

float **Position** { **get;** }
The position of the servo.

float **MinConfigPosition** { **get;** }
The minimum position of the servo, specified by the part configuration.

float **MaxConfigPosition** { **get;** }
The maximum position of the servo, specified by the part configuration.

float **MinPosition** { **get; set;** }
The minimum position of the servo, specified by the in-game tweak menu.

float **MaxPosition** { **get; set;** }
The maximum position of the servo, specified by the in-game tweak menu.

float **ConfigSpeed** { **get;** }
The speed multiplier of the servo, specified by the part configuration.

float **Speed** { **get; set;** }
The speed multiplier of the servo, specified by the in-game tweak menu.

float **CurrentSpeed** { **get; set;** }
The current speed at which the servo is moving.

float **Acceleration** { **get; set;** }
The current speed multiplier set in the UI.

bool **IsMoving** { **get;** }
Whether the servo is moving.

bool **IsFreeMoving** { **get;** }
Whether the servo is freely moving.

bool **IsLocked** { **get; set;** }
Whether the servo is locked.

bool **IsAxisInverted** { **get; set;** }
Whether the servos axis is inverted.

void **MoveRight** ()
Moves the servo to the right.

void **MoveLeft** ()
Moves the servo to the left.

void **MoveCenter** ()
Moves the servo to the center.

void **MoveNextPreset** ()
Moves the servo to the next preset.

void **MovePrevPreset** ()
Moves the servo to the previous preset.

void **MoveTo** (float *position*, float *speed*)
Moves the servo to *position* and sets the speed multiplier to *speed*.

Parameters

- **position** – The position to move the servo to.
- **speed** – Speed multiplier for the movement.

void **Stop** ()
Stops the servo.

3.3.4 Example

The following example gets the control group named "MyGroup", prints out the names and positions of all of the servos in the group, then moves all of the servos to the right for 1 second.

```
using KRPC.Client;
using KRPC.Client.Services.InfernalRobotics;
using System;
using System.Threading;
using System.Net;

class InfernalRoboticsExample
{
    public static void Main ()
    {
        var connection = new KRPC.Client.Connection (name: "InfernalRobotics Example");
```

```
        var ir = connection.InfernalRobotics ();

        var group = ir.ServoGroupWithName ("MyGroup");
        if (group == null) {
            Console.WriteLine ("Group not found");
            return;
        }

        foreach (var servo in group.Servos)
            Console.WriteLine (servo.Name + " " + servo.Position);

        group.MoveRight ();
        Thread.Sleep (1000);
        group.Stop ();
    }
}
```

3.4 Kerbal Alarm Clock API

Provides RPCs to interact with the Kerbal Alarm Clock mod. Provides the following classes:

3.4.1 KerbalAlarmClock

class KerbalAlarmClock

This service provides functionality to interact with the Kerbal Alarm Clock mod.

IList<*Alarm*> **Alarms** { **get;** }

A list of all the alarms.

Alarm **AlarmWithName** (string *name*)

Get the alarm with the given *name*, or `null` if no alarms have that name. If more than one alarm has the name, only returns one of them.

Parameters

- **name** – Name of the alarm to search for.

IList<*Alarm*> **AlarmsWithType** (*AlarmType* *type*)

Get a list of alarms of the specified *type*.

Parameters

- **type** – Type of alarm to return.

Alarm **CreateAlarm** (*AlarmType* *type*, string *name*, double *ut*)

Create a new alarm and return it.

Parameters

- **type** – Type of the new alarm.
- **name** – Name of the new alarm.
- **ut** – Time at which the new alarm should trigger.

3.4.2 Alarm

class Alarm
Represents an alarm. Obtained by calling `Alarms`, `AlarmWithName` or `AlarmsWithType`.

AlarmAction **Action** { **get; set;** }
The action that the alarm triggers.

double **Margin** { **get; set;** }
The number of seconds before the event that the alarm will fire.

double **Time** { **get; set;** }
The time at which the alarm will fire.

AlarmType **Type** { **get;** }
The type of the alarm.

string **ID** { **get;** }
The unique identifier for the alarm.

string **Name** { **get; set;** }
The short name of the alarm.

string **Notes** { **get; set;** }
The long description of the alarm.

double **Remaining** { **get;** }
The number of seconds until the alarm will fire.

bool **Repeat** { **get; set;** }
Whether the alarm will be repeated after it has fired.

double **RepeatPeriod** { **get; set;** }
The time delay to automatically create an alarm after it has fired.

SpaceCenter.Vessel **Vessel** { **get; set;** }
The vessel that the alarm is attached to.

SpaceCenter.CelestialBody **XferOriginBody** { **get; set;** }
The celestial body the vessel is departing from.

SpaceCenter.CelestialBody **XferTargetBody** { **get; set;** }
The celestial body the vessel is arriving at.

void **Remove** ()
Removes the alarm.

3.4.3 AlarmType

enum AlarmType
The type of an alarm.

Raw
An alarm for a specific date/time or a specific period in the future.

Maneuver
An alarm based on the next maneuver node on the

current ships flight path. This node will be stored and can be restored when you come back to the ship.

ManeuverAuto
See *AlarmType.Maneuver*.

Apoapsis
An alarm for furthest part of the orbit from the planet.

Periapsis
An alarm for nearest part of the orbit from the planet.

AscendingNode
Ascending node for the targeted object, or equatorial ascending node.

DescendingNode
Descending node for the targeted object, or equatorial descending node.

Closest
An alarm based on the closest approach of this vessel to the targeted vessel, some number of orbits into the future.

Contract
An alarm based on the expiry or deadline of contracts in career modes.

ContractAuto
See *AlarmType.Contract*.

Crew
An alarm that is attached to a crew member.

Distance
An alarm that is triggered when a selected target comes within a chosen distance.

EarthTime
An alarm based on the time in the "Earth" alternative Universe (aka the Real World).

LaunchRendevous
An alarm that fires as your landed craft passes under the orbit of your target.

SOIChange
An alarm manually based on when the next SOI point is on the flight path or set to continually monitor the active flight path and add alarms as it detects SOI changes.

SOIChangeAuto
See *AlarmType.SOIChange*.

Transfer
An alarm based on Interplanetary Transfer Phase Angles, i.e. when should I launch to planet X?

Based on Kosmo Not's post and used in Olex's Calculator.

TransferModelled
See *AlarmType.Transfer*.

3.4.4 AlarmAction

enum AlarmAction
The action performed by an alarm when it fires.

DoNothing
Don't do anything at all...

DoNothingDeleteWhenPassed
Don't do anything, and delete the alarm.

KillWarp
Drop out of time warp.

KillWarpOnly
Drop out of time warp.

MessageOnly
Display a message.

PauseGame
Pause the game.

3.4.5 Example

The following example creates a new alarm for the active vessel. The alarm is set to trigger after 10 seconds have passed, and display a message.

```
using KRPC.Client;
using KRPC.Client.Services.SpaceCenter;
using KRPC.Client.Services.KerbalAlarmClock;
using System;
using System.Net;

class KerbalAlarmClockExample
{
    public static void Main ()
    {
        var connection = new KRPC.Client.Connection (name: "Kerbal Alarm Clock Example");
        var kac = connection.KerbalAlarmClock ();
        var alarm = kac.CreateAlarm (AlarmType.Raw, "My New Alarm", connection.SpaceCenter ().UT + 10
        alarm.Notes = "10 seconds have now passed since the alarm was created.";
        alarm.Action = AlarmAction.MessageOnly;
    }
}
```

CHAPTER

FOUR

C++

4.1 C++ Client

The `krpc` library provides functionality to interact with a kRPC server from C++.

4.1.1 Compiling and Installing the Library

The source archive can be downloaded from github.

To compile and install the library using the configure script, extract the archive and execute the following commands:

```
./configure
make
sudo make install
```

Alternatively, you can use CMake:

```
cmake .
make
sudo make install
```

Installing to a Custom Location

To install the library to a different location, pass the `--prefix` argument to the configure script. For example:

```
./configure --prefix=/install/path
make
make install
```

Or set `CMAKE_INSTALL_PREFIX` when using CMake:

```
cmake . -DCMAKE_INSTALL_PREFIX=/install/path
make
make install
```

Using the Library

To use the library, simply include the main `krpc.hpp` header file, and the header files for the services that you would like to use. For example, `krpc/services/space_center.hpp`. Then link against *libkrpc.so* when compiling your application.

4.1.2 Connecting to the Server

To connect to a server, use the *krpc::connect()* function. This returns a connection object through which you can interact with the server. For example to connect to a server running on the local machine:

```cpp
#include <krpc.hpp>
#include <krpc/services/krpc.hpp>
#include <iostream>

using namespace krpc;

int main() {
  krpc::Client conn = krpc::connect("Example");
  krpc::services::KRPC krpc(&conn);
  std::cout << krpc.get_status().version() << std::endl;
}
```

This function also accepts arguments that specify what address and port numbers to connect to. For example:

```cpp
#include <krpc.hpp>
#include <krpc/services/krpc.hpp>
#include <iostream>

using namespace krpc;

int main() {
  krpc::Client conn = krpc::connect("Remote example", "my.domain.name", 1000, 1001);
  krpc::services::KRPC krpc(&conn);
  std::cout << krpc.get_status().version() << std::endl;
}
```

4.1.3 Interacting with the Server

Interaction with the server is performed via a client object (of type *krpc::Client*) returned by calling *krpc::connect()*.

Functionality for services are defined in the header files in `krpc/services/...`. For example, all of the functionality provided by the SpaceCenter service is contained in the header file `krpc/services/space_center.hpp` and the functionality provided by the InfernalRobotics service is contained in `krpc/services/infernal_robotics.hpp`.

Before a service can be used it must first be instantiated, and passed a copy of the *krpc::Client* object. Calling methods on the service are mapped to remote procedure calls and passed to the server by the client.

The following example connects to the server, instantiates the SpaceCenter service, and outputs the name of the active vessel:

```cpp
#include <krpc.hpp>
#include <krpc/services/space_center.hpp>
#include <iostream>

using namespace krpc;

int main() {
  krpc::Client conn = krpc::connect("Vessel Name");
  krpc::services::SpaceCenter sc(&conn);
  krpc::services::SpaceCenter::Vessel vessel = sc.active_vessel();
```

```
    std::cout << vessel.name() << std::endl;
}
```

4.1.4 Streaming Data from the Server

A stream repeatedly executes a function on the server, with a fixed set of argument values. It provides a more efficient way of repeatedly getting the result of calling function on the server, without having to invoke it directly – which incurs communication overheads.

For example, consider the following loop that continuously prints out the position of the active vessel. This loop incurs significant communication overheads, as the `vessel.position()` function is called repeatedly.

```
krpc::services::SpaceCenter::Vessel vessel = sc.active_vessel();
krpc::services::SpaceCenter::ReferenceFrame refframe = vessel.orbit().body().reference_frame();
while (true) {
    std::tuple<double,double,double> pos = vessel.position(refframe);
    std::cout << std::get<0>(pos) << ","
              << std::get<1>(pos) < ","
              << std::get<2>(pos) << std::endl;
}
```

The following code achieves the same thing, but is far more efficient. It calls `vessel.position_stream` once at the start of the program to create a stream, and then repeatedly gets the position from the stream. This avoids the communication overhead in the previous example.

```
krpc::services::SpaceCenter::Vessel vessel = sc.active_vessel();
krpc::services::SpaceCenter::ReferenceFrame refframe = vessel.orbit().body().reference_frame();
krpc::Stream<std::tuple<double,double,double>> pos_stream = vessel.position_stream(refframe);
while (true) {
    std::tuple<double,double,double> pos = pos_stream();
    std::cout << std::get<0>(pos) << ","
              << std::get<1>(pos) < ","
              << std::get<2>(pos) << std::endl;
}
```

A stream can be created for a function call by adding `_stream` to the end of the function's name. This returns a stream object of type `krpc::Stream`, where `T` is the return type of the original function. The most recent value of the stream can be obtained by calling `Stream<T>::operator()`. A stream can be stopped by calling `krpc::Stream<T>::remove()` on the stream object. All streams are automatically stopped when the connection is terminated.

4.1.5 Reference

krpc::*Client* **connect** (**const** std::string *&name* = "", **const** std::string *&address* = "127.0.0.1", unsigned int *rpc_port* = 50000, unsigned int *stream_port* = 50001)

This function creates a connection to a kRPC server. It returns a `krpc::Client` object, through which the server can be communicated with.

Parameters

- **name** (*std::string*) – A descriptive name for the connection. This is passed to the server and appears, for example, in the client connection dialog on the in-game server window.
- **address** (*std::string*) – The address of the server to connect to. Can either be a hostname or an IP address in dotted decimal notation. Defaults to '127.0.0.1'.
- **rpc_port** (*unsigned int*) – The port number of the RPC Server. Defaults to 50000.

- **stream_port** (*unsigned int*) – The port number of the Stream Server. Defaults to 50001. Set it to 0 to disable connection to the stream server.

class Client

This class provides the interface for communicating with the server. It is used by service class instances to invoke remote procedure calls. Instances of this class can be obtained by calling `krpc::connect()`.

class KRPC

This class provides access to the basic server functionality provided by the `KRPC` service. Most of this functionality is used internally by the client (for example to create and remove streams) and therefore does not need to be used directly from application code. The only exception that may be useful is `KRPC::get_status()`.

KRPC(krpc::*Client* **client*)

Construct an instance of this service from the given `krpc::Client` object.

krpc::schema::Status **get_status**()

Gets a status message from the server containing information including the server's version string and performance statistics.

For example, the following prints out the version string for the server:

```
#include <krpc.hpp>
#include <krpc/services/krpc.hpp>
#include <iostream>

using namespace krpc;

int main() {
  krpc::Client conn = krpc::connect();
  krpc::services::KRPC krpc(&conn);
  std::cout << "Server version = " << krpc.get_status().version() << std::endl;
}
```

Or to get the rate at which the server is sending and receiving data over the network:

```
#include <krpc.hpp>
#include <krpc/services/krpc.hpp>
#include <iostream>

using namespace krpc;

int main() {
  krpc::Client conn = krpc::connect();
  krpc::services::KRPC krpc(&conn);
  krpc::schema::Status status = krpc.get_status();
  std::cout << "Data in = " << (status.bytes_read_rate()/1024.0) << " KB/s" << std::endl;
  std::cout << "Data out = " << (status.bytes_written_rate()/1024.0) << " KB/s" << std::endl
}
```

class AddStream<T>

A stream object. Streams are created by calling a function with `_stream` appended to its name.

T **operator()**()

Get the most recently received value from the stream.

void **remove**()

Remove the stream from the server.

4.2 SpaceCenter API

4.2.1 SpaceCenter

class **SpaceCenter** : public krpc::**Service**

Provides functionality to interact with Kerbal Space Program. This includes controlling the active vessel, managing its resources, planning maneuver nodes and auto-piloting.

SpaceCenter(krpc::*Client* **client*)

Construct an instance of this service.

Vessel **active_vessel**()

void **set_active_vessel**(*Vessel value*)

The currently active vessel.

std::vector<*Vessel*> **vessels**()

A list of all the vessels in the game.

std::map<std::string, *CelestialBody*> **bodies**()

A dictionary of all celestial bodies (planets, moons, etc.) in the game, keyed by the name of the body.

CelestialBody **target_body**()

void **set_target_body**(*CelestialBody value*)

The currently targeted celestial body.

Vessel **target_vessel**()

void **set_target_vessel**(*Vessel value*)

The currently targeted vessel.

DockingPort **target_docking_port**()

void **set_target_docking_port**(*DockingPort value*)

The currently targeted docking port.

void **clear_target**()

Clears the current target.

void **launch_vessel_from_vab**(std::string *name*)

Launch a new vessel from the VAB onto the launchpad.

Parameters

- **name** – Name of the vessel's craft file.

void **launch_vessel_from_sph**(std::string *name*)

Launch a new vessel from the SPH onto the runway.

Parameters

- **name** – Name of the vessel's craft file.

double **ut**()

The current universal time in seconds.

float **g**()

The value of the gravitational constant G in $N(m/kg)^2$.

WarpMode **warp_mode**()

The current time warp mode. Returns `WarpMode::none` if time warp is not active, `WarpMode::rails` if regular "on-rails" time warp is active, or `WarpMode::physics` if physical time warp is active.

float **warp_rate**()

The current warp rate. This is the rate at which time is passing for either on-rails or physical time warp. For example, a value of 10 means time is passing 10x faster than normal. Returns 1 if time warp is not active.

float **warp_factor**()

The current warp factor. This is the index of the rate at which time is passing for either regular "on-rails" or physical time warp. Returns 0 if time warp is not active. When in on-rails time warp, this is equal to `rails_warp_factor()`, and in physics time warp, this is equal to `physics_warp_factor()`.

int32 **rails_warp_factor**()

void **set_rails_warp_factor**(int32 *value*)

The time warp rate, using regular "on-rails" time warp. A value between 0 and 7 inclusive. 0 means no time warp. Returns 0 if physical time warp is active. If requested time warp factor cannot be set, it will be set to the next lowest possible value. For example, if the vessel is too close to a planet. See the KSP wiki for details.

int32 **physics_warp_factor**()

void **set_physics_warp_factor**(int32 *value*)

The physical time warp rate. A value between 0 and 3 inclusive. 0 means no time warp. Returns 0 if regular "on-rails" time warp is active.

bool **can_rails_warp_at**(int32 *factor* = 1)

Returns `true` if regular "on-rails" time warp can be used, at the specified warp *factor*. The maximum time warp rate is limited by various things, including how close the active vessel is to a planet. See the KSP wiki for details.

Parameters

- **factor** – The warp factor to check.

int32 **maximum_rails_warp_factor**()

The current maximum regular "on-rails" warp factor that can be set. A value between 0 and 7 inclusive. See the KSP wiki for details.

void **warp_to**(double *ut*, float *max_rails_rate* = 100000.0, float *max_physics_rate* = 2.0)

Uses time acceleration to warp forward to a time in the future, specified by universal time *ut*. This call blocks until the desired time is reached. Uses regular "on-rails" or physical time warp as appropriate. For example, physical time warp is used when the active vessel is traveling through an atmosphere. When using regular "on-rails" time warp, the warp rate is limited by *max_rails_rate*, and when using physical time warp, the warp rate is limited by *max_physics_rate*.

Parameters

- **ut** – The universal time to warp to, in seconds.
- **max_rails_rate** – The maximum warp rate in regular "on-rails" time warp.
- **max_physics_rate** – The maximum warp rate in physical time warp.

Returns When the time warp is complete.

std::tuple<double, double, double> **transform_position**(std::tuple<double, double, double> *position*, *ReferenceFrame from*, *ReferenceFrame to*)

Converts a position vector from one reference frame to another.

Parameters

- **position** – Position vector in reference frame *from*.
- **from** – The reference frame that the position vector is in.
- **to** – The reference frame to covert the position vector to.

Returns The corresponding position vector in reference frame *to*.

std::tuple<double, double, double> **transform_direction**(std::tuple<double, double, double> *direction*, ReferenceFrame *from*, ReferenceFrame *to*)

Converts a direction vector from one reference frame to another.

Parameters

- **direction** – Direction vector in reference frame *from*.
- **from** – The reference frame that the direction vector is in.
- **to** – The reference frame to covert the direction vector to.

Returns The corresponding direction vector in reference frame *to*.

std::tuple<double, double, double, double> **transform_rotation**(std::tuple<double, double, double, double> *rotation*, ReferenceFrame *from*, ReferenceFrame *to*)

Converts a rotation from one reference frame to another.

Parameters

- **rotation** – Rotation in reference frame *from*.
- **from** – The reference frame that the rotation is in.
- **to** – The corresponding rotation in reference frame *to*.

Returns The corresponding rotation in reference frame *to*.

std::tuple<double, double, double> **transform_velocity**(std::tuple<double, double, double> *position*, std::tuple<double, double, double> *velocity*, ReferenceFrame *from*, ReferenceFrame *to*)

Converts a velocity vector (acting at the specified position vector) from one reference frame to another. The position vector is required to take the relative angular velocity of the reference frames into account.

Parameters

- **position** – Position vector in reference frame *from*.
- **velocity** – Velocity vector in reference frame *from*.
- **from** – The reference frame that the position and velocity vectors are in.
- **to** – The reference frame to covert the velocity vector to.

Returns The corresponding velocity in reference frame *to*.

bool **far_available**()

Whether Ferram Aerospace Research is installed.

bool **remote_tech_available**()

Whether RemoteTech is installed.

void **draw_direction**(std::tuple<double, double, double> *direction*, ReferenceFrame *reference_frame*, std::tuple<double, double, double> *color*, float *length* = 10.0)

Draw a direction vector on the active vessel.

Parameters

- **direction** – Direction to draw the line in.
- **reference_frame** – Reference frame that the direction is in.
- **color** – The color to use for the line, as an RGB color.
- **length** – The length of the line. Defaults to 10.

void **draw_line** (std::tuple<double, double, double> *start*, std::tuple<double, double, double> *end*, *ReferenceFrame* *reference_frame*, std::tuple<double, double, double> *color*)

Draw a line.

Parameters

- **start** – Position of the start of the line.
- **end** – Position of the end of the line.
- **reference_frame** – Reference frame that the position are in.
- **color** – The color to use for the line, as an RGB color.

void **clear_drawing** ()

Remove all directions and lines currently being drawn.

enum struct WarpMode

Returned by `warp_mode()`

enumerator rails

Time warp is active, and in regular "on-rails" mode.

enumerator physics

Time warp is active, and in physical time warp mode.

enumerator none

Time warp is not active.

4.2.2 Vessel

class Vessel

These objects are used to interact with vessels in KSP. This includes getting orbital and flight data, manipulating control inputs and managing resources.

std::string **name** ()

void **set_name** (std::string *value*)

The name of the vessel.

VesselType **type** ()

void **set_type** (*VesselType* *value*)

The type of the vessel.

VesselSituation **situation** ()

The situation the vessel is in.

double **met** ()

The mission elapsed time in seconds.

Flight **flight** (*ReferenceFrame* *reference_frame* = None)

Returns a `Flight` object that can be used to get flight telemetry for the vessel, in the specified reference frame.

Parameters

- **reference_frame** – Reference frame. Defaults to the vessel's surface reference frame (`Vessel::surface_reference_frame()`).

Vessel **target** ()

void **set_target** (*Vessel value*)

The target vessel. `NULL` if there is no target. When setting the target, the target cannot be the current vessel.

Orbit **orbit** ()

The current orbit of the vessel.

Control **control** ()

Returns a `Control` object that can be used to manipulate the vessel's control inputs. For example, its pitch/yaw/roll controls, RCS and thrust.

AutoPilot **auto_pilot** ()

An `AutoPilot` object, that can be used to perform simple auto-piloting of the vessel.

Resources **resources** ()

A `Resources` object, that can used to get information about resources stored in the vessel.

Resources **resources_in_decouple_stage** (int32 *stage*, bool *cumulative* = True)

Returns a `Resources` object, that can used to get information about resources stored in a given *stage*.

Parameters

- **stage** – Get resources for parts that are decoupled in this stage.
- **cumulative** – When `false`, returns the resources for parts decoupled in just the given stage. When `true` returns the resources decoupled in the given stage and all subsequent stages combined.

Note: For details on stage numbering, see the discussion on *Staging*.

Parts **parts** ()

A `Parts` object, that can used to interact with the parts that make up this vessel.

Comms **comms** ()

A `Comms` object, that can used to interact with RemoteTech for this vessel.

Note: Requires RemoteTech to be installed.

float **mass** ()

The total mass of the vessel, including resources, in kg.

float **dry_mass** ()

The total mass of the vessel, excluding resources, in kg.

float **thrust** ()

The total thrust currently being produced by the vessel's engines, in Newtons. This is computed by summing `Engine::thrust()` for every engine in the vessel.

float **available_thrust** ()

Gets the total available thrust that can be produced by the vessel's active engines, in Newtons. This is computed by summing `Engine::available_thrust()` for every active engine in the vessel.

float **max_thrust** ()

The total maximum thrust that can be produced by the vessel's active engines, in Newtons. This is computed by summing `Engine::max_thrust()` for every active engine.

float **max_vacuum_thrust** ()

The total maximum thrust that can be produced by the vessel's active engines when the vessel is in a vacuum, in Newtons. This is computed by summing `Engine::max_vacuum_thrust()` for every active engine.

float **specific_impulse** ()

The combined specific impulse of all active engines, in seconds. This is computed using the formula described here.

float **vacuum_specific_impulse** ()

The combined vacuum specific impulse of all active engines, in seconds. This is computed using the formula described here.

float **kerbin_sea_level_specific_impulse** ()

The combined specific impulse of all active engines at sea level on Kerbin, in seconds. This is computed using the formula described here.

ReferenceFrame **reference_frame** ()

The reference frame that is fixed relative to the vessel, and orientated with the vessel.

- The origin is at the center of mass of the vessel.
- The axes rotate with the vessel.
- The x-axis points out to the right of the vessel.
- The y-axis points in the forward direction of the vessel.
- The z-axis points out of the bottom off the vessel.

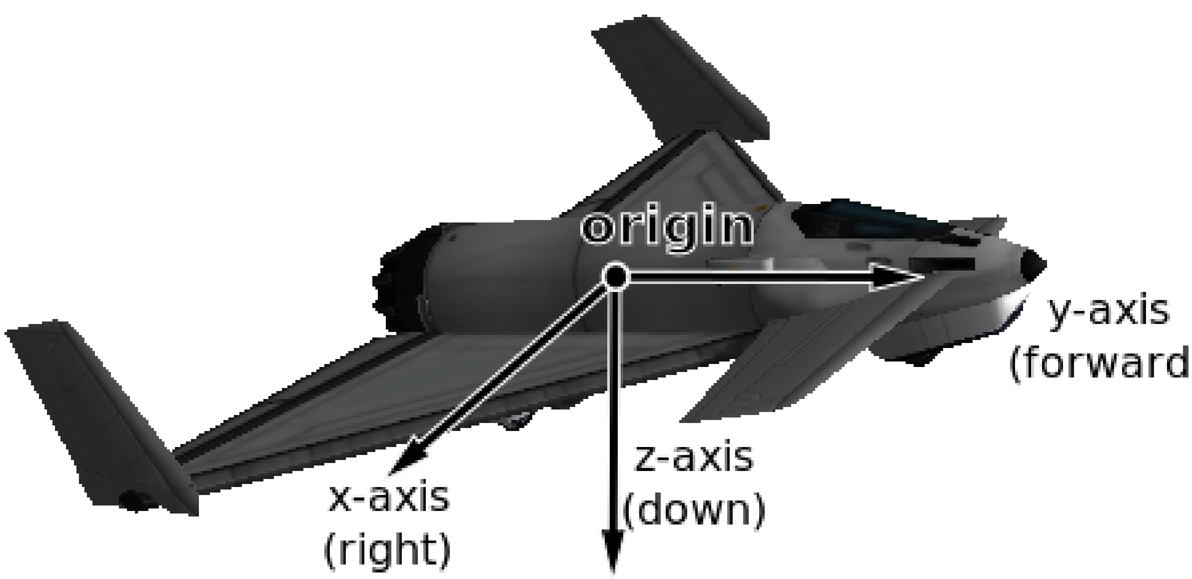


Fig. 4.1: Vessel reference frame origin and axes for the Aeris 3A aircraft

ReferenceFrame **orbital_reference_frame** ()

The reference frame that is fixed relative to the vessel, and orientated with the vessels orbital prograde/normal/radial directions.

- The origin is at the center of mass of the vessel.

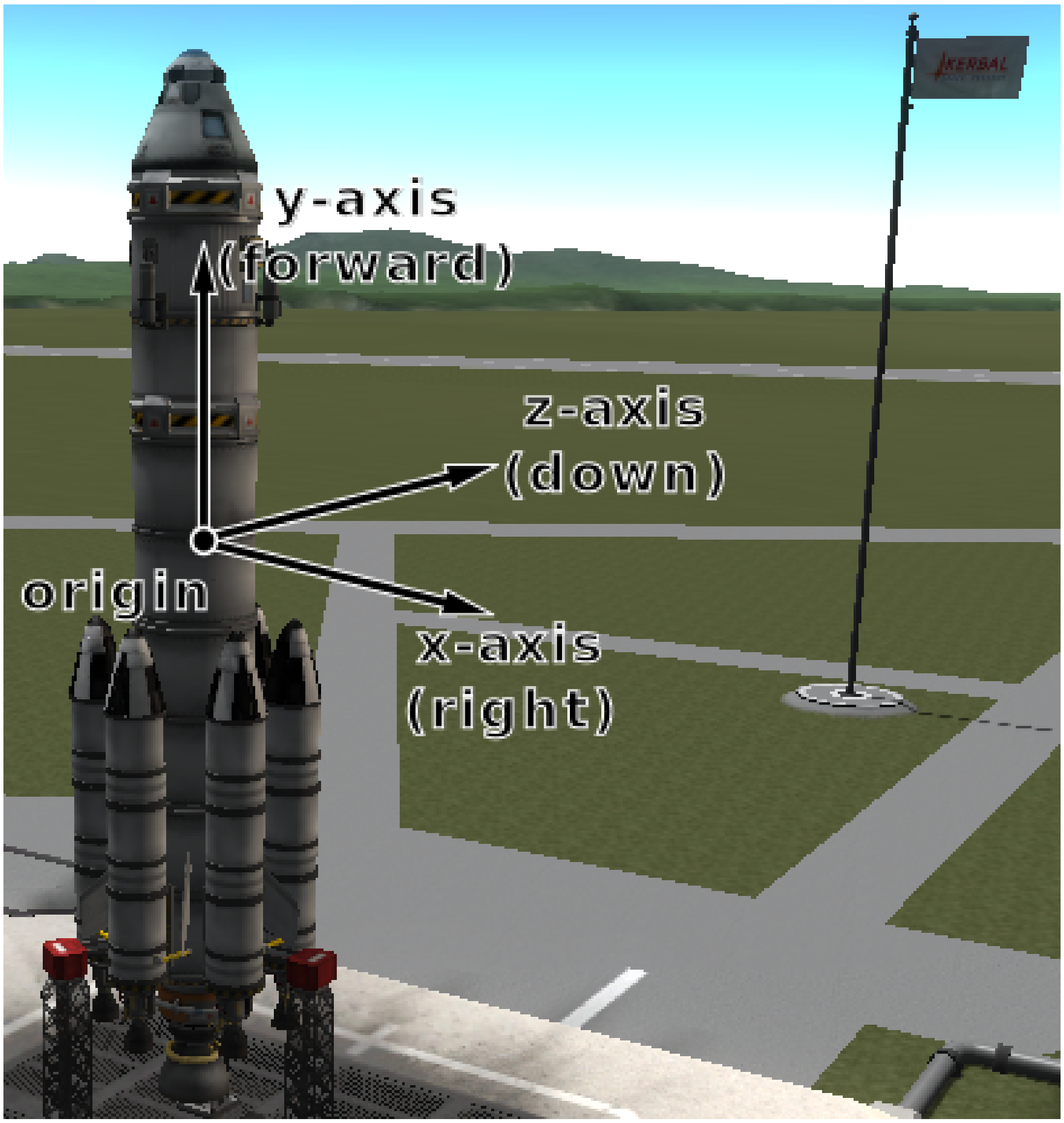


Fig. 4.2: Vessel reference frame origin and axes for the Kerbal-X rocket

- The axes rotate with the orbital prograde/normal/radial directions.
- The x-axis points in the orbital anti-radial direction.
- The y-axis points in the orbital prograde direction.
- The z-axis points in the orbital normal direction.

Note: Be careful not to confuse this with 'orbit' mode on the navball.

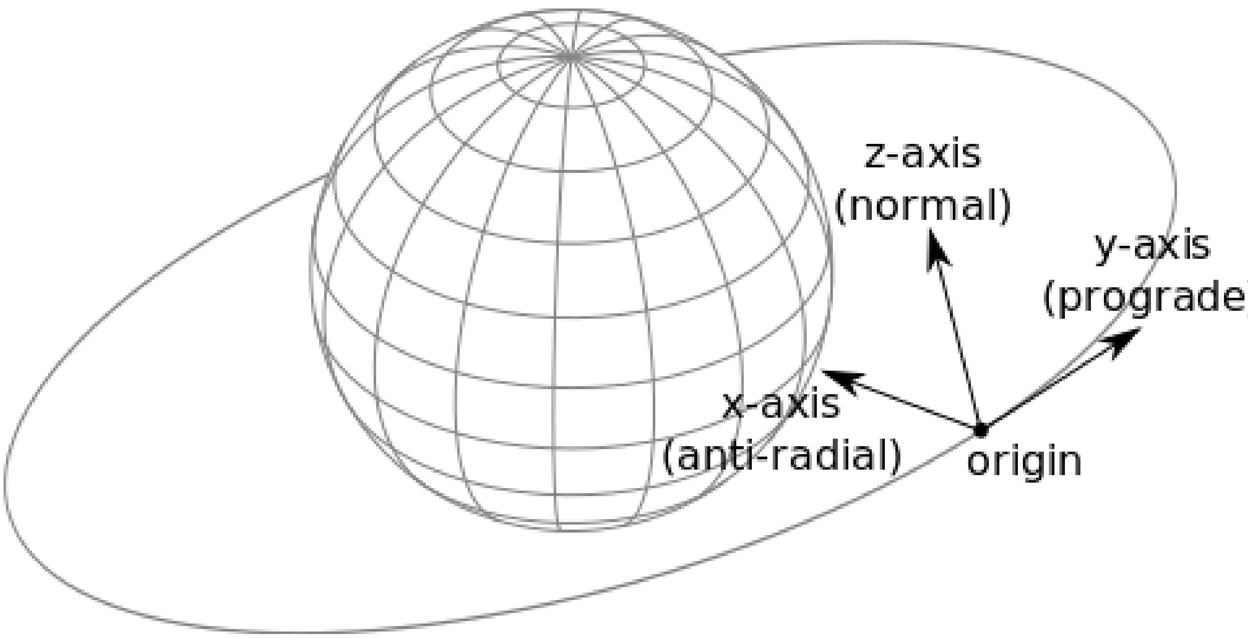


Fig. 4.3: Vessel orbital reference frame origin and axes

ReferenceFrame **surface_reference_frame**()

The reference frame that is fixed relative to the vessel, and orientated with the surface of the body being orbited.

- The origin is at the center of mass of the vessel.
- The axes rotate with the north and up directions on the surface of the body.
- The x-axis points in the zenith direction (upwards, normal to the body being orbited, from the center of the body towards the center of mass of the vessel).
- The y-axis points northwards towards the astronomical horizon (north, and tangential to the surface of the body – the direction in which a compass would point when on the surface).
- The z-axis points eastwards towards the astronomical horizon (east, and tangential to the surface of the body – east on a compass when on the surface).

Note: Be careful not to confuse this with 'surface' mode on the navball.

ReferenceFrame **surface_velocity_reference_frame**()

The reference frame that is fixed relative to the vessel, and orientated with the velocity vector of the vessel relative to the surface of the body being orbited.

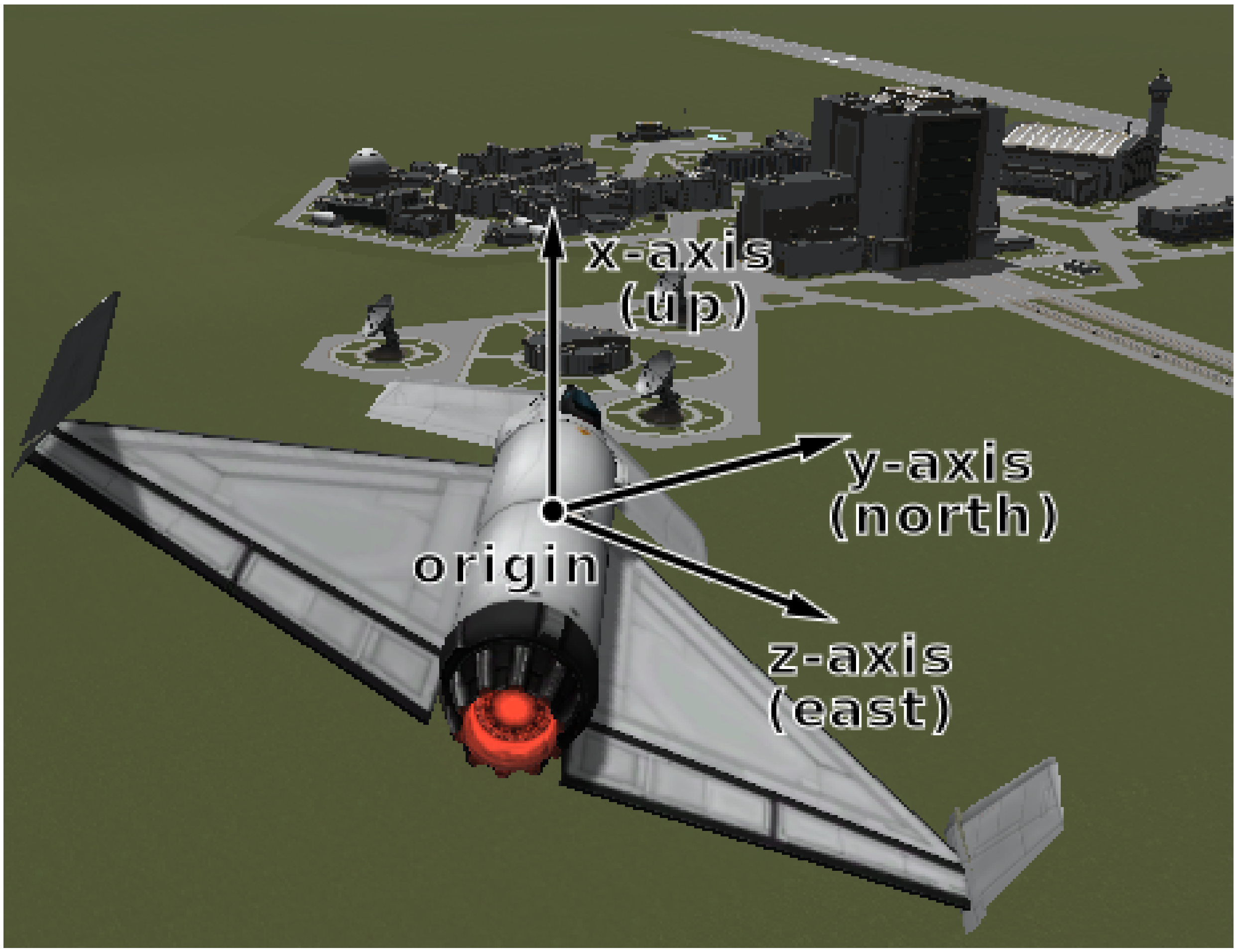


Fig. 4.4: Vessel surface reference frame origin and axes

- The origin is at the center of mass of the vessel.
- The axes rotate with the vessel's velocity vector.
- The y-axis points in the direction of the vessel's velocity vector, relative to the surface of the body being orbited.
- The z-axis is in the plane of the astronomical horizon.
- The x-axis is orthogonal to the other two axes.

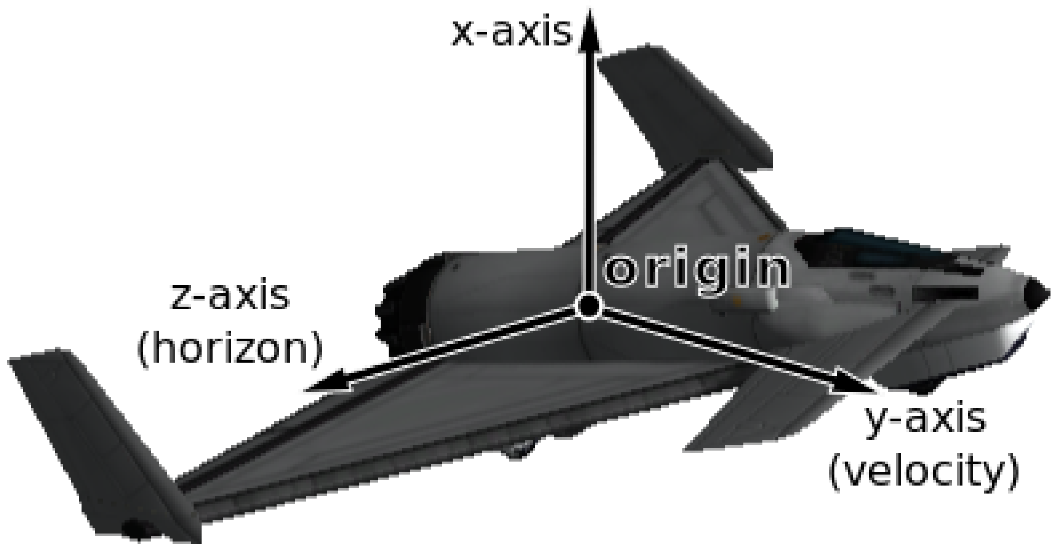


Fig. 4.5: Vessel surface velocity reference frame origin and axes

std::tuple<double, double, double> **position** (*ReferenceFrame reference_frame*)
Returns the position vector of the center of mass of the vessel in the given reference frame.

Parameters

std::tuple<double, double, double> **velocity** (*ReferenceFrame reference_frame*)
Returns the velocity vector of the center of mass of the vessel in the given reference frame.

Parameters

std::tuple<double, double, double, double> **rotation** (*ReferenceFrame reference_frame*)
Returns the rotation of the center of mass of the vessel in the given reference frame.

Parameters

std::tuple<double, double, double> **direction** (*ReferenceFrame reference_frame*)
Returns the direction in which the vessel is pointing, as a unit vector, in the given reference frame.

Parameters

std::tuple<double, double, double> **angular_velocity** (*ReferenceFrame reference_frame*)
Returns the angular velocity of the vessel in the given reference frame. The magnitude of the returned vector is the rotational speed in radians per second, and the direction of the vector indicates the axis of rotation (using the right hand rule).

Parameters

enum struct VesselType
See `Vessel::type()`.

enumerator ship
Ship.

enumerator station
Station.

enumerator lander
Lander.

enumerator probe
Probe.

enumerator rover
Rover.

enumerator base
Base.

enumerator debris
Debris.

enum struct VesselSituation
See *Vessel::situation()*.

enumerator docked
Vessel is docked to another.

enumerator escaping
Escaping.

enumerator flying
Vessel is flying through an atmosphere.

enumerator landed
Vessel is landed on the surface of a body.

enumerator orbiting
Vessel is orbiting a body.

enumerator pre_launch
Vessel is awaiting launch.

enumerator splashed
Vessel has splashed down in an ocean.

enumerator sub_orbital
Vessel is on a sub-orbital trajectory.

4.2.3 CelestialBody

class CelestialBody
Represents a celestial body (such as a planet or moon).

std::string **name** ()
The name of the body.

std::vector<*CelestialBody*> **satellites** ()
A list of celestial bodies that are in orbit around this celestial body.

Orbit **orbit** ()
The orbit of the body.

float **mass** ()
The mass of the body, in kilograms.

float **gravitational_parameter** ()
The standard gravitational parameter of the body in $m^3 s^{-2}$.

float **surface_gravity** ()
The acceleration due to gravity at sea level (mean altitude) on the body, in m/s^2.

float **rotational_period** ()
The sidereal rotational period of the body, in seconds.

float **rotational_speed** ()
The rotational speed of the body, in radians per second.

float **equatorial_radius** ()
The equatorial radius of the body, in meters.

double **surface_height** (double *latitude*, double *longitude*)
The height of the surface relative to mean sea level at the given position, in meters. When over water this is equal to 0.

Parameters

- **latitude** – Latitude in degrees
- **longitude** – Longitude in degrees

double **bedrock_height** (double *latitude*, double *longitude*)
The height of the surface relative to mean sea level at the given position, in meters. When over water, this is the height of the sea-bed and is therefore a negative value.

Parameters

- **latitude** – Latitude in degrees
- **longitude** – Longitude in degrees

std::tuple<double, double, double> **msl_position** (double *latitude*, double *longitude*, *ReferenceFrame reference_frame*)
The position at mean sea level at the given latitude and longitude, in the given reference frame.

Parameters

- **latitude** – Latitude in degrees
- **longitude** – Longitude in degrees
- **reference_frame** – Reference frame for the returned position vector

std::tuple<double, double, double> **surface_position** (double *latitude*, double *longitude*, *ReferenceFrame reference_frame*)
The position of the surface at the given latitude and longitude, in the given reference frame. When over water, this is the position of the surface of the water.

Parameters

- **latitude** – Latitude in degrees
- **longitude** – Longitude in degrees
- **reference_frame** – Reference frame for the returned position vector

std::tuple<double, double, double> **bedrock_position**(double *latitude*, double *longitude*, *ReferenceFrame reference_frame*)
The position of the surface at the given latitude and longitude, in the given reference frame. When over water, this is the position at the bottom of the sea-bed.

Parameters

- **latitude** – Latitude in degrees
- **longitude** – Longitude in degrees
- **reference_frame** – Reference frame for the returned position vector

float **sphere_of_influence**()
The radius of the sphere of influence of the body, in meters.

bool **has_atmosphere**()
`true` if the body has an atmosphere.

float **atmosphere_depth**()
The depth of the atmosphere, in meters.

bool **has_atmospheric_oxygen**()
`true` if there is oxygen in the atmosphere, required for air-breathing engines.

ReferenceFrame **reference_frame**()
The reference frame that is fixed relative to the celestial body.

- The origin is at the center of the body.
- The axes rotate with the body.
- The x-axis points from the center of the body towards the intersection of the prime meridian and equator (the position at 0° longitude, 0° latitude).
- The y-axis points from the center of the body towards the north pole.
- The z-axis points from the center of the body towards the equator at 90°E longitude.

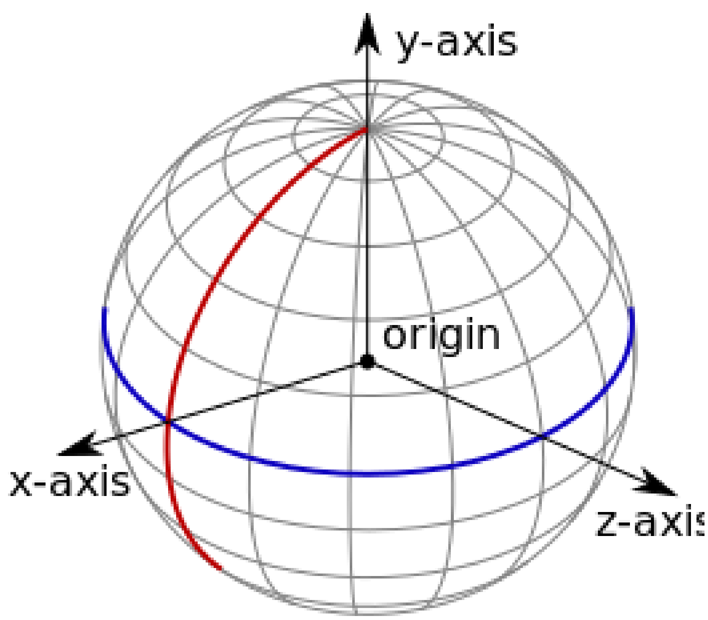


Fig. 4.6: Celestial body reference frame origin and axes. The equator is shown in blue, and the prime meridian in red.

ReferenceFrame **non_rotating_reference_frame**()

The reference frame that is fixed relative to this celestial body, and orientated in a fixed direction (it does not rotate with the body).

- The origin is at the center of the body.
- The axes do not rotate.
- The x-axis points in an arbitrary direction through the equator.
- The y-axis points from the center of the body towards the north pole.
- The z-axis points in an arbitrary direction through the equator.

ReferenceFrame **orbital_reference_frame**()

Gets the reference frame that is fixed relative to this celestial body, but orientated with the body's orbital prograde/normal/radial directions.

- The origin is at the center of the body.
- The axes rotate with the orbital prograde/normal/radial directions.
- The x-axis points in the orbital anti-radial direction.
- The y-axis points in the orbital prograde direction.
- The z-axis points in the orbital normal direction.

std::tuple<double, double, double> **position**(*ReferenceFrame reference_frame*)

Returns the position vector of the center of the body in the specified reference frame.

Parameters

std::tuple<double, double, double> **velocity**(*ReferenceFrame reference_frame*)

Returns the velocity vector of the body in the specified reference frame.

Parameters

std::tuple<double, double, double, double> **rotation**(*ReferenceFrame reference_frame*)

Returns the rotation of the body in the specified reference frame.

Parameters

std::tuple<double, double, double> **direction**(*ReferenceFrame reference_frame*)

Returns the direction in which the north pole of the celestial body is pointing, as a unit vector, in the specified reference frame.

Parameters

std::tuple<double, double, double> **angular_velocity**(*ReferenceFrame reference_frame*)

Returns the angular velocity of the body in the specified reference frame. The magnitude of the vector is the rotational speed of the body, in radians per second, and the direction of the vector indicates the axis of rotation, using the right-hand rule.

Parameters

4.2.4 Flight

class **Flight**

Used to get flight telemetry for a vessel, by calling `Vessel::flight()`. All of the information returned by this class is given in the reference frame passed to that method.

Note: To get orbital information, such as the apoapsis or inclination, see *Orbit*.

float **g_force** ()
The current G force acting on the vessel in m/s^2.

double **mean_altitude** ()
The altitude above sea level, in meters.

double **surface_altitude** ()
The altitude above the surface of the body or sea level, whichever is closer, in meters.

double **bedrock_altitude** ()
The altitude above the surface of the body, in meters. When over water, this is the altitude above the sea floor.

double **elevation** ()
The elevation of the terrain under the vessel, in meters. This is the height of the terrain above sea level, and is negative when the vessel is over the sea.

double **latitude** ()
The latitude of the vessel for the body being orbited, in degrees.

double **longitude** ()
The longitude of the vessel for the body being orbited, in degrees.

std::tuple<double, double, double> **velocity** ()
The velocity vector of the vessel. The magnitude of the vector is the speed of the vessel in meters per second. The direction of the vector is the direction of the vessels motion.

double **speed** ()
The speed of the vessel in meters per second.

double **horizontal_speed** ()
The horizontal speed of the vessel in meters per second.

double **vertical_speed** ()
The vertical speed of the vessel in meters per second.

std::tuple<double, double, double> **center_of_mass** ()
The position of the center of mass of the vessel.

std::tuple<double, double, double, double> **rotation** ()
The rotation of the vessel.

std::tuple<double, double, double> **direction** ()
The direction vector that the vessel is pointing in.

float **pitch** ()
The pitch angle of the vessel relative to the horizon, in degrees. A value between -90° and +90°.

float **heading** ()
The heading angle of the vessel relative to north, in degrees. A value between 0° and 360°.

float **roll** ()
The roll angle of the vessel relative to the horizon, in degrees. A value between -180° and +180°.

std::tuple<double, double, double> **prograde** ()
The unit direction vector pointing in the prograde direction.

std::tuple<double, double, double> **retrograde** ()
The unit direction vector pointing in the retrograde direction.

std::tuple<double, double, double> **normal**()
The unit direction vector pointing in the normal direction.

std::tuple<double, double, double> **anti_normal**()
The unit direction vector pointing in the anti-normal direction.

std::tuple<double, double, double> **radial**()
The unit direction vector pointing in the radial direction.

std::tuple<double, double, double> **anti_radial**()
The unit direction vector pointing in the anti-radial direction.

float **atmosphere_density**()
The current density of the atmosphere around the vessel, in kg/m^3.

float **dynamic_pressure**()
The dynamic pressure acting on the vessel, in Pascals. This is a measure of the strength of the aerodynamic forces. It is equal to $\frac{1}{2}$.air density.velocity^2. It is commonly denoted as Q.

Note: Calculated using KSPs stock aerodynamic model, or Ferram Aerospace Research if it is installed.

float **static_pressure**()
The static atmospheric pressure acting on the vessel, in Pascals.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

std::tuple<double, double, double> **aerodynamic_force**()
The total aerodynamic forces acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

std::tuple<double, double, double> **lift**()
The aerodynamic lift currently acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

std::tuple<double, double, double> **drag**()
The aerodynamic drag currently acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

float **speed_of_sound**()
The speed of sound, in the atmosphere around the vessel, in m/s.

Note: Not available when Ferram Aerospace Research is installed.

float **mach** ()

The speed of the vessel, in multiples of the speed of sound.

Note: Not available when Ferram Aerospace Research is installed.

float **equivalent_air_speed** ()

The equivalent air speed of the vessel, in m/s.

Note: Not available when Ferram Aerospace Research is installed.

float **terminal_velocity** ()

An estimate of the current terminal velocity of the vessel, in m/s. This is the speed at which the drag forces cancel out the force of gravity.

Note: Calculated using KSPs stock aerodynamic model, or Ferram Aerospace Research if it is installed.

float **angle_of_attack** ()

Gets the pitch angle between the orientation of the vessel and its velocity vector, in degrees.

float **sideslip_angle** ()

Gets the yaw angle between the orientation of the vessel and its velocity vector, in degrees.

float **total_air_temperature** ()

The total air temperature of the atmosphere around the vessel, in Kelvin. This temperature includes the *Flight::static_air_temperature()* and the vessel's kinetic energy.

float **static_air_temperature** ()

The static (ambient) temperature of the atmosphere around the vessel, in Kelvin.

float **stall_fraction** ()

Gets the current amount of stall, between 0 and 1. A value greater than 0.005 indicates a minor stall and a value greater than 0.5 indicates a large-scale stall.

Note: Requires Ferram Aerospace Research.

float **drag_coefficient** ()

Gets the coefficient of drag. This is the amount of drag produced by the vessel. It depends on air speed, air density and wing area.

Note: Requires Ferram Aerospace Research.

float **lift_coefficient** ()

Gets the coefficient of lift. This is the amount of lift produced by the vessel, and depends on air speed, air density and wing area.

Note: Requires Ferram Aerospace Research.

float **ballistic_coefficient** ()

Gets the ballistic coefficient.

Note: Requires Ferram Aerospace Research.

float **thrust_specific_fuel_consumption** ()

Gets the thrust specific fuel consumption for the jet engines on the vessel. This is a measure of the efficiency of the engines, with a lower value indicating a more efficient vessel. This value is the number of Newtons of fuel that are burned, per hour, to product one newton of thrust.

Note: Requires Ferram Aerospace Research.

4.2.5 Orbit

class **Orbit**

Describes an orbit. For example, the orbit of a vessel, obtained by calling `Vessel::orbit()`, or a celestial body, obtained by calling `CelestialBody::orbit()`.

CelestialBody **body** ()

The celestial body (e.g. planet or moon) around which the object is orbiting.

double **apoapsis** ()

Gets the apoapsis of the orbit, in meters, from the center of mass of the body being orbited.

Note: For the apoapsis altitude reported on the in-game map view, use `Orbit::apoapsis_altitude()`.

double **periapsis** ()

The periapsis of the orbit, in meters, from the center of mass of the body being orbited.

Note: For the periapsis altitude reported on the in-game map view, use `Orbit::periapsis_altitude()`.

double **apoapsis_altitude** ()

The apoapsis of the orbit, in meters, above the sea level of the body being orbited.

Note: This is equal to `Orbit::apoapsis()` minus the equatorial radius of the body.

double **periapsis_altitude** ()

The periapsis of the orbit, in meters, above the sea level of the body being orbited.

Note: This is equal to `Orbit::periapsis()` minus the equatorial radius of the body.

double **semi_major_axis** ()

The semi-major axis of the orbit, in meters.

double **semi_minor_axis** ()

The semi-minor axis of the orbit, in meters.

double **radius** ()
The current radius of the orbit, in meters. This is the distance between the center of mass of the object in orbit, and the center of mass of the body around which it is orbiting.

Note: This value will change over time if the orbit is elliptical.

double **speed** ()
The current orbital speed of the object in meters per second.

Note: This value will change over time if the orbit is elliptical.

double **period** ()
The orbital period, in seconds.

double **time_to_apoapsis** ()
The time until the object reaches apoapsis, in seconds.

double **time_to_periapsis** ()
The time until the object reaches periapsis, in seconds.

double **eccentricity** ()
The eccentricity of the orbit.

double **inclination** ()
The inclination of the orbit, in radians.

double **longitude_of_ascending_node** ()
The longitude of the ascending node, in radians.

double **argument_of_periapsis** ()
The argument of periapsis, in radians.

double **mean_anomaly_at_epoch** ()
The mean anomaly at epoch.

double **epoch** ()
The time since the epoch (the point at which the mean anomaly at epoch was measured, in seconds.

double **mean_anomaly** ()
The mean anomaly.

double **eccentric_anomaly** ()
The eccentric anomaly.

static std::tuple<double, double, double> **reference_plane_normal** (*ReferenceFrame reference_frame*)
The unit direction vector that is normal to the orbits reference plane, in the given reference frame. The reference plane is the plane from which the orbits inclination is measured.

Parameters

static std::tuple<double, double, double> **reference_plane_direction** (*ReferenceFrame reference_frame*)
The unit direction vector from which the orbits longitude of ascending node is measured, in the given reference frame.

Parameters

double **time_to_soi_change** ()

The time until the object changes sphere of influence, in seconds. Returns `NaN` if the object is not going to change sphere of influence.

Orbit **next_orbit** ()

If the object is going to change sphere of influence in the future, returns the new orbit after the change. Otherwise returns `NULL`.

4.2.6 Control

class **Control**

Used to manipulate the controls of a vessel. This includes adjusting the throttle, enabling/disabling systems such as SAS and RCS, or altering the direction in which the vessel is pointing.

Note: Control inputs (such as pitch, yaw and roll) are zeroed when all clients that have set one or more of these inputs are no longer connected.

bool **sas** ()

void **set_sas** (bool *value*)

The state of SAS.

Note: Equivalent to `AutoPilot::sas()`

SASMode **sas_mode** ()

void **set_sas_mode** (*SASMode* *value*)

The current `SASMode`. These modes are equivalent to the mode buttons to the left of the navball that appear when SAS is enabled.

Note: Equivalent to `AutoPilot::sas_mode()`

SpeedMode **speed_mode** ()

void **set_speed_mode** (*SpeedMode* *value*)

The current `SpeedMode` of the navball. This is the mode displayed next to the speed at the top of the navball.

bool **rcs** ()

void **set_rcs** (bool *value*)

The state of RCS.

bool **gear** ()

void **set_gear** (bool *value*)

The state of the landing gear/legs.

bool **lights** ()

void **set_lights** (bool *value*)

The state of the lights.

bool **brakes** ()

void **set_brakes** (bool *value*)
The state of the wheel brakes.

bool **abort** ()

void **set_abort** (bool *value*)
The state of the abort action group.

float **throttle** ()

void **set_throttle** (float *value*)
The state of the throttle. A value between 0 and 1.

float **pitch** ()

void **set_pitch** (float *value*)
The state of the pitch control. A value between -1 and 1. Equivalent to the w and s keys.

float **yaw** ()

void **set_yaw** (float *value*)
The state of the yaw control. A value between -1 and 1. Equivalent to the a and d keys.

float **roll** ()

void **set_roll** (float *value*)
The state of the roll control. A value between -1 and 1. Equivalent to the q and e keys.

float **forward** ()

void **set_forward** (float *value*)
The state of the forward translational control. A value between -1 and 1. Equivalent to the h and n keys.

float **up** ()

void **set_up** (float *value*)
The state of the up translational control. A value between -1 and 1. Equivalent to the i and k keys.

float **right** ()

void **set_right** (float *value*)
The state of the right translational control. A value between -1 and 1. Equivalent to the j and l keys.

float **wheel_throttle** ()

void **set_wheel_throttle** (float *value*)
The state of the wheel throttle. A value between -1 and 1. A value of 1 rotates the wheels forwards, a value of -1 rotates the wheels backwards.

float **wheel_steering** ()

void **set_wheel_steering** (float *value*)
The state of the wheel steering. A value between -1 and 1. A value of 1 steers to the left, and a value of -1 steers to the right.

int32 **current_stage** ()
The current stage of the vessel. Corresponds to the stage number in the in-game UI.

std::vector<*Vessel*> **activate_next_stage** ()
Activates the next stage. Equivalent to pressing the space bar in-game.

Returns A list of vessel objects that are jettisoned from the active vessel.

bool **get_action_group** (uint32 *group*)
Returns `true` if the given action group is enabled.

Parameters

- **group** – A number between 0 and 9 inclusive.

void **set_action_group** (uint32 *group*, bool *state*)
Sets the state of the given action group (a value between 0 and 9 inclusive).

Parameters

- **group** – A number between 0 and 9 inclusive.

void **toggle_action_group** (uint32 *group*)
Toggles the state of the given action group.

Parameters

- **group** – A number between 0 and 9 inclusive.

Node **add_node** (double *ut*, float *prograde* = 0.0, float *normal* = 0.0, float *radial* = 0.0)
Creates a maneuver node at the given universal time, and returns a `Node` object that can be used to modify it. Optionally sets the magnitude of the delta-v for the maneuver node in the prograde, normal and radial directions.

Parameters

- **ut** – Universal time of the maneuver node.
- **prograde** – Delta-v in the prograde direction.
- **normal** – Delta-v in the normal direction.
- **radial** – Delta-v in the radial direction.

std::vector<*Node*> **nodes** ()
Returns a list of all existing maneuver nodes, ordered by time from first to last.

void **remove_nodes** ()
Remove all maneuver nodes.

enum struct SASMode
The behavior of the SAS auto-pilot. See `AutoPilot::sas_mode()`.

enumerator stability_assist
Stability assist mode. Dampen out any rotation.

enumerator maneuver
Point in the burn direction of the next maneuver node.

enumerator prograde
Point in the prograde direction.

enumerator retrograde
Point in the retrograde direction.

enumerator normal
Point in the orbit normal direction.

enumerator anti_normal
Point in the orbit anti-normal direction.

enumerator radial
Point in the orbit radial direction.

enumerator anti_radial
Point in the orbit anti-radial direction.

enumerator target
Point in the direction of the current target.

enumerator anti_target
Point away from the current target.

enum struct SpeedMode
See *Control::speed_mode()*.

enumerator orbit
Speed is relative to the vessel's orbit.

enumerator surface
Speed is relative to the surface of the body being orbited.

enumerator target
Speed is relative to the current target.

4.2.7 Parts

The following classes allow interaction with a vessels individual parts.

Parts

class Parts
Instances of this class are used to interact with the parts of a vessel. An instance can be obtained by calling *Vessel::parts()*.

std::vector<*Part*> **all**()
A list of all of the vessels parts.

Part **root** ()
The vessels root part.

Note: See the discussion on *Trees of Parts*.

Part **controlling** ()

void **set_controlling** (*Part value*)
The part from which the vessel is controlled.

std::vector<*Part*> **with_name** (std::string *name*)
A list of parts whose `Part::name()` is *name*.

Parameters

std::vector<*Part*> **with_title** (std::string *title*)
A list of all parts whose `Part::title()` is *title*.

Parameters

std::vector<*Part*> **with_module** (std::string *module_name*)
A list of all parts that contain a `Module` whose `Module::name()` is *module_name*.

Parameters

std::vector<*Part*> **in_stage** (int32 *stage*)
A list of all parts that are activated in the given *stage*.

Parameters

Note: See the discussion on *Staging*.

std::vector<*Part*> **in_decouple_stage** (int32 *stage*)
A list of all parts that are decoupled in the given *stage*.

Parameters

Note: See the discussion on *Staging*.

std::vector<*Module*> **modules_with_name** (std::string *module_name*)
A list of modules (combined across all parts in the vessel) whose `Module::name()` is *module_name*.

Parameters

std::vector<*Decoupler*> **decouplers** ()
A list of all decouplers in the vessel.

std::vector<*DockingPort*> **docking_ports** ()
A list of all docking ports in the vessel.

DockingPort **docking_port_with_name** (std::string *name*)
The first docking port in the vessel with the given port name, as returned by `DockingPort::name()`. Returns `NULL` if there are no such docking ports.

Parameters

std::vector<*Engine*> **engines** ()
A list of all engines in the vessel.

std::vector<*LandingGear*> **landing_gear** ()
A list of all landing gear attached to the vessel.

std::vector<*LandingLeg*> **landing_legs** ()
A list of all landing legs attached to the vessel.

std::vector<*LaunchClamp*> **launch_clamps** ()
A list of all launch clamps attached to the vessel.

std::vector<*Light*> **lights** ()
A list of all lights in the vessel.

std::vector<*Parachute*> **parachutes** ()
A list of all parachutes in the vessel.

std::vector<*Radiator*> **radiators** ()
A list of all radiators in the vessel.

std::vector<*ResourceConverter*> **resource_converters** ()
A list of all resource converters in the vessel.

std::vector<*ResourceHarvester*> **resource_harvesters** ()
A list of all resource harvesters in the vessel.

std::vector<*ReactionWheel*> **reaction_wheels** ()
A list of all reaction wheels in the vessel.

std::vector<*Sensor*> **sensors** ()
A list of all sensors in the vessel.

std::vector<*SolarPanel*> **solar_panels** ()
A list of all solar panels in the vessel.

Part

class **Part**
Instances of this class represents a part. A vessel is made of multiple parts. Instances can be obtained by various methods in `Parts`.

std::string **name** ()
Internal name of the part, as used in part cfg files. For example "Mark1-2Pod".

std::string **title** ()
Title of the part, as shown when the part is right clicked in-game. For example "Mk1-2 Command Pod".

double **cost** ()
The cost of the part, in units of funds.

Vessel **vessel** ()
The vessel that contains this part.

Part **parent** ()
The parts parent. Returns `NULL` if the part does not have a parent. This, in combination with `Part::children()`, can be used to traverse the vessels parts tree.

Note: See the discussion on *Trees of Parts*.

std::vector<*Part*> **children** ()
The parts children. Returns an empty list if the part has no children. This, in combination with `Part::parent()`, can be used to traverse the vessels parts tree.

Note: See the discussion on *Trees of Parts*.

bool **axially_attached**()

Whether the part is axially attached to its parent, i.e. on the top or bottom of its parent. If the part has no parent, returns `false`.

Note: See the discussion on *Attachment Modes*.

bool **radially_attached**()

Whether the part is radially attached to its parent, i.e. on the side of its parent. If the part has no parent, returns `false`.

Note: See the discussion on *Attachment Modes*.

int32 **stage**()

The stage in which this part will be activated. Returns -1 if the part is not activated by staging.

Note: See the discussion on *Staging*.

int32 **decouple_stage**()

The stage in which this part will be decoupled. Returns -1 if the part is never decoupled from the vessel.

Note: See the discussion on *Staging*.

bool **massless**()

Whether the part is massless.

double **mass**()

The current mass of the part, including resources it contains, in kilograms. Returns zero if the part is massless.

double **dry_mass**()

The mass of the part, not including any resources it contains, in kilograms. Returns zero if the part is massless.

double **impact_tolerance**()

The impact tolerance of the part, in meters per second.

double **temperature**()

Temperature of the part, in Kelvin.

double **skin_temperature**()

Temperature of the skin of the part, in Kelvin.

double **max_temperature**()

Maximum temperature that the part can survive, in Kelvin.

double **max_skin_temperature**()

Maximum temperature that the skin of the part can survive, in Kelvin.

double **external_temperature** ()
Temperature of the atmosphere/vacuum surrounding the part, in Kelvin. This does not include heating from direct sunlight.

double **thermal_mass** ()
How much it takes to heat up the part.

double **thermal_skin_mass** ()
How much it takes to heat up the part's skin.

double **thermal_resource_mass** ()
How much it takes to heat up resources in the part.

double **thermal_conduction_flux** ()
The speed that heat is conducting into or out of the part through contact with other parts. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **thermal_convection_flux** ()
The speed that heat is convecting into or out of the part from the surrounding atmosphere. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **thermal_radiation_flux** ()
The speed that heat is radiating into or out of the part from the surrounding vacuum. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **thermal_internal_flux** ()
The speed that heat is generated by the part. For example, engines generate heat by burning fuel. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **thermal_skin_to_internal_flux** ()
The speed that heat is conducting between the part's skin and its internals.

Resources **resources** ()
A `Resources` object for the part.

bool **crossfeed** ()
Whether this part is crossfeed capable.

bool **is_fuel_line** ()
Whether this part is a fuel line.

std::vector<*Part*> **fuel_lines_from** ()
The parts that are connected to this part via fuel lines, where the direction of the fuel line is into this part.

Note: See the discussion on *Fuel Lines*.

std::vector<*Part*> **fuel_lines_to** ()
The parts that are connected to this part via fuel lines, where the direction of the fuel line is out of this part.

Note: See the discussion on *Fuel Lines*.

std::vector<*Module*> **modules** ()
The modules for this part.

Decoupler **decoupler** ()
A `Decoupler` if the part is a decoupler, otherwise `NULL`.

DockingPort **docking_port** ()
A `DockingPort` if the part is a docking port, otherwise `NULL`.

Engine **engine** ()
An `Engine` if the part is an engine, otherwise `NULL`.

LandingGear **landing_gear** ()
A `LandingGear` if the part is a landing gear , otherwise `NULL`.

LandingLeg **landing_leg** ()
A `LandingLeg` if the part is a landing leg, otherwise `NULL`.

LaunchClamp **launch_clamp** ()
A `LaunchClamp` if the part is a launch clamp, otherwise `NULL`.

Light **light** ()
A `Light` if the part is a light, otherwise `NULL`.

Parachute **parachute** ()
A `Parachute` if the part is a parachute, otherwise `NULL`.

Radiator **radiator** ()
A `Radiator` if the part is a radiator, otherwise `NULL`.

ReactionWheel **reaction_wheel** ()
A `ReactionWheel` if the part is a reaction wheel, otherwise `NULL`.

ResourceConverter **resource_converter** ()
A `ResourceConverter` if the part is a resource converter, otherwise `NULL`.

ResourceHarvester **resource_harvester** ()
A `ResourceHarvester` if the part is a resource harvester, otherwise `NULL`.

Sensor **sensor** ()
A `Sensor` if the part is a sensor, otherwise `NULL`.

SolarPanel **solar_panel** ()
A `SolarPanel` if the part is a solar panel, otherwise `NULL`.

std::tuple<double, double, double> **position** (*ReferenceFrame reference_frame*)
The position of the part in the given reference frame.

Parameters

std::tuple<double, double, double> **direction** (*ReferenceFrame reference_frame*)
The direction of the part in the given reference frame.

Parameters

std::tuple<double, double, double> **velocity** (*ReferenceFrame reference_frame*)
The velocity of the part in the given reference frame.

Parameters

std::tuple<double, double, double, double> **rotation** (*ReferenceFrame reference_frame*)
The rotation of the part in the given reference frame.

Parameters

ReferenceFrame **reference_frame** ()
The reference frame that is fixed relative to this part.

- The origin is at the position of the part.
- The axes rotate with the part.
- The x, y and z axis directions depend on the design of the part.

Note: For docking port parts, this reference frame is not necessarily equivalent to the reference frame for the docking port, returned by `DockingPort::reference_frame()`.

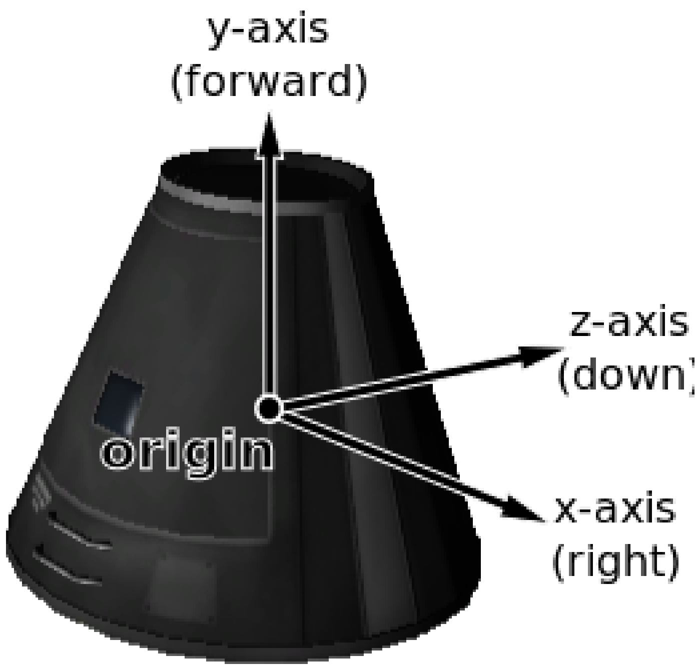


Fig. 4.7: Mk1 Command Pod reference frame origin and axes

Module

class **Module**

In KSP, each part has zero or more PartModules associated with it. Each one contains some of the functionality of the part. For example, an engine has a "ModuleEngines" PartModule that contains all the functionality of an engine. This class allows you to interact with KSPs PartModules, and any PartModules that have been added by other mods.

std::string **name** ()

Name of the PartModule. For example, "ModuleEngines".

Part **part** ()

The part that contains this module.

std::map<std::string, std::string> **fields** ()

The modules field names and their associated values, as a dictionary. These are the values visible in the right-click menu of the part.

bool **has_field** (std::string *name*)

Returns `true` if the module has a field with the given name.

Parameters

- **name** – Name of the field.

std::string **get_field** (std::string *name*)

Returns the value of a field.

Parameters

- **name** – Name of the field.

std::vector<std::string> **events** ()

A list of the names of all of the modules events. Events are the clickable buttons visible in the right-click menu of the part.

bool **has_event** (std::string *name*)

`true` if the module has an event with the given name.

Parameters

void **trigger_event** (std::string *name*)

Trigger the named event. Equivalent to clicking the button in the right-click menu of the part.

Parameters

std::vector<std::string> **actions** ()

A list of all the names of the modules actions. These are the parts actions that can be assigned to action groups in the in-game editor.

bool **has_action** (std::string *name*)

`true` if the part has an action with the given name.

Parameters

void **set_action** (std::string *name*, bool *value* = True)

Set the value of an action with the given name.

Parameters

Specific Types of Part

The following classes provide functionality for specific types of part.

Decoupler

class **Decoupler**

Obtained by calling `Part::decoupler()`

Part **part**()
The part object for this decoupler.

void **decouple**()
Fires the decoupler. Has no effect if the decoupler has already fired.

bool **decoupled**()
Whether the decoupler has fired.

float **impulse**()
The impulse that the decoupler imparts when it is fired, in Newton seconds.

Docking Port

class **DockingPort**
Obtained by calling `Part::docking_port()`

Part **part**()
The part object for this docking port.

std::string **name**()

void **set_name**(std::string *value*)
The port name of the docking port. This is the name of the port that can be set in the right click menu, when the Docking Port Alignment Indicator mod is installed. If this mod is not installed, returns the title of the part (`Part::title()`).

DockingPortState **state**()
The current state of the docking port.

Part **docked_part**()
The part that this docking port is docked to. Returns `NULL` if this docking port is not docked to anything.

Vessel **undock**()
Undocks the docking port and returns the vessel that was undocked from. After undocking, the active vessel may change (`active_vessel()`). This method can be called for either docking port in a docked pair - both calls will have the same effect. Returns `NULL` if the docking port is not docked to anything.

float **reengage_distance**()
The distance a docking port must move away when it undocks before it becomes ready to dock with another port, in meters.

bool **has_shield**()
Whether the docking port has a shield.

bool **shielded**()

void **set_shielded**(bool *value*)
The state of the docking ports shield, if it has one. Returns `true` if the docking port has a shield, and the shield is closed. Otherwise returns `false`. When set to `true`, the shield is closed, and when set to `false` the shield is opened. If the docking port does not have a shield, setting this attribute has no effect.

std::tuple<double, double, double> **position**(*ReferenceFrame reference_frame*)
The position of the docking port in the given reference frame.

Parameters

std::tuple<double, double, double> **direction**(*ReferenceFrame reference_frame*)
The direction that docking port points in, in the given reference frame.

Parameters

std::tuple<double, double, double, double> **rotation** (*ReferenceFrame reference_frame*)
The rotation of the docking port, in the given reference frame.

Parameters

ReferenceFrame **reference_frame** ()
The reference frame that is fixed relative to this docking port, and oriented with the port.

- The origin is at the position of the docking port.
- The axes rotate with the docking port.
- The x-axis points out to the right side of the docking port.
- The y-axis points in the direction the docking port is facing.
- The z-axis points out of the bottom off the docking port.

Note: This reference frame is not necessarily equivalent to the reference frame for the part, returned by `Part::reference_frame()`.

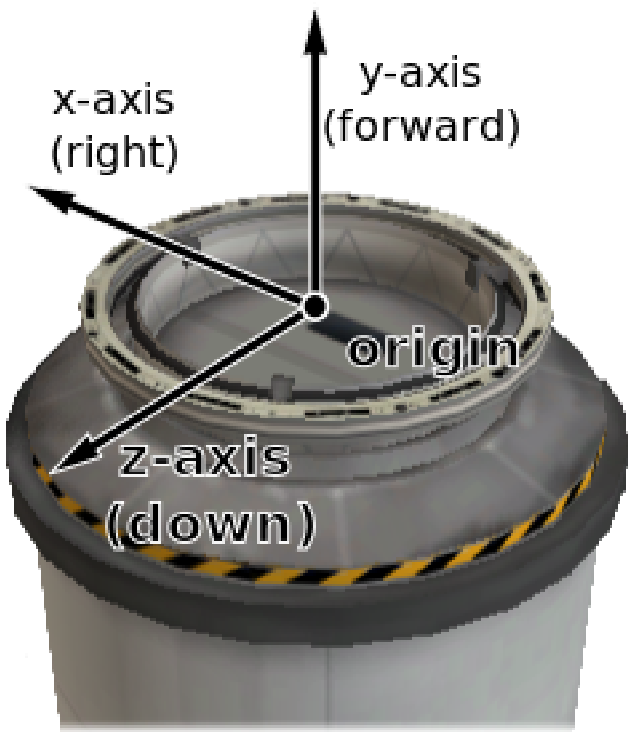


Fig. 4.8: Docking port reference frame origin and axes

enum struct DockingPortState
See `DockingPort::state()`.

enumerator ready
The docking port is ready to dock to another docking port.

enumerator docked
The docking port is docked to another docking port, or docked to another part (from the VAB/SPH).

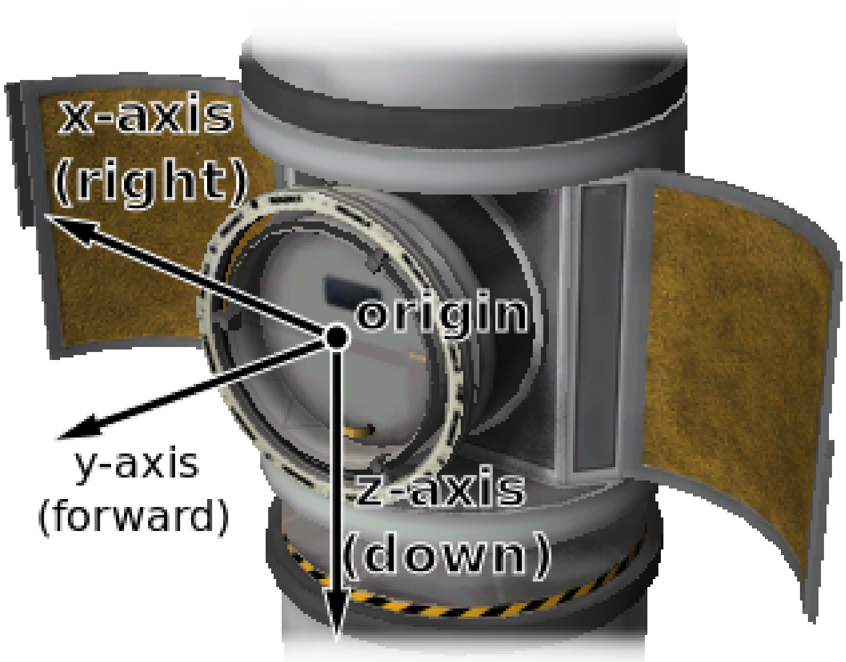


Fig. 4.9: Inline docking port reference frame origin and axes

enumerator docking
The docking port is very close to another docking port, but has not docked. It is using magnetic force to acquire a solid dock.

enumerator undocking
The docking port has just been undocked from another docking port, and is disabled until it moves away by a sufficient distance (*DockingPort::reengage_distance()*).

enumerator shielded
The docking port has a shield, and the shield is closed.

enumerator moving
The docking ports shield is currently opening/closing.

Engine

class Engine
Obtained by calling *Part::engine()*.

Part **part**()
The part object for this engine.

bool **active**()

void **set_active**(bool *value*)
Whether the engine is active. Setting this attribute may have no effect, depending on *Engine::can_shutdown()* and *Engine::can_restart()*.

float **thrust**()
The current amount of thrust being produced by the engine, in Newtons. Returns zero if the engine is not active or if it has no fuel.

float **available_thrust**()
The maximum available amount of thrust that can be produced by the engine, in Newtons. This takes *Engine::thrust_limit()* into account, and is the amount of thrust produced by the engine when activated and the main throttle is set to 100%. Returns zero if the engine does not have any fuel.

float **max_thrust**()
Gets the maximum amount of thrust that can be produced by the engine, in Newtons. This is the amount of thrust produced by the engine when activated, *Engine::thrust_limit()* is set to 100% and the main vessel's throttle is set to 100%.

float **max_vacuum_thrust**()
The maximum amount of thrust that can be produced by the engine in a vacuum, in Newtons. This is the amount of thrust produced by the engine when activated, *Engine::thrust_limit()* is set to 100%, the main vessel's throttle is set to 100% and the engine is in a vacuum.

float **thrust_limit**()

void **set_thrust_limit**(float *value*)
The thrust limiter of the engine. A value between 0 and 1. Setting this attribute may have no effect, for example the thrust limit for a solid rocket booster cannot be changed in flight.

float **specific_impulse**()
The current specific impulse of the engine, in seconds. Returns zero if the engine is not active.

float **vacuum_specific_impulse**()
The vacuum specific impulse of the engine, in seconds.

float **kerbin_sea_level_specific_impulse**()
The specific impulse of the engine at sea level on Kerbin, in seconds.

std::vector<std::string> **propellants**()
The names of resources that the engine consumes.

std::map<std::string, float> **propellant_ratios**()
The ratios of resources that the engine consumes. A dictionary mapping resource names to the ratios at which they are consumed by the engine.

bool **has_fuel**()
Whether the engine has run out of fuel (or flamed out).

float **throttle**()
The current throttle setting for the engine. A value between 0 and 1. This is not necessarily the same as the vessel's main throttle setting, as some engines take time to adjust their throttle (such as jet engines).

bool **throttle_locked**()
Whether the *Control::throttle()* affects the engine. For example, this is `true` for liquid fueled rockets, and `false` for solid rocket boosters.

bool **can_restart**()
Whether the engine can be restarted once shutdown. If the engine cannot be shutdown, returns `false`. For example, this is `true` for liquid fueled rockets and `false` for solid rocket boosters.

bool **can_shutdown**()
Gets whether the engine can be shutdown once activated. For example, this is `true` for liquid fueled rockets and `false` for solid rocket boosters.

bool **gimballed**()
Whether the engine nozzle is gimballed, i.e. can provide a turning force.

float **gimbal_range**()
The range over which the gimbal can move, in degrees.

bool **gimbal_locked** ()

void **set_gimbal_locked** (bool *value*)
Whether the engines gimbal is locked in place. Setting this attribute has no effect if the engine is not gimballed.

float **gimbal_limit** ()

void **set_gimbal_limit** (float *value*)
The gimbal limiter of the engine. A value between 0 and 1. Returns 0 if the gimbal is locked or the engine is not gimballed. Setting this attribute has no effect if the engine is not gimballed.

Landing Gear

class **LandingGear**
Obtained by calling `Part::landing_gear()`.

Part **part** ()
The part object for this landing gear.

LandingGearState **state** ()
Gets the current state of the landing gear.

bool **deployed** ()

void **set_deployed** (bool *value*)
Whether the landing gear is deployed.

enum struct **LandingGearState**
See `LandingGear::state()`.

enumerator **deployed**
Landing gear is fully deployed.

enumerator **retracted**
Landing gear is fully retracted.

enumerator **deploying**
Landing gear is being deployed.

enumerator **retracting**
Landing gear is being retracted.

Landing Leg

class **LandingLeg**
Obtained by calling `Part::landing_leg()`.

Part **part** ()
The part object for this landing leg.

LandingLegState **state** ()
The current state of the landing leg.

bool **deployed** ()

void **set_deployed** (bool *value*)
Whether the landing leg is deployed.

enum struct **LandingLegState**
See `LandingLeg::state()`.

enumerator deployed
Landing leg is fully deployed.

enumerator retracted
Landing leg is fully retracted.

enumerator deploying
Landing leg is being deployed.

enumerator retracting
Landing leg is being retracted.

enumerator broken
Landing leg is broken.

enumerator repairing
Landing leg is being repaired.

Launch Clamp

class LaunchClamp
Obtained by calling *Part::launch_clamp()*.

Part **part**()
The part object for this launch clamp.

void **release**()
Releases the docking clamp. Has no effect if the clamp has already been released.

Light

class Light
Obtained by calling *Part::light()*.

Part **part**()
The part object for this light.

bool **active**()

void **set_active**(bool *value*)
Whether the light is switched on.

float **power_usage**()
The current power usage, in units of charge per second.

Parachute

class Parachute
Obtained by calling *Part::parachute()*.

Part **part**()
The part object for this parachute.

void **deploy**()
Deploys the parachute. This has no effect if the parachute has already been deployed.

bool **deployed**()
Whether the parachute has been deployed.

ParachuteState **state**()

The current state of the parachute.

float **deploy_altitude**()

void **set_deploy_altitude**(float *value*)

The altitude at which the parachute will full deploy, in meters.

float **deploy_min_pressure**()

void **set_deploy_min_pressure**(float *value*)

The minimum pressure at which the parachute will semi-deploy, in atmospheres.

enum struct ParachuteState

See *Parachute::state()*.

enumerator stowed

The parachute is safely tucked away inside its housing.

enumerator active

The parachute is still stowed, but ready to semi-deploy.

enumerator semi_deployed

The parachute has been deployed and is providing some drag, but is not fully deployed yet.

enumerator deployed

The parachute is fully deployed.

enumerator cut

The parachute has been cut.

Radiator

class Radiator

Obtained by calling *Part::radiator()*.

Part **part**()

The part object for this radiator.

bool **deployed**()

void **set_deployed**(bool *value*)

Whether the radiator is extended.

RadiatorState **state**()

The current state of the radiator.

enum struct RadiatorState

RadiatorState

enumerator extended

Radiator is fully extended.

enumerator retracted

Radiator is fully retracted.

enumerator extending

Radiator is being extended.

enumerator retracting

Radiator is being retracted.

enumerator broken
Radiator is being broken.

Resource Converter

class ResourceConverter
Obtained by calling `Part::resource_converter()`.

Part **part** ()
The part object for this converter.

int32 **count** ()
The number of converters in the part.

std::string **name** (int32 *index*)
The name of the specified converter.

Parameters

- **index** – Index of the converter.

bool **active** (int32 *index*)
True if the specified converter is active.

Parameters

- **index** – Index of the converter.

void **start** (int32 *index*)
Start the specified converter.

Parameters

- **index** – Index of the converter.

void **stop** (int32 *index*)
Stop the specified converter.

Parameters

- **index** – Index of the converter.

ResourceConverterState **state** (int32 *index*)
The state of the specified converter.

Parameters

- **index** – Index of the converter.

std::string **status_info** (int32 *index*)
Status information for the specified converter. This is the full status message shown in the in-game UI.

Parameters

- **index** – Index of the converter.

std::vector<std::string> **inputs** (int32 *index*)
List of the names of resources consumed by the specified converter.

Parameters

- **index** – Index of the converter.

std::vector<std::string> **outputs** (int32 *index*)
List of the names of resources produced by the specified converter.

Parameters

- **index** – Index of the converter.

enum struct ResourceConverterState

See *ResourceConverter::state()*.

enumerator running

Converter is running.

enumerator idle

Converter is idle.

enumerator missing_resource

Converter is missing a required resource.

enumerator storage_full

No available storage for output resource.

enumerator capacity

At preset resource capacity.

enumerator unknown

Unknown state. Possible with modified resource converters. In this case, check *ResourceConverter::status_info()* for more information.

Resource Harvester

class ResourceHarvester

Obtained by calling *Part::resource_harvester()*.

Part **part**()

The part object for this harvester.

ResourceHarvesterState **state**()

The state of the harvester.

bool **deployed**()

void **set_deployed**(bool *value*)

Whether the harvester is deployed.

bool **active**()

void **set_active**(bool *value*)

Whether the harvester is actively drilling.

float **extraction_rate**()

The rate at which the drill is extracting ore, in units per second.

float **thermal_efficiency**()

The thermal efficiency of the drill, as a percentage of its maximum.

float **core_temperature**()

The core temperature of the drill, in Kelvin.

float **optimum_core_temperature**()

The core temperature at which the drill will operate with peak efficiency, in Kelvin.

Reaction Wheel

class ReactionWheel
Obtained by calling *Part::reaction_wheel()*.

Part **part**()
The part object for this reaction wheel.

bool **active**()

void **set_active**(bool *value*)
Whether the reaction wheel is active.

bool **broken**()
Whether the reaction wheel is broken.

float **pitch_torque**()
The torque in the pitch axis, in Newton meters.

float **yaw_torque**()
The torque in the yaw axis, in Newton meters.

float **roll_torque**()
The torque in the roll axis, in Newton meters.

Sensor

class Sensor
Obtained by calling *Part::sensor()*.

Part **part**()
The part object for this sensor.

bool **active**()

void **set_active**(bool *value*)
Whether the sensor is active.

std::string **value**()
The current value of the sensor.

float **power_usage**()
The current power usage of the sensor, in units of charge per second.

Solar Panel

class SolarPanel
Obtained by calling *Part::solar_panel()*.

Part **part**()
The part object for this solar panel.

bool **deployed**()

void **set_deployed**(bool *value*)
Whether the solar panel is extended.

SolarPanelState **state**()
The current state of the solar panel.

float **energy_flow** ()
: The current amount of energy being generated by the solar panel, in units of charge per second.

float **sun_exposure** ()
: The current amount of sunlight that is incident on the solar panel, as a percentage. A value between 0 and 1.

enum struct SolarPanelState
: See *SolarPanel::state()*.

enumerator extended
: Solar panel is fully extended.

enumerator retracted
: Solar panel is fully retracted.

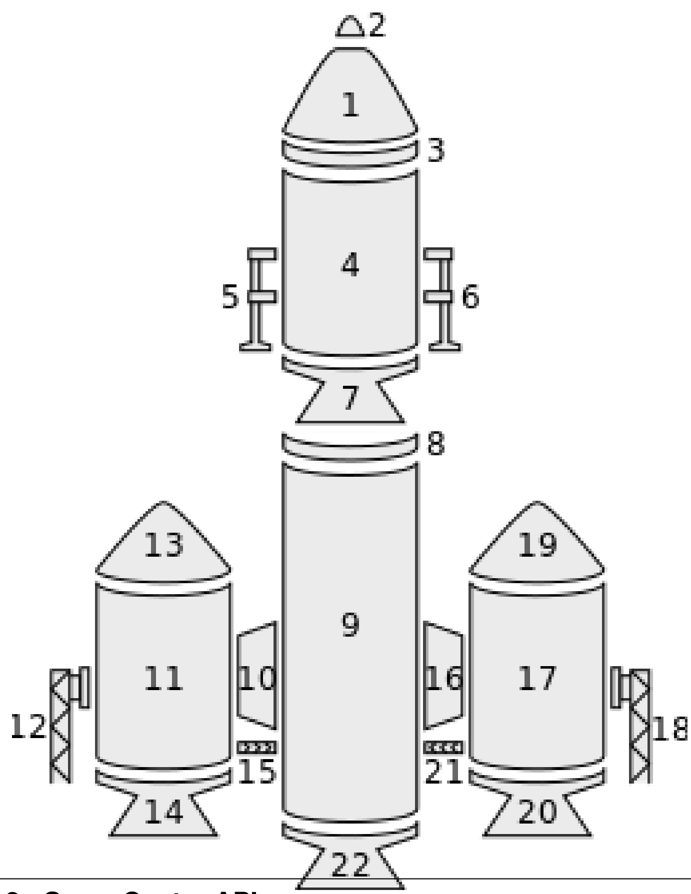
enumerator extending
: Solar panel is being extended.

enumerator retracting
: Solar panel is being retracted.

enumerator broken
: Solar panel is broken.

Trees of Parts

Vessels in KSP are comprised of a number of parts, connected to one another in a *tree* structure. An example vessel is shown in Figure 1, and the corresponding tree of parts in Figure 2. The craft file for this example can also be downloaded here.



Traversing the Tree

The tree of parts can be traversed using the attributes *SpaceCenter::Parts::root()*, *SpaceCenter::Part::parent()* and *SpaceCenter::Part::children()*.

The root of the tree is the same as the vessels *root part* (part number 1 in the example above) and can be obtained by calling *SpaceCenter::Parts::root()*. A parts children can be obtained by calling *SpaceCenter::Part::children()*. If the part does not have any children, *SpaceCenter::Part::children()* returns an empty list. A parts parent can be obtained by calling *SpaceCenter::Part::parent()*. If the part does not have a parent (as is the case for the root part), *SpaceCenter::Part::parent()* returns `NULL`.

Fig. 4.10: **Figure 1** – Example parts making up a vessel.

The following C++ example uses these attributes to perform a depth-first traversal over all of the parts in a vessel:

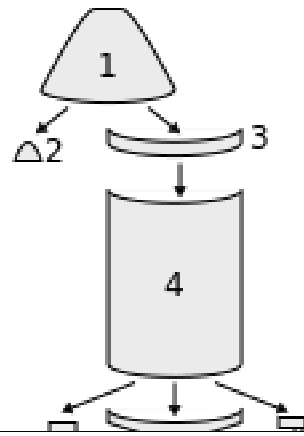
```
#include <krpc.hpp>
#include <krpc/services/space_center.hpp>
#include <iostream>
#include <stack>

using namespace krpc;
using namespace krpc::services;

int main() {
  Client conn = krpc::connect("");
  SpaceCenter sc(&conn);
  auto vessel = sc.active_vessel();

  auto root = vessel.parts().root();
  std::stack<std::pair<SpaceCenter::Part,int> >
  stack.push(std::pair<SpaceCenter::Part,int>(ro
  while (stack.size() > 0) {
    auto part = stack.top().first;
    auto depth = stack.top().second;
    stack.pop();
    std::cout << std::string(depth, ' ') << part
    auto children = part.children();
    for (std::vector<SpaceCenter::Part>::iterato
      stack.push(std::pair<SpaceCenter::Part,int
    }
  }
}
```

When this code is execute using the craft file for the example vessel pictured above, the following is printed out:

```
Command Pod Mk1
 TR-18A Stack Decoupler
  FL-T400 Fuel Tank
   LV-909 Liquid Fuel Engine
    TR-18A Stack Decoupler
     FL-T800 Fuel Tank
      LV-909 Liquid Fuel Engine
      TT-70 Radial Decoupler
       FL-T400 Fuel Tank
        TT18-A Launch Stability Enhancer
        FTX-2 External Fuel Duct
        LV-909 Liquid Fuel Engine
        Aerodynamic Nose Cone
      TT-70 Radial Decoupler
       FL-T400 Fuel Tank
        TT18-A Launch Stability Enhancer
        FTX-2 External Fuel Duct
        LV-909 Liquid Fuel Engine
        Aerodynamic Nose Cone
   LT-1 Landing Struts
   LT-1 Landing Struts
 Mk16 Parachute
```

Attachment Modes

Parts can be attached to other parts either *radially* (on the side of the parent part) or *axially* (on the end of the parent part, to form a stack).



For example, in the vessel pictured above, the parachute (part 2) is *axially* connected to its parent (the command pod – part 1), and the landing leg (part 5) is *radially* connected to its parent (the fuel tank – part 4).

The root part of a vessel (for example the command pod – part 1) does not have a parent part, so does not have an attachment mode. However, the part is consider to be *axially* attached to nothing.

The following C++ example does a depth-first traversal as before, but also prints out the attachment mode used by the part:

```
#include <krpc.hpp>
#include <krpc/services/space_center.hpp>
#include <iostream>
#include <stack>

using namespace krpc;
using namespace krpc::services;

int main() {
  Client conn = krpc::connect("");
  SpaceCenter sc(&conn);
  auto vessel = sc.active_vessel();

  auto root = vessel.parts().root();
  std::stack<std::pair<SpaceCenter::Part,int> > stack;
  stack.push(std::pair<SpaceCenter::Part,int>(root, 0));
  while (stack.size() > 0) {
    auto part = stack.top().first;
    auto depth = stack.top().second;
    stack.pop();
    std::string attach_mode;
    if (part.axially_attached()) {
      attach_mode = "axial";
    } else { // radially_attached
      attach_mode = "radial";
    }
    std::cout << std::string(depth, ' ') << part.title() << " - " << attach_mode << std::endl;
    auto children = part.children();
    for (std::vector<SpaceCenter::Part>::iterator child = children.begin(); child != children.end();
      stack.push(std::pair<SpaceCenter::Part,int>(*child, depth+1));
    }
  }
}
```

point from the parent part to the child part.

When this code is execute using the craft file for the example vessel pictured above, the following is printed out:

```
Command Pod Mk1 - axial
 TR-18A Stack Decoupler - axial
  FL-T400 Fuel Tank - axial
   LV-909 Liquid Fuel Engine - axial
    TR-18A Stack Decoupler - axial
     FL-T800 Fuel Tank - axial
      LV-909 Liquid Fuel Engine - axial
      TT-70 Radial Decoupler - radial
       FL-T400 Fuel Tank - radial
        TT18-A Launch Stability Enhancer - radial
        FTX-2 External Fuel Duct - radial
        LV-909 Liquid Fuel Engine - axial
        Aerodynamic Nose Cone - axial
      TT-70 Radial Decoupler - radial
       FL-T400 Fuel Tank - radial
        TT18-A Launch Stability Enhancer - radial
        FTX-2 External Fuel Duct - radial
        LV-909 Liquid Fuel Engine - axial
        Aerodynamic Nose Cone - axial
   LT-1 Landing Struts - radial
   LT-1 Landing Struts - radial
 Mk16 Parachute - axial
```

Fuel Lines

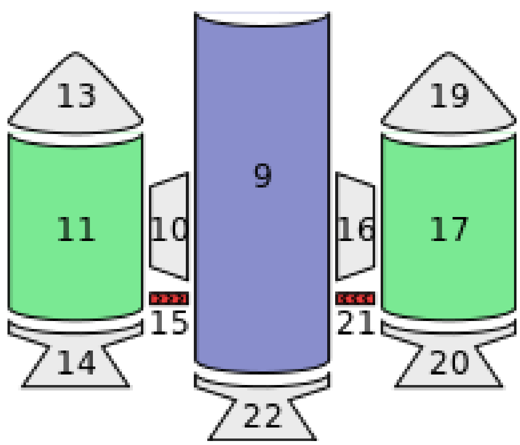
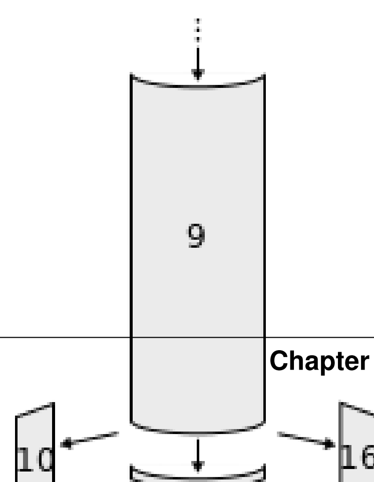


Fig. 4.12: **Figure 5** – Fuel lines from the example in Figure 1. Fuel flows from the parts highlighted in green, into the part highlighted in blue.

Fuel lines are considered parts, and are included in the parts tree (for example, as pictured in Figure 4). However, the parts tree does not contain information about which parts fuel lines connect to. The parent part of a fuel line is the part from which it will take fuel (as shown in Figure 4) however the part that it will send fuel to is not represented in the parts tree.

Figure 5 shows the fuel lines from the example vessel pictured earlier. Fuel line part 15 (in red) takes fuel from a fuel tank (part 11 – in green) and feeds it into another fuel tank (part 9 – in blue).



The fuel line is therefore a child of part 11, but its connection to part 9 is not represented in the tree.

The attributes `SpaceCenter::Part::fuel_lines_from()` and `SpaceCenter::Part::fuel_lines_to()` can be used to discover these connections. In the example in Figure 5, when `SpaceCenter::Part::fuel_lines_to()` is called on fuel tank part 11, it will return a list of parts containing just fuel tank part 9 (the blue part). When `SpaceCenter::Part::fuel_lines_from()` is called on fuel tank part 9, it will return a list containing fuel tank parts 11 and 17 (the parts colored green).

Staging

Each part has two staging numbers associated with it: the stage in which the part is *activated* and the stage in which the part is *decoupled*. These values can be obtained using `SpaceCenter::Part::stage()` and `SpaceCenter::Part::decouple_stage()` respectively. For parts that are not activated by staging, `SpaceCenter::Part::stage()` returns -1. For parts that are never decoupled, `SpaceCenter::Part::decouple_stage()` returns a value of -1.

Figure 6 shows an example staging sequence for a vessel. Figure 7 shows the stages in which each part of the vessel will be *activated*. Figure 8 shows the stages in which each part of the vessel will be *decoupled*.

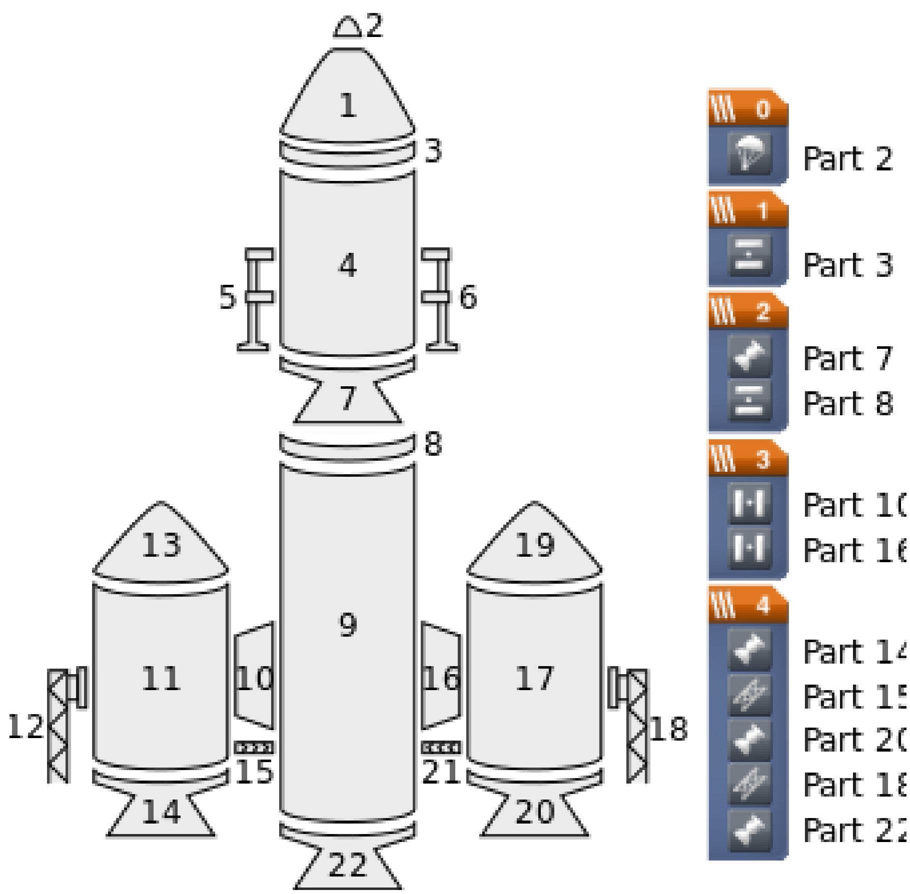


Fig. 4.14: **Figure 6** – Example vessel from Figure 1 with a staging sequence.

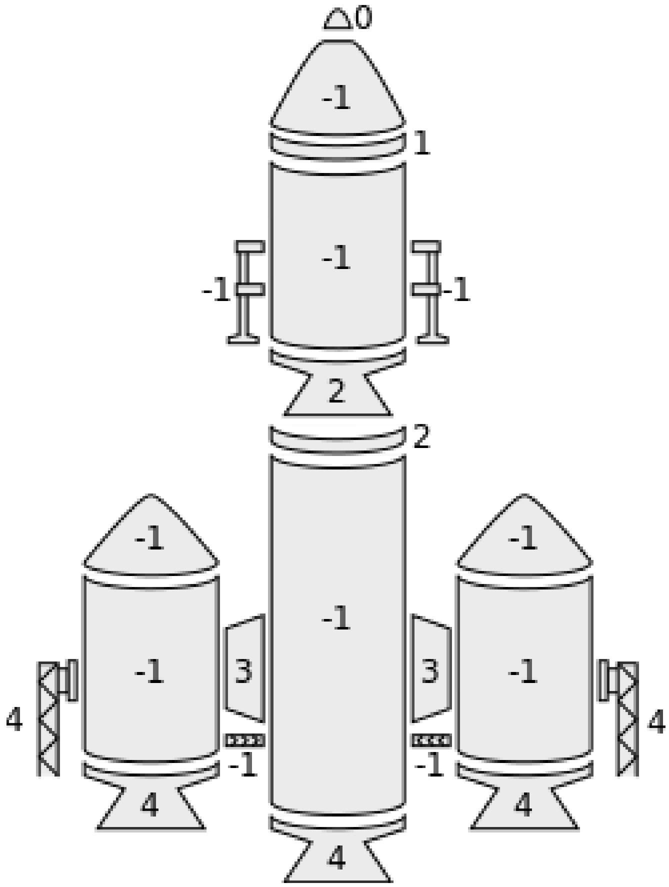


Fig. 4.15: **Figure 7** – The stage in which each part is *activated*.

4.2.8 Resources

class Resources

Created by calling *Vessel::resources()*, *Vessel::resources_in_decouple_stage()* or *Part::resources()*.

std::vector<std::string> **names** ()

A list of resource names that can be stored.

bool **has_resource** (std::string *name*)

Check whether the named resource can be stored.

Parameters

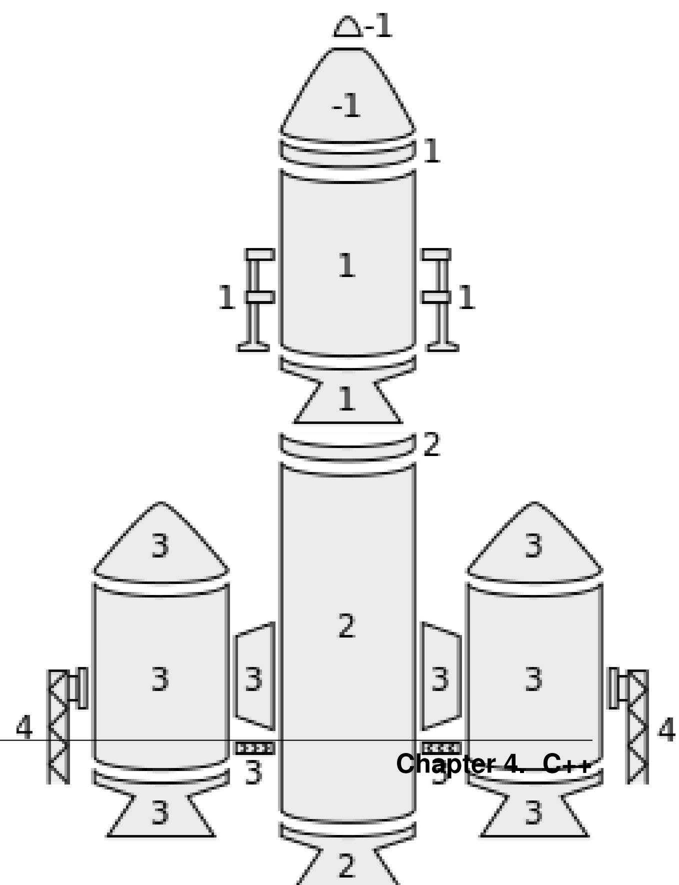
- **name** – The name of the resource.

float **max** (std::string *name*)

Returns the amount of a resource that can be stored.

Parameters

- **name** – The name of the resource.



float **amount** (std::string *name*)
Returns the amount of a resource that is currently stored.

Parameters

- **name** – The name of the resource.

static float **density** (std::string *name*)
Returns the density of a resource, in kg/l.

Parameters

- **name** – The name of the resource.

static *ResourceFlowMode* **flow_mode** (std::string *name*)
Returns the flow mode of a resource.

Parameters

- **name** – The name of the resource.

enum struct ResourceFlowMode
See `Resources::flow_mode()`.

enumerator vessel
The resource flows to any part in the vessel. For example, electric charge.

enumerator stage
The resource flows from parts in the first stage, followed by the second, and so on. For example, mono-propellant.

enumerator adjacent
The resource flows between adjacent parts within the vessel. For example, liquid fuel or oxidizer.

enumerator none
The resource does not flow. For example, solid fuel.

4.2.9 Node

class Node
Represents a maneuver node. Can be created using `Control::add_node()`.

float **prograde** ()

void **set_prograde** (float *value*)
The magnitude of the maneuver nodes delta-v in the prograde direction, in meters per second.

float **normal** ()

void **set_normal** (float *value*)
The magnitude of the maneuver nodes delta-v in the normal direction, in meters per second.

float **radial** ()

void **set_radial** (float *value*)
The magnitude of the maneuver nodes delta-v in the radial direction, in meters per second.

float **delta_v** ()

void **set_delta_v** (float *value*)
The delta-v of the maneuver node, in meters per second.

Note: Does not change when executing the maneuver node. See *Node::remaining_delta_v()*.

float **remaining_delta_v** ()
Gets the remaining delta-v of the maneuver node, in meters per second. Changes as the node is executed. This is equivalent to the delta-v reported in-game.

std::tuple<double, double, double> **burn_vector** (*ReferenceFrame reference_frame* = None)
Returns a vector whose direction the direction of the maneuver node burn, and whose magnitude is the delta-v of the burn in m/s.

Parameters

Note: Does not change when executing the maneuver node. See *Node::remaining_burn_vector()*.

std::tuple<double, double, double> **remaining_burn_vector** (*ReferenceFrame reference_frame* = None)
Returns a vector whose direction the direction of the maneuver node burn, and whose magnitude is the delta-v of the burn in m/s. The direction and magnitude change as the burn is executed.

Parameters

double **ut** ()

void **set_ut** (double *value*)
The universal time at which the maneuver will occur, in seconds.

double **time_to** ()
The time until the maneuver node will be encountered, in seconds.

Orbit **orbit** ()
The orbit that results from executing the maneuver node.

void **remove**()
Removes the maneuver node.

ReferenceFrame **reference_frame**()
Gets the reference frame that is fixed relative to the maneuver node's burn.

- The origin is at the position of the maneuver node.
- The y-axis points in the direction of the burn.
- The x-axis and z-axis point in arbitrary but fixed directions.

ReferenceFrame **orbital_reference_frame**()
Gets the reference frame that is fixed relative to the maneuver node, and orientated with the orbital prograde/normal/radial directions of the original orbit at the maneuver node's position.

- The origin is at the position of the maneuver node.
- The x-axis points in the orbital anti-radial direction of the original orbit, at the position of the maneuver node.
- The y-axis points in the orbital prograde direction of the original orbit, at the position of the maneuver node.
- The z-axis points in the orbital normal direction of the original orbit, at the position of the maneuver node.

std::tuple<double, double, double> **position**(*ReferenceFrame reference_frame*)
Returns the position vector of the maneuver node in the given reference frame.

Parameters

std::tuple<double, double, double> **direction**(*ReferenceFrame reference_frame*)
Returns the unit direction vector of the maneuver nodes burn in the given reference frame.

Parameters

4.2.10 Comms

class **Comms**
Used to interact with RemoteTech. Created using a call to `Vessel::comms()`.

Note: This class requires RemoteTech to be installed.

bool **has_local_control**()
Whether the vessel can be controlled locally.

bool **has_flight_computer**()
Whether the vessel has a RemoteTech flight computer on board.

bool **has_connection**()
Whether the vessel can receive commands from the KSC or a command station.

bool **has_connection_to_ground_station**()
Whether the vessel can transmit science data to a ground station.

double **signal_delay**()
The signal delay when sending commands to the vessel, in seconds.

double **signal_delay_to_ground_station**()
The signal delay between the vessel and the closest ground station, in seconds.

double **signal_delay_to_vessel**(*Vessel other*)
Returns the signal delay between the current vessel and another vessel, in seconds.

Parameters

4.2.11 ReferenceFrame

class **ReferenceFrame**
Represents a reference frame for positions, rotations and velocities. Contains:

- The position of the origin.
- The directions of the x, y and z axes.
- The linear velocity of the frame.
- The angular velocity of the frame.

Note: This class does not contain any properties or methods. It is only used as a parameter to other functions.

4.2.12 AutoPilot

class **AutoPilot**
Provides basic auto-piloting utilities for a vessel. Created by calling `Vessel::auto_pilot()`.

void **engage**()
Engage the auto-pilot.

void **disengage**()
Disengage the auto-pilot.

void **wait** ()

Blocks until the vessel is pointing in the target direction (if set) and has the target roll (if set).

float **error** ()

The error, in degrees, between the direction the ship has been asked to point in and the direction it is pointing in. Returns zero if the auto-pilot has not been engaged, SAS is not enabled, SAS is in stability assist mode, or no target direction is set.

float **roll_error** ()

The error, in degrees, between the roll the ship has been asked to be in and the actual roll. Returns zero if the auto-pilot has not been engaged or no target roll is set.

ReferenceFrame **reference_frame** ()

void **set_reference_frame** (*ReferenceFrame value*)

The reference frame for the target direction (`AutoPilot::target_direction()`).

std::tuple<double, double, double> **target_direction** ()

void **set_target_direction** (std::tuple<double, double, double> *value*)

The target direction. `NULL` if no target direction is set.

void **target_pitch_and_heading** (float *pitch*, float *heading*)

Set (`AutoPilot::target_direction()`) from a pitch and heading angle.

Parameters

- **pitch** – Target pitch angle, in degrees between -90° and +90°.
- **heading** – Target heading angle, in degrees between 0° and 360°.

float **target_roll** ()

void **set_target_roll** (float *value*)

The target roll, in degrees. `NaN` if no target roll is set.

bool **sas** ()

void **set_sas** (bool *value*)

The state of SAS.

Note: Equivalent to `Control::sas()`

SASMode **sas_mode** ()

void **set_sas_mode** (*SASMode value*)
The current *SASMode*. These modes are equivalent to the mode buttons to the left of the navball that appear when SAS is enabled.

Note: Equivalent to `Control::sas_mode()`

float **rotation_speed_multiplier** ()

void **set_rotation_speed_multiplier** (float *value*)
Target rotation speed multiplier. Defaults to 1.

float **max_rotation_speed** ()

void **set_max_rotation_speed** (float *value*)
Maximum target rotation speed. Defaults to 1.

float **roll_speed_multiplier** ()

void **set_roll_speed_multiplier** (float *value*)
Target roll speed multiplier. Defaults to 1.

float **max_roll_speed** ()

void **set_max_roll_speed** (float *value*)
Maximum target roll speed. Defaults to 1.

void **set_pid_parameters** (float *kp* = 1.0, float *ki* = 0.0, float *kd* = 0.0)
Sets the gains for the rotation rate PID controller.

Parameters

- **kp** – Proportional gain.
- **ki** – Integral gain.
- **kd** – Derivative gain.

4.2.13 Geometry Types

class **Vector3**
3-dimensional vectors are represented as a 3-tuple.
For example:

```
#include <krpc.hpp>
#include <krpc/services/space_center.hpp>
#include <iostream>

using namespace krpc;
using namespace krpc::services;

int main() {
  Client conn = krpc::connect();
  SpaceCenter sc(&conn);
  auto v = sc.active_vessel().flight().prograde();
```

```
    std::cout << v.get<0>() << " " << v.get<1>() << " " << v.get<2>() << std::endl;
  }
```

class **Quaternion**

Quaternions (rotations in 3-dimensional space) are encoded as a 4-tuple containing the x, y, z and w components. For example:

```
  #include <krpc.hpp>
  #include <krpc/services/space_center.hpp>
  #include <iostream>

  using namespace krpc;
  using namespace krpc::services;

  int main() {
    Client conn = krpc::connect();
    SpaceCenter sc(&conn);
    auto q = sc.active_vessel().flight().rotation();
    std::cout << q.get<0>() << " " << q.get<1>() << " " << q.get<2>() << " " << q.get<3>() << std:
  }
```

4.3 InfernalRobotics API

Provides RPCs to interact with the InfernalRobotics mod. Provides the following classes:

4.3.1 InfernalRobotics

class **InfernalRobotics** : **public** krpc::**Service**

This service provides functionality to interact with the InfernalRobotics mod.

InfernalRobotics(krpc::*Client* **client*)

Construct an instance of this service.

std::vector<*ControlGroup*> **servo_groups**()

A list of all the servo groups in the active vessel.

ControlGroup **servo_group_with_name**(std::string *name*)

Returns the servo group with the given *name* or `NULL` if none exists. If multiple servo groups have the same name, only one of them is returned.

Parameters

- **name** – Name of servo group to find.

Servo **servo_with_name**(std::string *name*)

Returns the servo with the given *name*, from all servo groups, or `NULL` if none exists. If multiple servos have the same name, only one of them is returned.

Parameters

- **name** – Name of the servo to find.

4.3.2 ControlGroup

class **ControlGroup**

A group of servos, obtained by calling *servo_groups()* or *servo_group_with_name()*. Represents the "Servo Groups" in the InfernalRobotics UI.

std::string **name** ()

void **set_name** (std::string *value*)

The name of the group.

std::string **forward_key** ()

void **set_forward_key** (std::string *value*)

The key assigned to be the "forward" key for the group.

std::string **reverse_key** ()

void **set_reverse_key** (std::string *value*)

The key assigned to be the "reverse" key for the group.

float **speed** ()

void **set_speed** (float *value*)

The speed multiplier for the group.

bool **expanded** ()

void **set_expanded** (bool *value*)

Whether the group is expanded in the InfernalRobotics UI.

std::vector<*Servo*> **servos** ()

The servos that are in the group.

Servo **servo_with_name** (std::string *name*)

Returns the servo with the given *name* from this group, or `NULL` if none exists.

Parameters

- **name** – Name of servo to find.

void **move_right** ()

Moves all of the servos in the group to the right.

void **move_left** ()

Moves all of the servos in the group to the left.

void **move_center** ()

Moves all of the servos in the group to the center.

void **move_next_preset**()
: Moves all of the servos in the group to the next preset.

void **move_prev_preset**()
: Moves all of the servos in the group to the previous preset.

void **stop**()
: Stops the servos in the group.

4.3.3 Servo

class **Servo**
: Represents a servo. Obtained using *ControlGroup::servos()*, *ControlGroup::servo_with_name()* or *servo_with_name()*.

std::string **name**()

void **set_name**(std::string *value*)
: The name of the servo.

void **set_highlight**(bool *value*)
: Whether the servo should be highlighted in-game.

float **position**()
: The position of the servo.

float **min_config_position**()
: The minimum position of the servo, specified by the part configuration.

float **max_config_position**()
: The maximum position of the servo, specified by the part configuration.

float **min_position**()

void **set_min_position**(float *value*)
: The minimum position of the servo, specified by the in-game tweak menu.

float **max_position**()

void **set_max_position**(float *value*)
: The maximum position of the servo, specified by the in-game tweak menu.

float **config_speed**()
: The speed multiplier of the servo, specified by the part configuration.

float **speed**()

void **set_speed** (float *value*)
The speed multiplier of the servo, specified by the in-game tweak menu.

float **current_speed** ()

void **set_current_speed** (float *value*)
The current speed at which the servo is moving.

float **acceleration** ()

void **set_acceleration** (float *value*)
The current speed multiplier set in the UI.

bool **is_moving** ()
Whether the servo is moving.

bool **is_free_moving** ()
Whether the servo is freely moving.

bool **is_locked** ()

void **set_is_locked** (bool *value*)
Whether the servo is locked.

bool **is_axis_inverted** ()

void **set_is_axis_inverted** (bool *value*)
Whether the servos axis is inverted.

void **move_right** ()
Moves the servo to the right.

void **move_left** ()
Moves the servo to the left.

void **move_center** ()
Moves the servo to the center.

void **move_next_preset** ()
Moves the servo to the next preset.

void **move_prev_preset** ()
Moves the servo to the previous preset.

void **move_to** (float *position*, float *speed*)
Moves the servo to *position* and sets the speed multiplier to *speed*.

Parameters

- **position** – The position to move the servo to.
- **speed** – Speed multiplier for the movement.

void **stop** ()
Stops the servo.

4.3.4 Example

The following example gets the control group named "MyGroup", prints out the names and positions of all of the servos in the group, then moves all of the servos to the right for 1 second.

```
#include <krpc.hpp>
#include <krpc/services/infernal_robotics.hpp>
#include <iostream>
#include <vector>

using namespace krpc;
using namespace krpc::services;

int main() {
  Client conn = krpc::connect("InfernalRobotics Example");
  InfernalRobotics infernal_robotics(&conn);

  InfernalRobotics::ControlGroup group = infernal_robotics.servo_group_with_name("MyGroup");
  if (group == InfernalRobotics::ControlGroup()) {
    std::cout << "Group not found" << std::endl;
    return 1;
  }

  std::vector<InfernalRobotics::Servo> servos = group.servos();
  for (std::vector<InfernalRobotics::Servo>::iterator i = servos.begin();
       i != servos.end(); i++) {
    std::cout << i->name() << " " << i->position() << std::endl;
  }

  group.move_right();
  sleep(1); //Note: platform dependent
  group.stop();
}
```

4.4 Kerbal Alarm Clock API

Provides RPCs to interact with the Kerbal Alarm Clock mod. Provides the following classes:

4.4.1 KerbalAlarmClock

class **KerbalAlarmClock** : **public** `krpc::`**Service**

This service provides functionality to interact with the Kerbal Alarm Clock mod.

KerbalAlarmClock(krpc::*Client* **client*)

Construct an instance of this service.

std::vector<*Alarm*> **alarms**()

A list of all the alarms.

Alarm **alarm_with_name**(std::string *name*)

Get the alarm with the given *name*, or `NULL` if no alarms have that name. If more than one alarm has the name, only returns one of them.

Parameters

- **name** – Name of the alarm to search for.

std::vector<*Alarm*> **alarms_with_type** (*AlarmType type*)

Get a list of alarms of the specified *type*.

Parameters

- **type** – Type of alarm to return.

Alarm **create_alarm** (*AlarmType type*, std::string *name*, double *ut*)

Create a new alarm and return it.

Parameters

- **type** – Type of the new alarm.
- **name** – Name of the new alarm.
- **ut** – Time at which the new alarm should trigger.

4.4.2 Alarm

class **Alarm**

Represents an alarm. Obtained by calling `alarms()`, `alarm_with_name()` or `alarms_with_type()`.

AlarmAction **action** ()

void **set_action** (*AlarmAction value*)

The action that the alarm triggers.

double **margin** ()

void **set_margin** (double *value*)

The number of seconds before the event that the alarm will fire.

double **time** ()

void **set_time** (double *value*)

The time at which the alarm will fire.

AlarmType **type** ()

The type of the alarm.

std::string **id** ()

The unique identifier for the alarm.

std::string **name** ()

void **set_name** (std::string *value*)

The short name of the alarm.

std::string **notes** ()

void **set_notes** (std::string *value*)
The long description of the alarm.

double **remaining** ()
The number of seconds until the alarm will fire.

bool **repeat** ()

void **set_repeat** (bool *value*)
Whether the alarm will be repeated after it has fired.

double **repeat_period** ()

void **set_repeat_period** (double *value*)
The time delay to automatically create an alarm after it has fired.

SpaceCenter::*Vessel* **vessel** ()

void **set_vessel** (*SpaceCenter*::*Vessel* *value*)
The vessel that the alarm is attached to.

SpaceCenter::*CelestialBody* **xfer_origin_body** ()

void **set_xfer_origin_body** (*SpaceCenter*::*CelestialBody* *value*)
The celestial body the vessel is departing from.

SpaceCenter::*CelestialBody* **xfer_target_body** ()

void **set_xfer_target_body** (*SpaceCenter*::*CelestialBody* *value*)
The celestial body the vessel is arriving at.

void **remove** ()
Removes the alarm.

4.4.3 AlarmType

enum struct AlarmType
The type of an alarm.

enumerator raw
An alarm for a specific date/time or a specific period in the future.

enumerator maneuver
An alarm based on the next maneuver node on the current ships flight path. This node will be stored and can be restored when you come back to the ship.

enumerator maneuver_auto
See `AlarmType::maneuver`.

enumerator apoapsis
An alarm for furthest part of the orbit from the planet.

enumerator periapsis
An alarm for nearest part of the orbit from the planet.

enumerator ascending_node
Ascending node for the targeted object, or equatorial ascending node.

enumerator descending_node
Descending node for the targeted object, or equatorial descending node.

enumerator closest
An alarm based on the closest approach of this vessel to the targeted vessel, some number of orbits into the future.

enumerator contract
An alarm based on the expiry or deadline of contracts in career modes.

enumerator contract_auto
See *AlarmType::contract*.

enumerator crew
An alarm that is attached to a crew member.

enumerator distance
An alarm that is triggered when a selected target comes within a chosen distance.

enumerator earth_time
An alarm based on the time in the "Earth" alternative Universe (aka the Real World).

enumerator launch_rendevous
An alarm that fires as your landed craft passes under the orbit of your target.

enumerator soi_change
An alarm manually based on when the next SOI point is on the flight path or set to continually monitor the active flight path and add alarms as it detects SOI changes.

enumerator soi_change_auto
See *AlarmType::soi_change*.

enumerator transfer
An alarm based on Interplanetary Transfer Phase Angles, i.e. when should I launch to planet X? Based on Kosmo Not's post and used in Olex's Calculator.

enumerator transfer_modelled
See *AlarmType::transfer*.

4.4.4 AlarmAction

enum struct AlarmAction
The action performed by an alarm when it fires.

enumerator do_nothing
Don't do anything at all...

enumerator do_nothing_delete_when_passed
Don't do anything, and delete the alarm.

enumerator kill_warp
Drop out of time warp.

enumerator kill_warp_only
Drop out of time warp.

enumerator message_only
Display a message.

enumerator pause_game
Pause the game.

4.4.5 Example

The following example creates a new alarm for the active vessel. The alarm is set to trigger after 10 seconds have passed, and display a message.

```
#include <krpc.hpp>
#include <krpc/services/space_center.hpp>
#include <krpc/services/kerbal_alarm_clock.hpp>
#include <iostream>

using namespace krpc;
using namespace krpc::services;

int main() {
  Client conn = krpc::connect("Kerbal Alarm Clock Example");
  SpaceCenter sc(&conn);
  KerbalAlarmClock kac(&conn);

  auto alarm = kac.create_alarm(KerbalAlarmClock::AlarmType::raw,
                                "My New Alarm",
                                sc.ut()+10);

  alarm.set_notes("10 seconds have now passed since the alarm was created.");
  alarm.set_action(KerbalAlarmClock::AlarmAction::message_only);
}
```

CHAPTER

FIVE

JAVA

5.1 Java Client

The `krpc.client` package provides functionality to interact with a kRPC server from Java.

5.1.1 Connecting to the Server

To connect to a server, use the *Connection.newInstance()* function. This returns a connection object through which you can interact with the server. For example to connect to a server running on the local machine:

```
Connection conn = Connection.newInstance("Example");
System.out.println(KRPC.newInstance(conn).getStatus().getVersion());
```

This function also accepts arguments that specify what address and port numbers to connect to. For example:

```
Connection conn = Connection.newInstance("Remote example", "my.domain.name", 1000, 1001);
System.out.println(KRPC.newInstance(conn).getStatus().getVersion());
```

5.1.2 Interacting with the Server

Interaction with the server is performed via a connection object. Functionality for services are defined in the package `krpc.client.services.*`.

Before a service can be used it must first be instantiated. The following example connects to the server, instantiates the SpaceCenter service, and outputs the name of the active vessel:

```
import java.io.IOException;
import krpc.client.Connection;
import krpc.client.RPCException;
import krpc.client.services.SpaceCenter;
import krpc.client.services.SpaceCenter.Vessel;

public class Program
{
    public static void main (String[] args) throws IOException, RPCException
    {
        Connection connection = Connection.newInstance("Vessel Name");
        SpaceCenter sc = SpaceCenter.newInstance(connection);
        Vessel vessel = sc.getActiveVessel();
        System.out.println(vessel.getName());
    }
}
```

5.1.3 Streaming Data from the Server

A stream repeatedly executes a function on the server, with a fixed set of argument values. It provides a more efficient way of repeatedly getting the result of calling function on the server, without having to invoke it directly – which incurs communication overheads.

For example, consider the following loop that continuously prints out the position of the active vessel. This loop incurs significant communication overheads, as the `vessel.position()` function is called repeatedly.

```
Vessel vessel = spaceCenter.getActiveVessel();
ReferenceFrame refframe = vessel.getOrbit().getBody().getReferenceFrame();
while (true)
    System.out.println(vessel.position(refframe));
```

The following code achieves the same thing, but is far more efficient. It makes a single call to *`Connection.addStream`* to create the stream, which avoids the communication overhead in the previous example.

```
Vessel vessel = spaceCenter.getActiveVessel();
ReferenceFrame refframe = vessel.getOrbit().getBody().getReferenceFrame();
Stream<Triplet<Double,Double,Double>> vessel_stream = connection.addStream(vessel, "position", reffra
while (true)
    System.out.println(vessel_stream.get());;
```

Streams are created by calling *`Connection.addStream`* and passing it information about which method to stream. The example above passes a remote object, the name of the method to call, followed by the arguments to pass to the method (if any). The most recent value for the stream can be obtained by calling *`Stream.get`*.

Streams can also be added for static methods as follows:

```
Stream<Double> time_stream = connection.addStream(SpaceCenter.class, "getUt");
```

A stream can be removed by calling *`Stream.remove()`*.

5.1.4 Reference

class **`Connection`**

This class provides the interface for communicating with the server.

static *Connection* **`newInstance`**()

static *Connection* **`newInstance`**(String *name*)

static *Connection* **`newInstance`**(String *name*, String *address*)

static *Connection* **`newInstance`**(String *name*, String *address*, int *rpcPort*, int *streamPort*)

static *Connection* **`newInstance`**(String *name*, InetAddress *address*)

static *Connection* **`newInstance`**(String *name*, InetAddress *address*, int *rpcPort*, int *streamPort*)

Create a connection to the server, using the given connection details.

Parameters

- **`name`** (*`String`*) – A descriptive name for the connection. This is passed to the server and appears, for example, in the client connection dialog on the in-game server window.
- **`address`** (*`String`*) – The address of the server to connect to. Can either be a hostname, an IP address as a string or an InetAddress object. Defaults to '127.0.0.1'.

- **rpc_port** (*int*) – The port number of the RPC Server. Defaults to 50000.
- **stream_port** (*int*) – The port number of the Stream Server. Defaults to 50001.

void **close**()
Close the connection.

Stream<T> **addStream**(Class<?> *clazz*, String *method*, Object... *args*)
Create a stream for a static method call to the given class.

Stream<T> **addStream**(*RemoteObject instance*, String *method*, Object... *args*)
Create a stream for a method call to the given remote object.

class **Stream**<T>
A stream object.

T **get**()
Get the most recent value for the stream.

void **remove**()
Remove the stream from the server.

abstract class **RemoteObject**
The abstract base class for all remote objects.

5.2 SpaceCenter API

5.2.1 SpaceCenter

public class **SpaceCenter**
Provides functionality to interact with Kerbal Space Program. This includes controlling the active vessel, managing its resources, planning maneuver nodes and auto-piloting.

Vessel **getActiveVessel**()

void **setActiveVessel**(*Vessel value*)
The currently active vessel.

java.util.List<*Vessel*> **getVessels**()
A list of all the vessels in the game.

java.util.Map<String, *CelestialBody*> **getBodies**()
A dictionary of all celestial bodies (planets, moons, etc.) in the game, keyed by the name of the body.

CelestialBody **getTargetBody**()

void **setTargetBody**(*CelestialBody value*)
The currently targeted celestial body.

Vessel **getTargetVessel**()

void **setTargetVessel**(*Vessel value*)
The currently targeted vessel.

DockingPort **getTargetDockingPort**()

void **setTargetDockingPort**(*DockingPort value*)
The currently targeted docking port.

void **ClearTarget**()
Clears the current target.

void **LaunchVesselFromVAB** (String *name*)
Launch a new vessel from the VAB onto the launchpad.

Parameters

- **name** (*String*) – Name of the vessel's craft file.

void **LaunchVesselFromSPH** (String *name*)
Launch a new vessel from the SPH onto the runway.

Parameters

- **name** (*String*) – Name of the vessel's craft file.

double **getUT** ()
The current universal time in seconds.

float **getG** ()
The value of the gravitational constant G in $N(m/kg)^2$.

WarpMode **getWarpMode** ()
The current time warp mode. Returns `WarpMode.None` if time warp is not active, `WarpMode.Rails` if regular "on-rails" time warp is active, or `WarpMode.Physics` if physical time warp is active.

float **getWarpRate** ()
The current warp rate. This is the rate at which time is passing for either on-rails or physical time warp. For example, a value of 10 means time is passing 10x faster than normal. Returns 1 if time warp is not active.

float **getWarpFactor** ()
The current warp factor. This is the index of the rate at which time is passing for either regular "on-rails" or physical time warp. Returns 0 if time warp is not active. When in on-rails time warp, this is equal to `RailsWarpFactor`, and in physics time warp, this is equal to `PhysicsWarpFactor`.

int **getRailsWarpFactor** ()

void **setRailsWarpFactor** (int *value*)
The time warp rate, using regular "on-rails" time warp. A value between 0 and 7 inclusive. 0 means no time warp. Returns 0 if physical time warp is active. If requested time warp factor cannot be set, it will be set to the next lowest possible value. For example, if the vessel is too close to a planet. See the KSP wiki for details.

int **getPhysicsWarpFactor** ()

void **setPhysicsWarpFactor** (int *value*)
The physical time warp rate. A value between 0 and 3 inclusive. 0 means no time warp. Returns 0 if regular "on-rails" time warp is active.

boolean **CanRailsWarpAt** (int *factor*)
Returns `true` if regular "on-rails" time warp can be used, at the specified warp *factor*. The maximum time warp rate is limited by various things, including how close the active vessel is to a planet. See the KSP wiki for details.

Parameters

- **factor** (*int*) – The warp factor to check.

int **getMaximumRailsWarpFactor** ()
The current maximum regular "on-rails" warp factor that can be set. A value between 0 and 7 inclusive. See the KSP wiki for details.

void **WarpTo** (double *UT*, float *maxRailsRate*, float *maxPhysicsRate*)
Uses time acceleration to warp forward to a time in the future, specified by universal time *UT*. This call

blocks until the desired time is reached. Uses regular "on-rails" or physical time warp as appropriate. For example, physical time warp is used when the active vessel is traveling through an atmosphere. When using regular "on-rails" time warp, the warp rate is limited by *maxRailsRate*, and when using physical time warp, the warp rate is limited by *maxPhysicsRate*.

Parameters

- **UT** (*double*) – The universal time to warp to, in seconds.
- **maxRailsRate** (*float*) – The maximum warp rate in regular "on-rails" time warp.
- **maxPhysicsRate** (*float*) – The maximum warp rate in physical time warp.

Returns When the time warp is complete.

org.javatuples.Triplet<Double, Double, Double> **TransformPosition** (org.javatuples.Triplet<Double, Double, Double> *position*, *ReferenceFrame from*, *ReferenceFrame to*)

Converts a position vector from one reference frame to another.

Parameters

- **position** (*org.javatuples.Triplet<Double,Double,Double>*) – Position vector in reference frame *from*.
- **from** (ReferenceFrame) – The reference frame that the position vector is in.
- **to** (ReferenceFrame) – The reference frame to covert the position vector to.

Returns The corresponding position vector in reference frame *to*.

org.javatuples.Triplet<Double, Double, Double> **TransformDirection** (org.javatuples.Triplet<Double, Double, Double> *direction*, *ReferenceFrame from*, *ReferenceFrame to*)

Converts a direction vector from one reference frame to another.

Parameters

- **direction** (*org.javatuples.Triplet<Double,Double,Double>*) – Direction vector in reference frame *from*.
- **from** (ReferenceFrame) – The reference frame that the direction vector is in.
- **to** (ReferenceFrame) – The reference frame to covert the direction vector to.

Returns The corresponding direction vector in reference frame *to*.

org.javatuples.Quartet<Double, Double, Double, Double> **TransformRotation** (org.javatuples.Quartet<Double, Double, Double, Double> *rotation*, *ReferenceFrame from*, *ReferenceFrame to*)

Converts a rotation from one reference frame to another.

Parameters

- **rotation** (*org.javatuples.Quartet<Double,Double,Double,Double>*) – Rotation in reference frame *from*.
- **from** (ReferenceFrame) – The reference frame that the rotation is in.
- **to** (ReferenceFrame) – The corresponding rotation in reference frame *to*.

Returns The corresponding rotation in reference frame *to*.

org.javatuples.Triplet<Double, Double, Double> **TransformVelocity** (org.javatuples.Triplet<Double, Double, Double> *position*, org.javatuples.Triplet<Double, Double, Double> *velocity*, *ReferenceFrame from*, *ReferenceFrame to*)

Converts a velocity vector (acting at the specified position vector) from one reference frame to another. The position vector is required to take the relative angular velocity of the reference frames into account.

Parameters

- **position** (*org.javatuples.Triplet<Double,Double,Double>*) – Position vector in reference frame *from*.
- **velocity** (*org.javatuples.Triplet<Double,Double,Double>*) – Velocity vector in reference frame *from*.
- **from** (`ReferenceFrame`) – The reference frame that the position and velocity vectors are in.
- **to** (`ReferenceFrame`) – The reference frame to covert the velocity vector to.

Returns The corresponding velocity in reference frame *to*.

boolean **getFARAvailable** ()

Whether Ferram Aerospace Research is installed.

boolean **getRemoteTechAvailable** ()

Whether RemoteTech is installed.

void **DrawDirection** (org.javatuples.Triplet<Double, Double, Double> *direction*, *ReferenceFrame referenceFrame*, org.javatuples.Triplet<Double, Double, Double> *color*, float *length*)

Draw a direction vector on the active vessel.

Parameters

- **direction** (*org.javatuples.Triplet<Double,Double,Double>*) – Direction to draw the line in.
- **referenceFrame** (`ReferenceFrame`) – Reference frame that the direction is in.
- **color** (*org.javatuples.Triplet<Double,Double,Double>*) – The color to use for the line, as an RGB color.
- **length** (*float*) – The length of the line. Defaults to 10.

void **DrawLine** (org.javatuples.Triplet<Double, Double, Double> *start*, org.javatuples.Triplet<Double, Double, Double> *end*, *ReferenceFrame referenceFrame*, org.javatuples.Triplet<Double, Double, Double> *color*)

Draw a line.

Parameters

- **start** (*org.javatuples.Triplet<Double,Double,Double>*) – Position of the start of the line.
- **end** (*org.javatuples.Triplet<Double,Double,Double>*) – Position of the end of the line.
- **referenceFrame** (`ReferenceFrame`) – Reference frame that the position are in.

- **color** (*org.javatuples.Triplet<Double,Double,Double>*) – The color to use for the line, as an RGB color.

void **ClearDrawing**()
Remove all directions and lines currently being drawn.

public enum **WarpMode**
Returned by `WarpMode`

public *WarpMode* **Rails**
Time warp is active, and in regular "on-rails" mode.

public *WarpMode* **Physics**
Time warp is active, and in physical time warp mode.

public *WarpMode* **None**
Time warp is not active.

5.2.2 Vessel

public class **Vessel**
These objects are used to interact with vessels in KSP. This includes getting orbital and flight data, manipulating control inputs and managing resources.

String **getName**()

void **setName**(String *value*)
The name of the vessel.

VesselType **getType**()

void **setType**(*VesselType* *value*)
The type of the vessel.

VesselSituation **getSituation**()
The situation the vessel is in.

double **getMET**()
The mission elapsed time in seconds.

Flight **Flight**(*ReferenceFrame* *referenceFrame*)
Returns a `Flight` object that can be used to get flight telemetry for the vessel, in the specified reference frame.

Parameters

- **referenceFrame** (`ReferenceFrame`) – Reference frame. Defaults to the vessel's surface reference frame (`Vessel.SurfaceReferenceFrame`).

Vessel **getTarget**()

void **setTarget**(*Vessel* *value*)
The target vessel. `null` if there is no target. When setting the target, the target cannot be the current vessel.

Orbit **getOrbit**()
The current orbit of the vessel.

Control **getControl**()
Returns a `Control` object that can be used to manipulate the vessel's control inputs. For example, its pitch/yaw/roll controls, RCS and thrust.

AutoPilot **getAutoPilot** ()

An `AutoPilot` object, that can be used to perform simple auto-piloting of the vessel.

Resources **getResources** ()

A `Resources` object, that can used to get information about resources stored in the vessel.

Resources **ResourcesInDecoupleStage** (int *stage*, boolean *cumulative*)

Returns a `Resources` object, that can used to get information about resources stored in a given *stage*.

Parameters

- **stage** (*int*) – Get resources for parts that are decoupled in this stage.
- **cumulative** (*boolean*) – When `false`, returns the resources for parts decoupled in just the given stage. When `true` returns the resources decoupled in the given stage and all subsequent stages combined.

Note: For details on stage numbering, see the discussion on `java-api-parts-staging`.

Parts **getParts** ()

A `Parts` object, that can used to interact with the parts that make up this vessel.

Comms **getComms** ()

A `Comms` object, that can used to interact with RemoteTech for this vessel.

Note: Requires RemoteTech to be installed.

float **getMass** ()

The total mass of the vessel, including resources, in kg.

float **getDryMass** ()

The total mass of the vessel, excluding resources, in kg.

float **getThrust** ()

The total thrust currently being produced by the vessel's engines, in Newtons. This is computed by summing `Engine.Thrust` for every engine in the vessel.

float **getAvailableThrust** ()

Gets the total available thrust that can be produced by the vessel's active engines, in Newtons. This is computed by summing `Engine.AvailableThrust` for every active engine in the vessel.

float **getMaxThrust** ()

The total maximum thrust that can be produced by the vessel's active engines, in Newtons. This is computed by summing `Engine.MaxThrust` for every active engine.

float **getMaxVacuumThrust** ()

The total maximum thrust that can be produced by the vessel's active engines when the vessel is in a vacuum, in Newtons. This is computed by summing `Engine.MaxVacuumThrust` for every active engine.

float **getSpecificImpulse** ()

The combined specific impulse of all active engines, in seconds. This is computed using the formula described here.

float **getVacuumSpecificImpulse** ()

The combined vacuum specific impulse of all active engines, in seconds. This is computed using the formula described here.

float **getKerbinSeaLevelSpecificImpulse** ()
The combined specific impulse of all active engines at sea level on Kerbin, in seconds. This is computed using the formula described here.

ReferenceFrame **getReferenceFrame** ()
The reference frame that is fixed relative to the vessel, and orientated with the vessel.

- The origin is at the center of mass of the vessel.
- The axes rotate with the vessel.
- The x-axis points out to the right of the vessel.
- The y-axis points in the forward direction of the vessel.
- The z-axis points out of the bottom off the vessel.

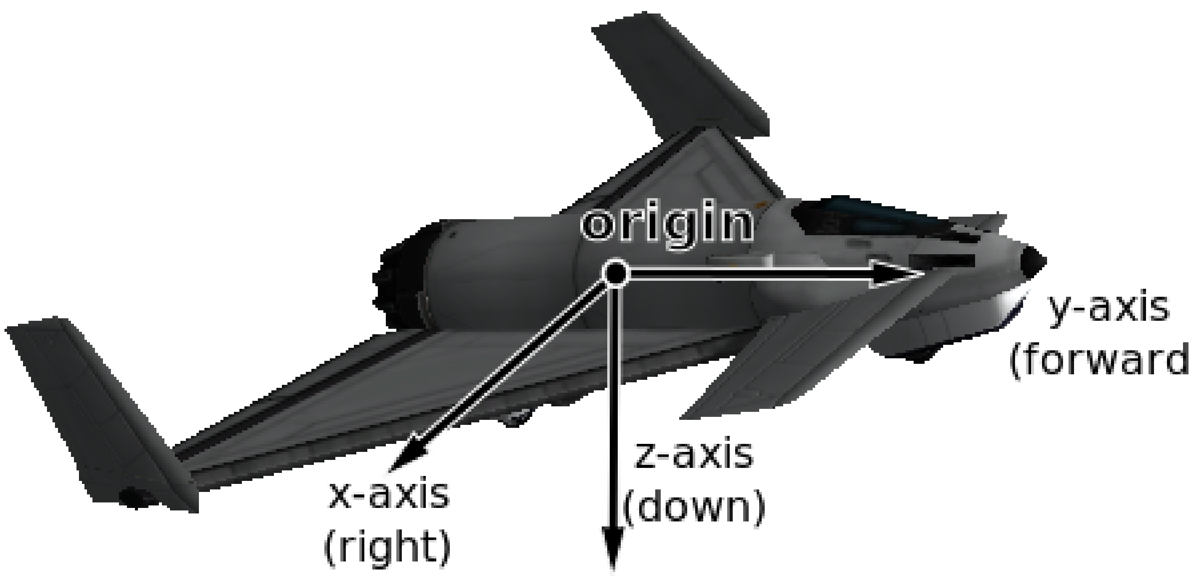


Fig. 5.1: Vessel reference frame origin and axes for the Aeris 3A aircraft

ReferenceFrame **getOrbitalReferenceFrame** ()
The reference frame that is fixed relative to the vessel, and orientated with the vessels orbital prograde/normal/radial directions.

- The origin is at the center of mass of the vessel.
- The axes rotate with the orbital prograde/normal/radial directions.
- The x-axis points in the orbital anti-radial direction.
- The y-axis points in the orbital prograde direction.
- The z-axis points in the orbital normal direction.

Note: Be careful not to confuse this with 'orbit' mode on the navball.

ReferenceFrame **getSurfaceReferenceFrame** ()
The reference frame that is fixed relative to the vessel, and orientated with the surface of the body being orbited.

- The origin is at the center of mass of the vessel.

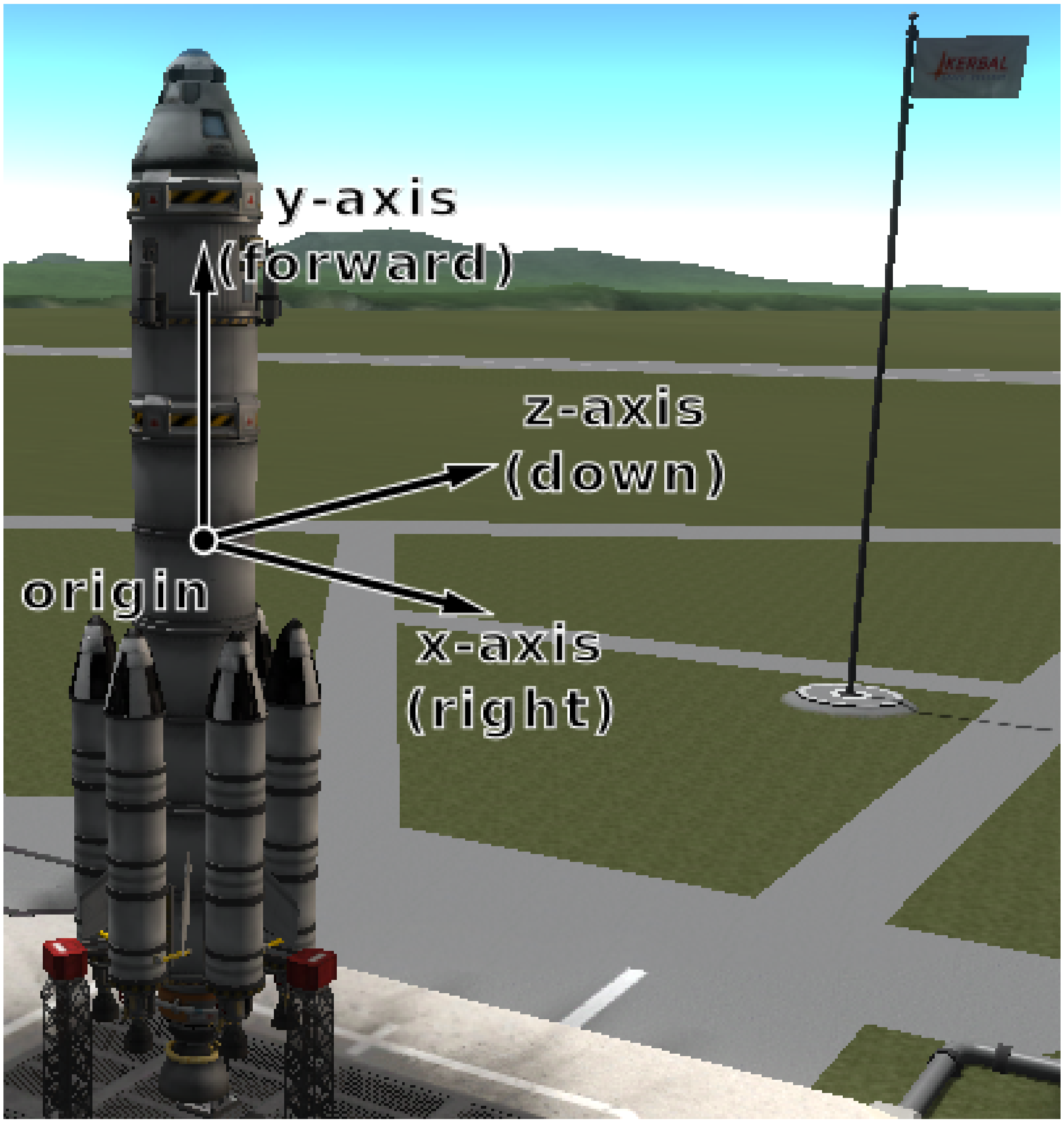


Fig. 5.2: Vessel reference frame origin and axes for the Kerbal-X rocket

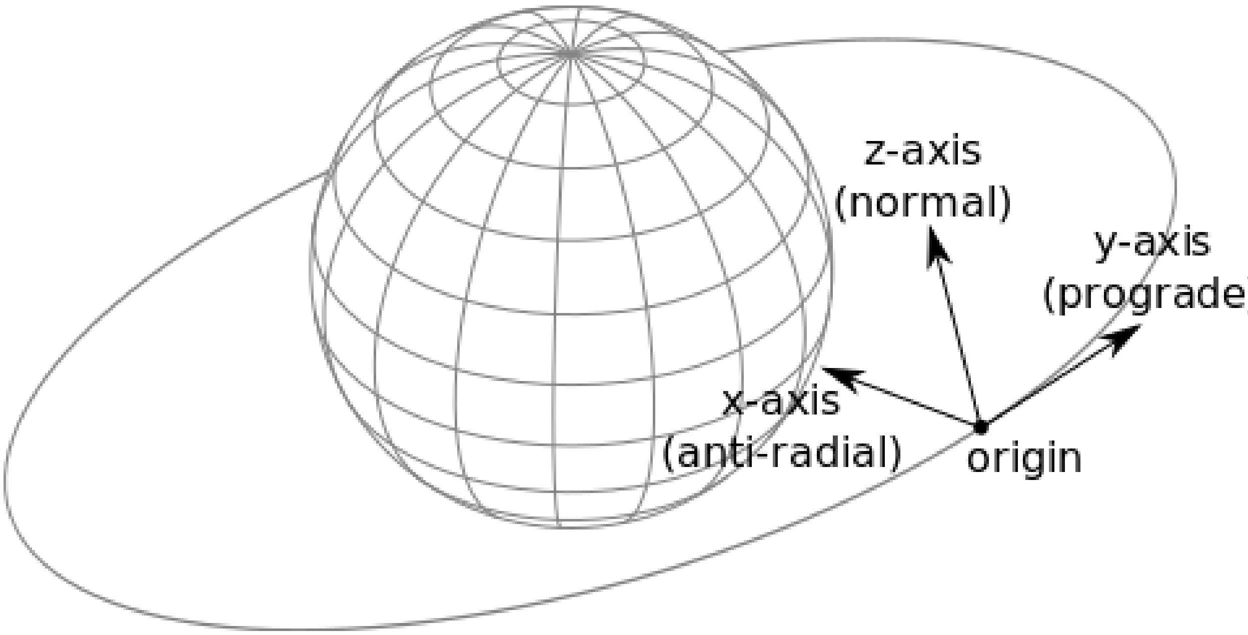


Fig. 5.3: Vessel orbital reference frame origin and axes

- The axes rotate with the north and up directions on the surface of the body.
- The x-axis points in the zenith direction (upwards, normal to the body being orbited, from the center of the body towards the center of mass of the vessel).
- The y-axis points northwards towards the astronomical horizon (north, and tangential to the surface of the body – the direction in which a compass would point when on the surface).
- The z-axis points eastwards towards the astronomical horizon (east, and tangential to the surface of the body – east on a compass when on the surface).

Note: Be careful not to confuse this with 'surface' mode on the navball.

ReferenceFrame **getSurfaceVelocityReferenceFrame**()

The reference frame that is fixed relative to the vessel, and orientated with the velocity vector of the vessel relative to the surface of the body being orbited.

- The origin is at the center of mass of the vessel.
- The axes rotate with the vessel's velocity vector.
- The y-axis points in the direction of the vessel's velocity vector, relative to the surface of the body being orbited.
- The z-axis is in the plane of the astronomical horizon.
- The x-axis is orthogonal to the other two axes.

org.javatuples.Triplet<Double, Double, Double> **Position**(*ReferenceFrame referenceFrame*)

Returns the position vector of the center of mass of the vessel in the given reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

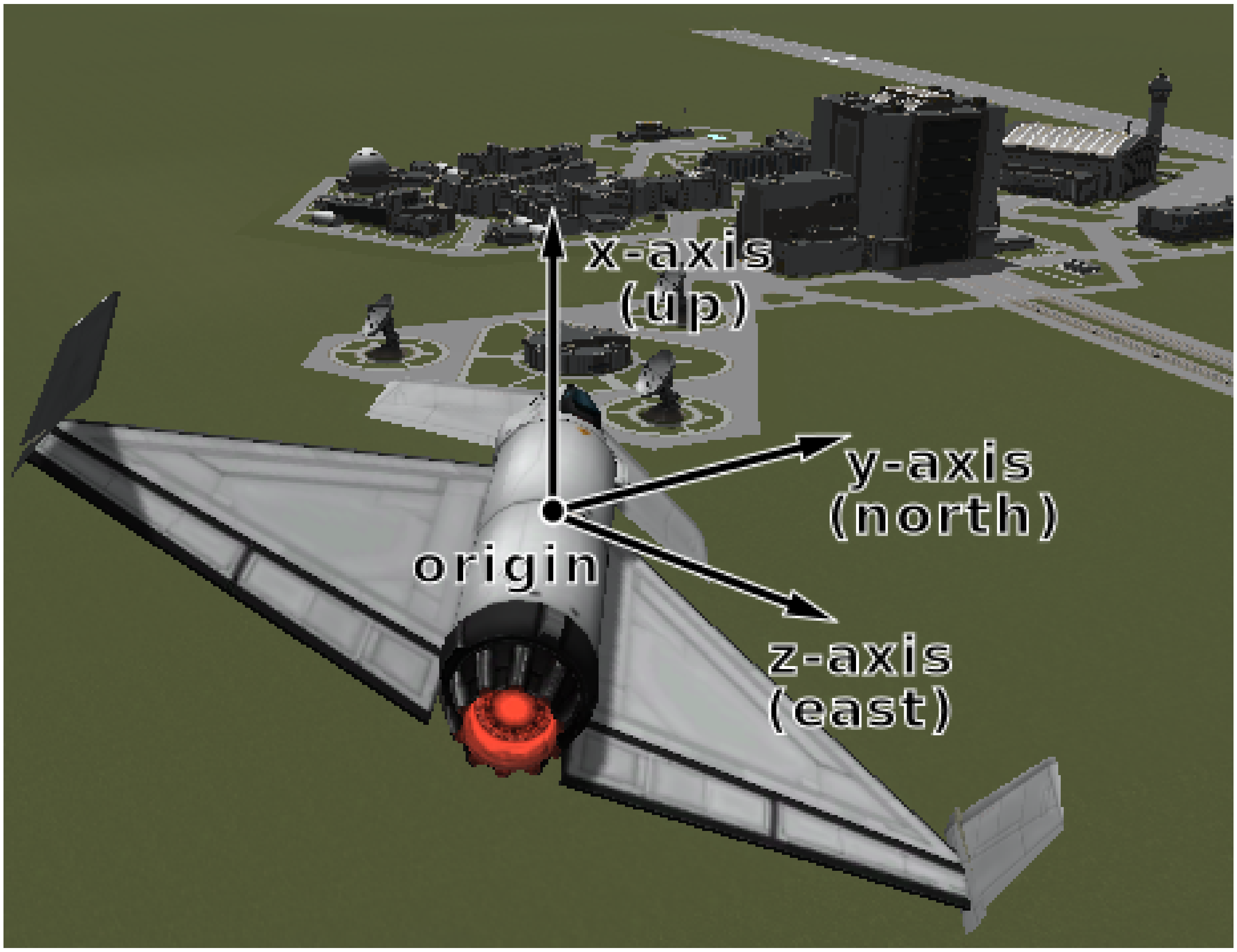


Fig. 5.4: Vessel surface reference frame origin and axes

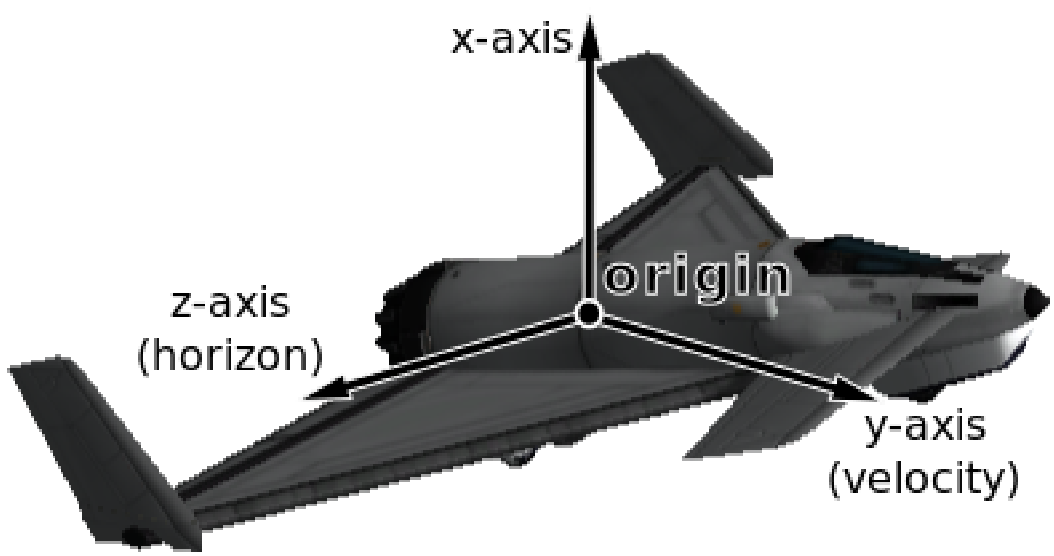


Fig. 5.5: Vessel surface velocity reference frame origin and axes

org.javatuples.Triplet<Double, Double, Double> **Velocity** (*ReferenceFrame referenceFrame*)
Returns the velocity vector of the center of mass of the vessel in the given reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

org.javatuples.Quartet<Double, Double, Double, Double> **Rotation** (*ReferenceFrame referenceFrame*)
Returns the rotation of the center of mass of the vessel in the given reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

org.javatuples.Triplet<Double, Double, Double> **Direction** (*ReferenceFrame referenceFrame*)
Returns the direction in which the vessel is pointing, as a unit vector, in the given reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

org.javatuples.Triplet<Double, Double, Double> **AngularVelocity** (*ReferenceFrame referenceFrame*)
Returns the angular velocity of the vessel in the given reference frame. The magnitude of the returned vector is the rotational speed in radians per second, and the direction of the vector indicates the axis of rotation (using the right hand rule).

Parameters

- **referenceFrame** (ReferenceFrame) –

public enum **VesselType**
See `Vessel.Type`.

public *VesselType* **Ship**
Ship.

public *VesselType* **Station**
Station.

public *VesselType* **Lander**
Lander.

public *VesselType* **Probe**
Probe.

public *VesselType* **Rover**
Rover.

public *VesselType* **Base**
Base.

public *VesselType* **Debris**
Debris.

public enum **VesselSituation**
See `Vessel.Situation`.

public *VesselSituation* **Docked**
Vessel is docked to another.

public *VesselSituation* **Escaping**
Escaping.

public *VesselSituation* **Flying**
Vessel is flying through an atmosphere.

public *VesselSituation* **Landed**
Vessel is landed on the surface of a body.

public *VesselSituation* **Orbiting**
Vessel is orbiting a body.

public *VesselSituation* **PreLaunch**
Vessel is awaiting launch.

public *VesselSituation* **Splashed**
Vessel has splashed down in an ocean.

public *VesselSituation* **SubOrbital**
Vessel is on a sub-orbital trajectory.

5.2.3 CelestialBody

public class **CelestialBody**
Represents a celestial body (such as a planet or moon).

String **getName**()
The name of the body.

java.util.List<*CelestialBody*> **getSatellites**()
A list of celestial bodies that are in orbit around this celestial body.

Orbit **getOrbit**()
The orbit of the body.

float **getMass**()
The mass of the body, in kilograms.

float **getGravitationalParameter**()
The standard gravitational parameter of the body in $m^3 s^{-2}$.

float **getSurfaceGravity**()
The acceleration due to gravity at sea level (mean altitude) on the body, in m/s^2.

float **getRotationalPeriod**()
The sidereal rotational period of the body, in seconds.

float **getRotationalSpeed**()
The rotational speed of the body, in radians per second.

float **getEquatorialRadius**()
The equatorial radius of the body, in meters.

double **SurfaceHeight**(double *latitude*, double *longitude*)
The height of the surface relative to mean sea level at the given position, in meters. When over water this is equal to 0.

Parameters

- **latitude** (*double*) – Latitude in degrees
- **longitude** (*double*) – Longitude in degrees

double **BedrockHeight**(double *latitude*, double *longitude*)
The height of the surface relative to mean sea level at the given position, in meters. When over water, this is the height of the sea-bed and is therefore a negative value.

Parameters

- **latitude** (*double*) – Latitude in degrees
- **longitude** (*double*) – Longitude in degrees

org.javatuples.Triplet<Double, Double, Double> **MSLPosition**(double *latitude*, double *longitude*, *ReferenceFrame referenceFrame*)

The position at mean sea level at the given latitude and longitude, in the given reference frame.

Parameters

- **latitude** (*double*) – Latitude in degrees
- **longitude** (*double*) – Longitude in degrees
- **referenceFrame** (ReferenceFrame) – Reference frame for the returned position vector

org.javatuples.Triplet<Double, Double, Double> **SurfacePosition**(double *latitude*, double *longitude*, *ReferenceFrame referenceFrame*)

The position of the surface at the given latitude and longitude, in the given reference frame. When over water, this is the position of the surface of the water.

Parameters

- **latitude** (*double*) – Latitude in degrees
- **longitude** (*double*) – Longitude in degrees
- **referenceFrame** (ReferenceFrame) – Reference frame for the returned position vector

org.javatuples.Triplet<Double, Double, Double> **BedrockPosition**(double *latitude*, double *longitude*, *ReferenceFrame referenceFrame*)

The position of the surface at the given latitude and longitude, in the given reference frame. When over water, this is the position at the bottom of the sea-bed.

Parameters

- **latitude** (*double*) – Latitude in degrees
- **longitude** (*double*) – Longitude in degrees
- **referenceFrame** (ReferenceFrame) – Reference frame for the returned position vector

float **getSphereOfInfluence**()

The radius of the sphere of influence of the body, in meters.

boolean **getHasAtmosphere**()

`true` if the body has an atmosphere.

float **getAtmosphereDepth**()

The depth of the atmosphere, in meters.

boolean **getHasAtmosphericOxygen**()

`true` if there is oxygen in the atmosphere, required for air-breathing engines.

ReferenceFrame **getReferenceFrame**()

The reference frame that is fixed relative to the celestial body.

- The origin is at the center of the body.
- The axes rotate with the body.

- The x-axis points from the center of the body towards the intersection of the prime meridian and equator (the position at 0° longitude, 0° latitude).
- The y-axis points from the center of the body towards the north pole.
- The z-axis points from the center of the body towards the equator at 90°E longitude.

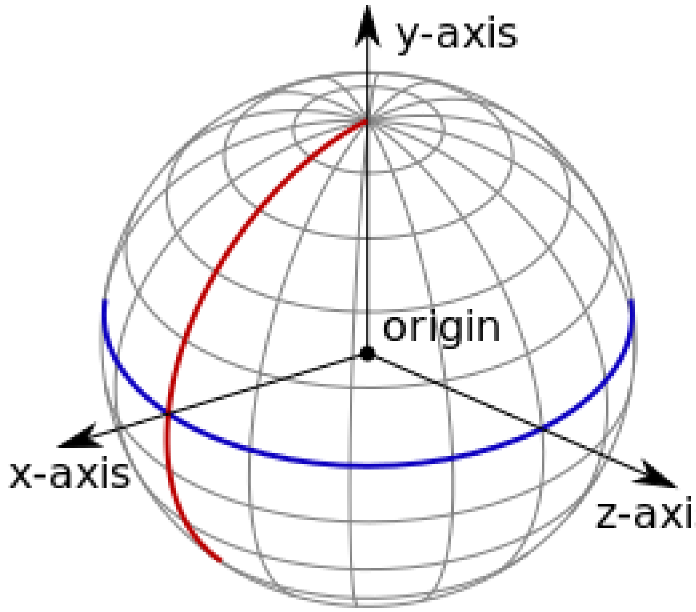


Fig. 5.6: Celestial body reference frame origin and axes. The equator is shown in blue, and the prime meridian in red.

ReferenceFrame **getNonRotatingReferenceFrame**()

The reference frame that is fixed relative to this celestial body, and orientated in a fixed direction (it does not rotate with the body).

- The origin is at the center of the body.
- The axes do not rotate.
- The x-axis points in an arbitrary direction through the equator.
- The y-axis points from the center of the body towards the north pole.
- The z-axis points in an arbitrary direction through the equator.

ReferenceFrame **getOrbitalReferenceFrame**()

Gets the reference frame that is fixed relative to this celestial body, but orientated with the body's orbital prograde/normal/radial directions.

- The origin is at the center of the body.
- The axes rotate with the orbital prograde/normal/radial directions.
- The x-axis points in the orbital anti-radial direction.
- The y-axis points in the orbital prograde direction.
- The z-axis points in the orbital normal direction.

org.javatuples.Triplet<Double, Double, Double> **Position**(*ReferenceFrame referenceFrame*)

Returns the position vector of the center of the body in the specified reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

org.javatuples.Triplet<Double, Double, Double> **Velocity** (*ReferenceFrame referenceFrame*)
Returns the velocity vector of the body in the specified reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

org.javatuples.Quartet<Double, Double, Double, Double> **Rotation** (*ReferenceFrame referenceFrame*)
Returns the rotation of the body in the specified reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

org.javatuples.Triplet<Double, Double, Double> **Direction** (*ReferenceFrame referenceFrame*)
Returns the direction in which the north pole of the celestial body is pointing, as a unit vector, in the specified reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

org.javatuples.Triplet<Double, Double, Double> **AngularVelocity** (*ReferenceFrame referenceFrame*)
Returns the angular velocity of the body in the specified reference frame. The magnitude of the vector is the rotational speed of the body, in radians per second, and the direction of the vector indicates the axis of rotation, using the right-hand rule.

Parameters

- **referenceFrame** (ReferenceFrame) –

5.2.4 Flight

public class **Flight**
Used to get flight telemetry for a vessel, by calling `Vessel.Flight`. All of the information returned by this class is given in the reference frame passed to that method.

Note: To get orbital information, such as the apoapsis or inclination, see *Orbit*.

float **getGForce** ()
The current G force acting on the vessel in m/s^2.

double **getMeanAltitude** ()
The altitude above sea level, in meters.

double **getSurfaceAltitude** ()
The altitude above the surface of the body or sea level, whichever is closer, in meters.

double **getBedrockAltitude** ()
The altitude above the surface of the body, in meters. When over water, this is the altitude above the sea floor.

double **getElevation** ()
The elevation of the terrain under the vessel, in meters. This is the height of the terrain above sea level, and is negative when the vessel is over the sea.

double **getLatitude**()
: The latitude of the vessel for the body being orbited, in degrees.

double **getLongitude**()
: The longitude of the vessel for the body being orbited, in degrees.

org.javatuples.Triplet<Double, Double, Double> **getVelocity**()
: The velocity vector of the vessel. The magnitude of the vector is the speed of the vessel in meters per second. The direction of the vector is the direction of the vessels motion.

double **getSpeed**()
: The speed of the vessel in meters per second.

double **getHorizontalSpeed**()
: The horizontal speed of the vessel in meters per second.

double **getVerticalSpeed**()
: The vertical speed of the vessel in meters per second.

org.javatuples.Triplet<Double, Double, Double> **getCenterOfMass**()
: The position of the center of mass of the vessel.

org.javatuples.Quartet<Double, Double, Double, Double> **getRotation**()
: The rotation of the vessel.

org.javatuples.Triplet<Double, Double, Double> **getDirection**()
: The direction vector that the vessel is pointing in.

float **getPitch**()
: The pitch angle of the vessel relative to the horizon, in degrees. A value between -90° and +90°.

float **getHeading**()
: The heading angle of the vessel relative to north, in degrees. A value between 0° and 360°.

float **getRoll**()
: The roll angle of the vessel relative to the horizon, in degrees. A value between -180° and +180°.

org.javatuples.Triplet<Double, Double, Double> **getPrograde**()
: The unit direction vector pointing in the prograde direction.

org.javatuples.Triplet<Double, Double, Double> **getRetrograde**()
: The unit direction vector pointing in the retrograde direction.

org.javatuples.Triplet<Double, Double, Double> **getNormal**()
: The unit direction vector pointing in the normal direction.

org.javatuples.Triplet<Double, Double, Double> **getAntiNormal**()
: The unit direction vector pointing in the anti-normal direction.

org.javatuples.Triplet<Double, Double, Double> **getRadial**()
: The unit direction vector pointing in the radial direction.

org.javatuples.Triplet<Double, Double, Double> **getAntiRadial**()
: The unit direction vector pointing in the anti-radial direction.

float **getAtmosphereDensity**()
: The current density of the atmosphere around the vessel, in kg/m^3.

float **getDynamicPressure**()
: The dynamic pressure acting on the vessel, in Pascals. This is a measure of the strength of the aerodynamic forces. It is equal to $\frac{1}{2}$.air density.velocity^2. It is commonly denoted as Q.

Note: Calculated using KSPs stock aerodynamic model, or Ferram Aerospace Research if it is installed.

float **getStaticPressure**()

The static atmospheric pressure acting on the vessel, in Pascals.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

org.javatuples.Triplet<Double, Double, Double> **getAerodynamicForce**()

The total aerodynamic forces acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

org.javatuples.Triplet<Double, Double, Double> **getLift**()

The aerodynamic lift currently acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

org.javatuples.Triplet<Double, Double, Double> **getDrag**()

The aerodynamic drag currently acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

float **getSpeedOfSound**()

The speed of sound, in the atmosphere around the vessel, in m/s.

Note: Not available when Ferram Aerospace Research is installed.

float **getMach**()

The speed of the vessel, in multiples of the speed of sound.

Note: Not available when Ferram Aerospace Research is installed.

float **getEquivalentAirSpeed**()

The equivalent air speed of the vessel, in m/s.

Note: Not available when Ferram Aerospace Research is installed.

float **getTerminalVelocity** ()
An estimate of the current terminal velocity of the vessel, in m/s. This is the speed at which the drag forces cancel out the force of gravity.

Note: Calculated using KSPs stock aerodynamic model, or Ferram Aerospace Research if it is installed.

float **getAngleOfAttack** ()
Gets the pitch angle between the orientation of the vessel and its velocity vector, in degrees.

float **getSideslipAngle** ()
Gets the yaw angle between the orientation of the vessel and its velocity vector, in degrees.

float **getTotalAirTemperature** ()
The total air temperature of the atmosphere around the vessel, in Kelvin. This temperature includes the `Flight.StaticAirTemperature` and the vessel's kinetic energy.

float **getStaticAirTemperature** ()
The static (ambient) temperature of the atmosphere around the vessel, in Kelvin.

float **getStallFraction** ()
Gets the current amount of stall, between 0 and 1. A value greater than 0.005 indicates a minor stall and a value greater than 0.5 indicates a large-scale stall.

Note: Requires Ferram Aerospace Research.

float **getDragCoefficient** ()
Gets the coefficient of drag. This is the amount of drag produced by the vessel. It depends on air speed, air density and wing area.

Note: Requires Ferram Aerospace Research.

float **getLiftCoefficient** ()
Gets the coefficient of lift. This is the amount of lift produced by the vessel, and depends on air speed, air density and wing area.

Note: Requires Ferram Aerospace Research.

float **getBallisticCoefficient** ()
Gets the ballistic coefficient.

Note: Requires Ferram Aerospace Research.

float **getThrustSpecificFuelConsumption** ()
Gets the thrust specific fuel consumption for the jet engines on the vessel. This is a measure of the efficiency of the engines, with a lower value indicating a more efficient vessel. This value is the number of Newtons of fuel that are burned, per hour, to product one newton of thrust.

Note: Requires Ferram Aerospace Research.

5.2.5 Orbit

public class **Orbit**

Describes an orbit. For example, the orbit of a vessel, obtained by calling `Vessel.Orbit`, or a celestial body, obtained by calling `CelestialBody.Orbit`.

CelestialBody **getBody**()

The celestial body (e.g. planet or moon) around which the object is orbiting.

double **getApoapsis**()

Gets the apoapsis of the orbit, in meters, from the center of mass of the body being orbited.

Note: For the apoapsis altitude reported on the in-game map view, use `Orbit.ApoapsisAltitude`.

double **getPeriapsis**()

The periapsis of the orbit, in meters, from the center of mass of the body being orbited.

Note: For the periapsis altitude reported on the in-game map view, use `Orbit.PeriapsisAltitude`.

double **getApoapsisAltitude**()

The apoapsis of the orbit, in meters, above the sea level of the body being orbited.

Note: This is equal to `Orbit.Apoapsis` minus the equatorial radius of the body.

double **getPeriapsisAltitude**()

The periapsis of the orbit, in meters, above the sea level of the body being orbited.

Note: This is equal to `Orbit.Periapsis` minus the equatorial radius of the body.

double **getSemiMajorAxis**()

The semi-major axis of the orbit, in meters.

double **getSemiMinorAxis**()

The semi-minor axis of the orbit, in meters.

double **getRadius**()

The current radius of the orbit, in meters. This is the distance between the center of mass of the object in orbit, and the center of mass of the body around which it is orbiting.

Note: This value will change over time if the orbit is elliptical.

double **getSpeed**()

The current orbital speed of the object in meters per second.

Note: This value will change over time if the orbit is elliptical.

double **getPeriod**()

The orbital period, in seconds.

double **getTimeToApoapsis**()
The time until the object reaches apoapsis, in seconds.

double **getTimeToPeriapsis**()
The time until the object reaches periapsis, in seconds.

double **getEccentricity**()
The eccentricity of the orbit.

double **getInclination**()
The inclination of the orbit, in radians.

double **getLongitudeOfAscendingNode**()
The longitude of the ascending node, in radians.

double **getArgumentOfPeriapsis**()
The argument of periapsis, in radians.

double **getMeanAnomalyAtEpoch**()
The mean anomaly at epoch.

double **getEpoch**()
The time since the epoch (the point at which the mean anomaly at epoch was measured, in seconds.

double **getMeanAnomaly**()
The mean anomaly.

double **getEccentricAnomaly**()
The eccentric anomaly.

org.javatuples.Triplet<Double, Double, Double> **ReferencePlaneNormal**(*ReferenceFrame referenceFrame*)
The unit direction vector that is normal to the orbits reference plane, in the given reference frame. The reference plane is the plane from which the orbits inclination is measured.

Parameters

- **referenceFrame** (ReferenceFrame) –

org.javatuples.Triplet<Double, Double, Double> **ReferencePlaneDirection**(*ReferenceFrame referenceFrame*)
The unit direction vector from which the orbits longitude of ascending node is measured, in the given reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

double **getTimeToSOIChange**()
The time until the object changes sphere of influence, in seconds. Returns `NaN` if the object is not going to change sphere of influence.

Orbit **getNextOrbit**()
If the object is going to change sphere of influence in the future, returns the new orbit after the change. Otherwise returns `null`.

5.2.6 Control

public class **Control**
Used to manipulate the controls of a vessel. This includes adjusting the throttle, enabling/disabling systems such as SAS and RCS, or altering the direction in which the vessel is pointing.

Note: Control inputs (such as pitch, yaw and roll) are zeroed when all clients that have set one or more of these inputs are no longer connected.

boolean **getSAS**()

void **setSAS**(boolean *value*)
The state of SAS.

Note: Equivalent to `AutoPilot.SAS`

SASMode **getSASMode**()

void **setSASMode**(*SASMode value*)
The current `SASMode`. These modes are equivalent to the mode buttons to the left of the navball that appear when SAS is enabled.

Note: Equivalent to `AutoPilot.SASMode`

SpeedMode **getSpeedMode**()

void **setSpeedMode**(*SpeedMode value*)
The current `SpeedMode` of the navball. This is the mode displayed next to the speed at the top of the navball.

boolean **getRCS**()

void **setRCS**(boolean *value*)
The state of RCS.

boolean **getGear**()

void **setGear**(boolean *value*)
The state of the landing gear/legs.

boolean **getLights**()

void **setLights**(boolean *value*)
The state of the lights.

boolean **getBrakes**()

void **setBrakes**(boolean *value*)
The state of the wheel brakes.

boolean **getAbort**()

void **setAbort**(boolean *value*)
The state of the abort action group.

float **getThrottle**()

void **setThrottle**(float *value*)
The state of the throttle. A value between 0 and 1.

float **getPitch**()

void **setPitch**(float *value*)
The state of the pitch control. A value between -1 and 1. Equivalent to the w and s keys.

float **getYaw** ()

void **setYaw** (float *value*)
The state of the yaw control. A value between -1 and 1. Equivalent to the a and d keys.

float **getRoll** ()

void **setRoll** (float *value*)
The state of the roll control. A value between -1 and 1. Equivalent to the q and e keys.

float **getForward** ()

void **setForward** (float *value*)
The state of the forward translational control. A value between -1 and 1. Equivalent to the h and n keys.

float **getUp** ()

void **setUp** (float *value*)
The state of the up translational control. A value between -1 and 1. Equivalent to the i and k keys.

float **getRight** ()

void **setRight** (float *value*)
The state of the right translational control. A value between -1 and 1. Equivalent to the j and l keys.

float **getWheelThrottle** ()

void **setWheelThrottle** (float *value*)
The state of the wheel throttle. A value between -1 and 1. A value of 1 rotates the wheels forwards, a value of -1 rotates the wheels backwards.

float **getWheelSteering** ()

void **setWheelSteering** (float *value*)
The state of the wheel steering. A value between -1 and 1. A value of 1 steers to the left, and a value of -1 steers to the right.

int **getCurrentStage** ()
The current stage of the vessel. Corresponds to the stage number in the in-game UI.

java.util.List<*Vessel*> **ActivateNextStage** ()
Activates the next stage. Equivalent to pressing the space bar in-game.

Returns A list of vessel objects that are jettisoned from the active vessel.

boolean **GetActionGroup** (int *group*)
Returns `true` if the given action group is enabled.

Parameters

- **group** (*int*) – A number between 0 and 9 inclusive.

void **SetActionGroup** (int *group*, boolean *state*)
Sets the state of the given action group (a value between 0 and 9 inclusive).

Parameters

- **group** (*int*) – A number between 0 and 9 inclusive.
- **state** (*boolean*) –

void **ToggleActionGroup** (int *group*)
Toggles the state of the given action group.

Parameters

- **group** (*int*) – A number between 0 and 9 inclusive.

Node **AddNode** (double *UT*, float *prograde*, float *normal*, float *radial*)
Creates a maneuver node at the given universal time, and returns a `Node` object that can be used to modify it. Optionally sets the magnitude of the delta-v for the maneuver node in the prograde, normal and radial directions.

Parameters

- **UT** (*double*) – Universal time of the maneuver node.
- **prograde** (*float*) – Delta-v in the prograde direction.
- **normal** (*float*) – Delta-v in the normal direction.
- **radial** (*float*) – Delta-v in the radial direction.

java.util.List<*Node*> **getNodes** ()
Returns a list of all existing maneuver nodes, ordered by time from first to last.

void **RemoveNodes** ()
Remove all maneuver nodes.

public enum **SASMode**
The behavior of the SAS auto-pilot. See `AutoPilot.SASMode`.

public *SASMode* **StabilityAssist**
Stability assist mode. Dampen out any rotation.

public *SASMode* **Maneuver**
Point in the burn direction of the next maneuver node.

public *SASMode* **Prograde**
Point in the prograde direction.

public *SASMode* **Retrograde**
Point in the retrograde direction.

public *SASMode* **Normal**
Point in the orbit normal direction.

public *SASMode* **AntiNormal**
Point in the orbit anti-normal direction.

public *SASMode* **Radial**
Point in the orbit radial direction.

public *SASMode* **AntiRadial**
Point in the orbit anti-radial direction.

public *SASMode* **Target**
Point in the direction of the current target.

public *SASMode* **AntiTarget**
Point away from the current target.

public enum **SpeedMode**
See `Control.SpeedMode`.

public *SpeedMode* **Orbit**
Speed is relative to the vessel's orbit.

public *SpeedMode* **Surface**
Speed is relative to the surface of the body being orbited.

public *SpeedMode* **Target**
Speed is relative to the current target.

5.2.7 Parts

The following classes allow interaction with a vessels individual parts.

Parts

public class **Parts**

Instances of this class are used to interact with the parts of a vessel. An instance can be obtained by calling `Vessel.Parts`.

java.util.List<*Part*> **getAll** ()

A list of all of the vessels parts.

Part **getRoot** ()

The vessels root part.

Note: See the discussion on `java-api-parts-trees-of-parts`.

Part **getControlling** ()

void **setControlling** (*Part* *value*)

The part from which the vessel is controlled.

java.util.List<*Part*> **WithName** (String *name*)

A list of parts whose `Part.Name` is *name*.

Parameters

- **name** (*String*) –

java.util.List<*Part*> **WithTitle** (String *title*)

A list of all parts whose `Part.Title` is *title*.

Parameters

- **title** (*String*) –

java.util.List<*Part*> **WithModule** (String *moduleName*)

A list of all parts that contain a *Module* whose `Module.Name` is *moduleName*.

Parameters

- **moduleName** (*String*) –

java.util.List<*Part*> **InStage** (int *stage*)

A list of all parts that are activated in the given *stage*.

Parameters

- **stage** (*int*) –

Note: See the discussion on `java-api-parts-staging`.

java.util.List<*Part*> **InDecoupleStage** (int *stage*)

A list of all parts that are decoupled in the given *stage*.

Parameters

- **stage** (*int*) –

Note: See the discussion on `java-api-parts-staging`.

java.util.List<*Module*> **ModulesWithName** (String *moduleName*)

A list of modules (combined across all parts in the vessel) whose `Module.Name` is *moduleName*.

Parameters

- **moduleName** (*String*) –

java.util.List<*Decoupler*> **getDecouplers** ()

A list of all decouplers in the vessel.

java.util.List<*DockingPort*> **getDockingPorts** ()

A list of all docking ports in the vessel.

DockingPort **DockingPortWithName** (String *name*)

The first docking port in the vessel with the given port name, as returned by `DockingPort.Name`. Returns `null` if there are no such docking ports.

Parameters

- **name** (*String*) –

java.util.List<*Engine*> **getEngines** ()

A list of all engines in the vessel.

java.util.List<*LandingGear*> **getLandingGear** ()

A list of all landing gear attached to the vessel.

java.util.List<*LandingLeg*> **getLandingLegs** ()

A list of all landing legs attached to the vessel.

java.util.List<*LaunchClamp*> **getLaunchClamps** ()
A list of all launch clamps attached to the vessel.

java.util.List<*Light*> **getLights** ()
A list of all lights in the vessel.

java.util.List<*Parachute*> **getParachutes** ()
A list of all parachutes in the vessel.

java.util.List<*Radiator*> **getRadiators** ()
A list of all radiators in the vessel.

java.util.List<*ResourceConverter*> **getResourceConverters** ()
A list of all resource converters in the vessel.

java.util.List<*ResourceHarvester*> **getResourceHarvesters** ()
A list of all resource harvesters in the vessel.

java.util.List<*ReactionWheel*> **getReactionWheels** ()
A list of all reaction wheels in the vessel.

java.util.List<*Sensor*> **getSensors** ()
A list of all sensors in the vessel.

java.util.List<*SolarPanel*> **getSolarPanels** ()
A list of all solar panels in the vessel.

Part

public class **Part**
Instances of this class represents a part. A vessel is made of multiple parts. Instances can be obtained by various methods in `Parts`.

String **getName** ()
Internal name of the part, as used in part cfg files. For example “Mark1-2Pod”.

String **getTitle** ()
Title of the part, as shown when the part is right clicked in-game. For example “Mk1-2 Command Pod”.

double **getCost** ()
The cost of the part, in units of funds.

Vessel **getVessel** ()
The vessel that contains this part.

Part **getParent** ()
The parts parent. Returns `null` if the part does not have a parent. This, in combination with `Part.Children`, can be used to traverse the vessels parts tree.

Note: See the discussion on `java-api-parts-trees-of-parts`.

java.util.List<*Part*> **getChildren** ()
The parts children. Returns an empty list if the part has no children. This, in combination with `Part.Parent`, can be used to traverse the vessels parts tree.

Note: See the discussion on `java-api-parts-trees-of-parts`.

boolean **getAxiallyAttached**()

Whether the part is axially attached to its parent, i.e. on the top or bottom of its parent. If the part has no parent, returns `false`.

Note: See the discussion on `java-api-parts-attachment-modes`.

boolean **getRadiallyAttached**()

Whether the part is radially attached to its parent, i.e. on the side of its parent. If the part has no parent, returns `false`.

Note: See the discussion on `java-api-parts-attachment-modes`.

int **getStage**()

The stage in which this part will be activated. Returns -1 if the part is not activated by staging.

Note: See the discussion on `java-api-parts-staging`.

int **getDecoupleStage**()

The stage in which this part will be decoupled. Returns -1 if the part is never decoupled from the vessel.

Note: See the discussion on `java-api-parts-staging`.

boolean **getMassless**()

Whether the part is massless.

double **getMass**()

The current mass of the part, including resources it contains, in kilograms. Returns zero if the part is massless.

double **getDryMass**()

The mass of the part, not including any resources it contains, in kilograms. Returns zero if the part is massless.

double **getImpactTolerance**()

The impact tolerance of the part, in meters per second.

double **getTemperature**()

Temperature of the part, in Kelvin.

double **getSkinTemperature**()

Temperature of the skin of the part, in Kelvin.

double **getMaxTemperature**()

Maximum temperature that the part can survive, in Kelvin.

double **getMaxSkinTemperature**()

Maximum temperature that the skin of the part can survive, in Kelvin.

double **getExternalTemperature**()

Temperature of the atmosphere/vacuum surrounding the part, in Kelvin. This does not include heating from direct sunlight.

double **getThermalMass**()

How much it takes to heat up the part.

double **getThermalSkinMass** ()
How much it takes to heat up the part's skin.

double **getThermalResourceMass** ()
How much it takes to heat up resources in the part.

double **getThermalConductionFlux** ()
The speed that heat is conducting into or out of the part through contact with other parts. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **getThermalConvectionFlux** ()
The speed that heat is convecting into or out of the part from the surrounding atmosphere. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **getThermalRadiationFlux** ()
The speed that heat is radiating into or out of the part from the surrounding vacuum. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **getThermalInternalFlux** ()
The speed that heat is generated by the part. For example, engines generate heat by burning fuel. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

double **getThermalSkinToInternalFlux** ()
The speed that heat is conducting between the part's skin and its internals.

Resources **getResources** ()
A `Resources` object for the part.

boolean **getCrossfeed** ()
Whether this part is crossfeed capable.

boolean **getIsFuelLine** ()
Whether this part is a fuel line.

java.util.List<*Part*> **getFuelLinesFrom** ()
The parts that are connected to this part via fuel lines, where the direction of the fuel line is into this part.

Note: See the discussion on `java-api-parts-fuel-lines`.

java.util.List<*Part*> **getFuelLinesTo** ()
The parts that are connected to this part via fuel lines, where the direction of the fuel line is out of this part.

Note: See the discussion on `java-api-parts-fuel-lines`.

java.util.List<*Module*> **getModules** ()
The modules for this part.

Decoupler **getDecoupler** ()
A `Decoupler` if the part is a decoupler, otherwise `null`.

DockingPort **getDockingPort** ()
A `DockingPort` if the part is a docking port, otherwise `null`.

Engine **getEngine** ()
An `Engine` if the part is an engine, otherwise `null`.

LandingGear **getLandingGear** ()
A `LandingGear` if the part is a landing gear , otherwise `null`.

LandingLeg **getLandingLeg** ()
A *LandingLeg* if the part is a landing leg, otherwise `null`.

LaunchClamp **getLaunchClamp** ()
A *LaunchClamp* if the part is a launch clamp, otherwise `null`.

Light **getLight** ()
A *Light* if the part is a light, otherwise `null`.

Parachute **getParachute** ()
A *Parachute* if the part is a parachute, otherwise `null`.

Radiator **getRadiator** ()
A *Radiator* if the part is a radiator, otherwise `null`.

ReactionWheel **getReactionWheel** ()
A *ReactionWheel* if the part is a reaction wheel, otherwise `null`.

ResourceConverter **getResourceConverter** ()
A *ResourceConverter* if the part is a resource converter, otherwise `null`.

ResourceHarvester **getResourceHarvester** ()
A *ResourceHarvester* if the part is a resource harvester, otherwise `null`.

Sensor **getSensor** ()
A *Sensor* if the part is a sensor, otherwise `null`.

SolarPanel **getSolarPanel** ()
A *SolarPanel* if the part is a solar panel, otherwise `null`.

org.javatuples.Triplet<Double, Double, Double> **Position** (*ReferenceFrame referenceFrame*)
The position of the part in the given reference frame.

Parameters

- **referenceFrame** (`ReferenceFrame`) –

org.javatuples.Triplet<Double, Double, Double> **Direction** (*ReferenceFrame referenceFrame*)
The direction of the part in the given reference frame.

Parameters

- **referenceFrame** (`ReferenceFrame`) –

org.javatuples.Triplet<Double, Double, Double> **Velocity** (*ReferenceFrame referenceFrame*)
The velocity of the part in the given reference frame.

Parameters

- **referenceFrame** (`ReferenceFrame`) –

org.javatuples.Quartet<Double, Double, Double, Double> **Rotation** (*ReferenceFrame referenceFrame*)
The rotation of the part in the given reference frame.

Parameters

- **referenceFrame** (`ReferenceFrame`) –

ReferenceFrame **getReferenceFrame** ()
The reference frame that is fixed relative to this part.

- The origin is at the position of the part.
- The axes rotate with the part.
- The x, y and z axis directions depend on the design of the part.

Note: For docking port parts, this reference frame is not necessarily equivalent to the reference frame for the docking port, returned by `DockingPort.ReferenceFrame`.

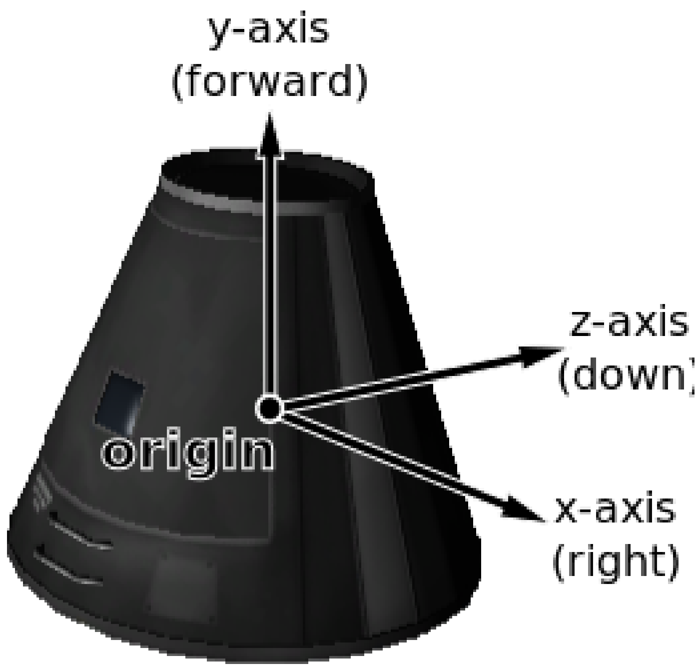


Fig. 5.7: Mk1 Command Pod reference frame origin and axes

Module

public class **Module**

In KSP, each part has zero or more PartModules associated with it. Each one contains some of the functionality of the part. For example, an engine has a "ModuleEngines" PartModule that contains all the functionality of an engine. This class allows you to interact with KSPs PartModules, and any PartModules that have been added by other mods.

String **getName** ()

Name of the PartModule. For example, "ModuleEngines".

Part **getPart** ()

The part that contains this module.

java.util.Map<String, String> **getFields** ()

The modules field names and their associated values, as a dictionary. These are the values visible in the right-click menu of the part.

boolean **HasField** (String *name*)

Returns `true` if the module has a field with the given name.

Parameters

- **name** (*String*) – Name of the field.

String **GetField** (String *name*)

Returns the value of a field.

Parameters

- **name** (*String*) – Name of the field.

java.util.List<String> **getEvents**()

A list of the names of all of the modules events. Events are the clickable buttons visible in the right-click menu of the part.

boolean **HasEvent**(String *name*)

`true` if the module has an event with the given name.

Parameters

- **name** (*String*) –

void **TriggerEvent**(String *name*)

Trigger the named event. Equivalent to clicking the button in the right-click menu of the part.

Parameters

- **name** (*String*) –

java.util.List<String> **getActions**()

A list of all the names of the modules actions. These are the parts actions that can be assigned to action groups in the in-game editor.

boolean **HasAction**(String *name*)

`true` if the part has an action with the given name.

Parameters

- **name** (*String*) –

void **SetAction**(String *name*, boolean *value*)

Set the value of an action with the given name.

Parameters

- **name** (*String*) –
- **value** (*boolean*) –

Specific Types of Part

The following classes provide functionality for specific types of part.

- *Decoupler*
- *Docking Port*
- *Engine*
- *Landing Gear*
- *Landing Leg*
- *Launch Clamp*
- *Light*
- *Parachute*
- *Radiator*
- *Resource Converter*
- *Resource Harvester*
- *Reaction Wheel*
- *Sensor*
- *Solar Panel*

Decoupler

public class **Decoupler**

Obtained by calling `Part.Decoupler`

Part **getPart**()

The part object for this decoupler.

void **Decouple**()

Fires the decoupler. Has no effect if the decoupler has already fired.

boolean **getDecoupled**()

Whether the decoupler has fired.

float **getImpulse**()

The impulse that the decoupler imparts when it is fired, in Newton seconds.

Docking Port

public class **DockingPort**

Obtained by calling `Part.DockingPort`

Part **getPart**()

The part object for this docking port.

String **getName**()

void **setName**(String *value*)

The port name of the docking port. This is the name of the port that can be set in the right click menu, when the Docking Port Alignment Indicator mod is installed. If this mod is not installed, returns the title of the part (`Part.Title`).

DockingPortState **getState**()

The current state of the docking port.

Part **getDockedPart**()

The part that this docking port is docked to. Returns `null` if this docking port is not docked to anything.

Vessel **Undock**()

Undocks the docking port and returns the vessel that was undocked from. After undocking, the active vessel may change (`ActiveVessel`). This method can be called for either docking port in a docked pair - both calls will have the same effect. Returns `null` if the docking port is not docked to anything.

float **getReengageDistance**()

The distance a docking port must move away when it undocks before it becomes ready to dock with another port, in meters.

boolean **getHasShield**()

Whether the docking port has a shield.

boolean **getShielded**()

void **setShielded**(boolean *value*)

The state of the docking ports shield, if it has one. Returns `true` if the docking port has a shield, and the shield is closed. Otherwise returns `false`. When set to `true`, the shield is closed, and when set to `false` the shield is opened. If the docking port does not have a shield, setting this attribute has no effect.

org.javatuples.Triplet<Double, Double, Double> **Position**(*ReferenceFrame referenceFrame*)

The position of the docking port in the given reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

org.javatuples.Triplet<Double, Double, Double> **Direction** (*ReferenceFrame referenceFrame*)

The direction that docking port points in, in the given reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

org.javatuples.Quartet<Double, Double, Double, Double> **Rotation** (*ReferenceFrame referenceFrame*)

The rotation of the docking port, in the given reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

ReferenceFrame **getReferenceFrame** ()

The reference frame that is fixed relative to this docking port, and oriented with the port.

- The origin is at the position of the docking port.
- The axes rotate with the docking port.
- The x-axis points out to the right side of the docking port.
- The y-axis points in the direction the docking port is facing.
- The z-axis points out of the bottom off the docking port.

Note: This reference frame is not necessarily equivalent to the reference frame for the part, returned by `Part.ReferenceFrame`.

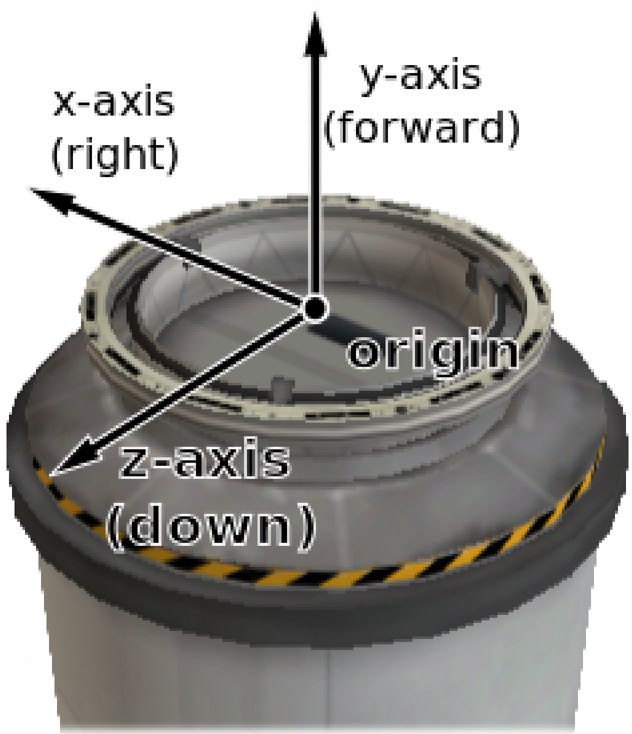


Fig. 5.8: Docking port reference frame origin and axes

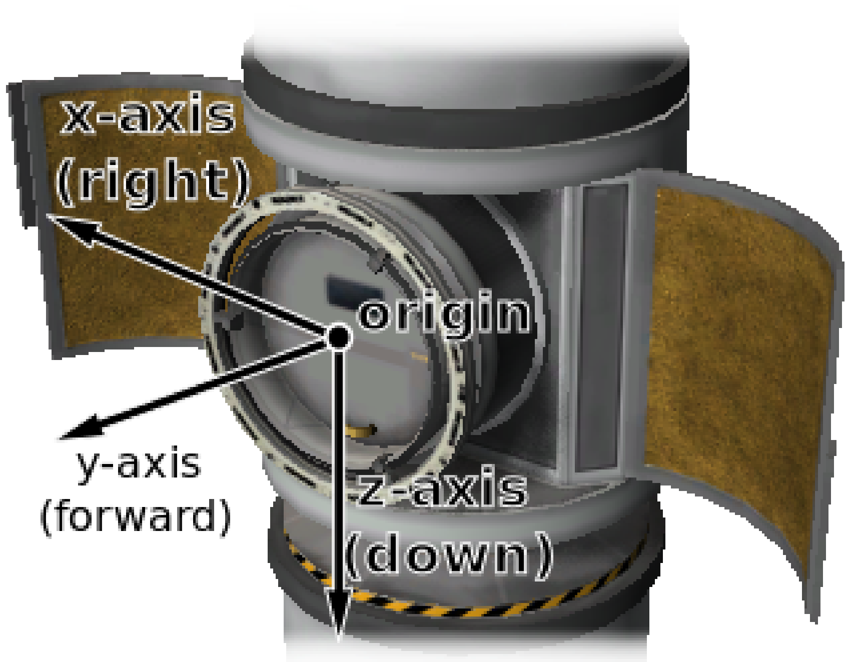


Fig. 5.9: Inline docking port reference frame origin and axes

public enum **DockingPortState**

See `DockingPort.State`.

public *DockingPortState* **Ready**

The docking port is ready to dock to another docking port.

public *DockingPortState* **Docked**

The docking port is docked to another docking port, or docked to another part (from the VAB/SPH).

public *DockingPortState* **Docking**

The docking port is very close to another docking port, but has not docked. It is using magnetic force to acquire a solid dock.

public *DockingPortState* **Undocking**

The docking port has just been undocked from another docking port, and is disabled until it moves away by a sufficient distance (`DockingPort.ReengageDistance`).

public *DockingPortState* **Shielded**

The docking port has a shield, and the shield is closed.

public *DockingPortState* **Moving**

The docking ports shield is currently opening/closing.

Engine

public class **Engine**

Obtained by calling `Part.Engine`.

Part **getPart**()

The part object for this engine.

boolean **getActive**()

void **setActive**(boolean *value*)
: Whether the engine is active. Setting this attribute may have no effect, depending on `Engine.CanShutdown` and `Engine.CanRestart`.

float **getThrust**()
: The current amount of thrust being produced by the engine, in Newtons. Returns zero if the engine is not active or if it has no fuel.

float **getAvailableThrust**()
: The maximum available amount of thrust that can be produced by the engine, in Newtons. This takes `Engine.ThrustLimit` into account, and is the amount of thrust produced by the engine when activated and the main throttle is set to 100%. Returns zero if the engine does not have any fuel.

float **getMaxThrust**()
: Gets the maximum amount of thrust that can be produced by the engine, in Newtons. This is the amount of thrust produced by the engine when activated, `Engine.ThrustLimit` is set to 100% and the main vessel's throttle is set to 100%.

float **getMaxVacuumThrust**()
: The maximum amount of thrust that can be produced by the engine in a vacuum, in Newtons. This is the amount of thrust produced by the engine when activated, `Engine.ThrustLimit` is set to 100%, the main vessel's throttle is set to 100% and the engine is in a vacuum.

float **getThrustLimit**()

void **setThrustLimit**(float *value*)
: The thrust limiter of the engine. A value between 0 and 1. Setting this attribute may have no effect, for example the thrust limit for a solid rocket booster cannot be changed in flight.

float **getSpecificImpulse**()
: The current specific impulse of the engine, in seconds. Returns zero if the engine is not active.

float **getVacuumSpecificImpulse**()
: The vacuum specific impulse of the engine, in seconds.

float **getKerbinSeaLevelSpecificImpulse**()
: The specific impulse of the engine at sea level on Kerbin, in seconds.

java.util.List<String> **getPropellants**()
: The names of resources that the engine consumes.

java.util.Map<String, Single> **getPropellantRatios**()
: The ratios of resources that the engine consumes. A dictionary mapping resource names to the ratios at which they are consumed by the engine.

boolean **getHasFuel**()
: Whether the engine has run out of fuel (or flamed out).

float **getThrottle**()
: The current throttle setting for the engine. A value between 0 and 1. This is not necessarily the same as the vessel's main throttle setting, as some engines take time to adjust their throttle (such as jet engines).

boolean **getThrottleLocked**()
: Whether the `Control.Throttle` affects the engine. For example, this is `true` for liquid fueled rockets, and `false` for solid rocket boosters.

boolean **getCanRestart**()
: Whether the engine can be restarted once shutdown. If the engine cannot be shutdown, returns `false`. For example, this is `true` for liquid fueled rockets and `false` for solid rocket boosters.

boolean **getCanShutdown**()
: Gets whether the engine can be shutdown once activated. For example, this is `true` for liquid fueled rockets and `false` for solid rocket boosters.

boolean **getGimballed**()
: Whether the engine nozzle is gimballed, i.e. can provide a turning force.

float **getGimbalRange**()
: The range over which the gimbal can move, in degrees.

boolean **getGimbalLocked**()

void **setGimbalLocked**(boolean *value*)
: Whether the engines gimbal is locked in place. Setting this attribute has no effect if the engine is not gimballed.

float **getGimbalLimit**()

void **setGimbalLimit**(float *value*)
: The gimbal limiter of the engine. A value between 0 and 1. Returns 0 if the gimbal is locked or the engine is not gimballed. Setting this attribute has no effect if the engine is not gimballed.

Landing Gear

public class **LandingGear**
: Obtained by calling `Part.LandingGear`.

Part **getPart**()
: The part object for this landing gear.

LandingGearState **getState**()
: Gets the current state of the landing gear.

boolean **getDeployed**()

void **setDeployed**(boolean *value*)
: Whether the landing gear is deployed.

public enum **LandingGearState**
: See `LandingGear.State`.

public *LandingGearState* **Deployed**
: Landing gear is fully deployed.

public *LandingGearState* **Retracted**
: Landing gear is fully retracted.

public *LandingGearState* **Deploying**
: Landing gear is being deployed.

public *LandingGearState* **Retracting**
: Landing gear is being retracted.

Landing Leg

public class **LandingLeg**
: Obtained by calling `Part.LandingLeg`.

Part **getPart**()
: The part object for this landing leg.

LandingLegState **getState**()
The current state of the landing leg.

boolean **getDeployed**()

void **setDeployed**(boolean *value*)
Whether the landing leg is deployed.

public enum **LandingLegState**
See `LandingLeg.State`.

public *LandingLegState* **Deployed**
Landing leg is fully deployed.

public *LandingLegState* **Retracted**
Landing leg is fully retracted.

public *LandingLegState* **Deploying**
Landing leg is being deployed.

public *LandingLegState* **Retracting**
Landing leg is being retracted.

public *LandingLegState* **Broken**
Landing leg is broken.

public *LandingLegState* **Repairing**
Landing leg is being repaired.

Launch Clamp

public class **LaunchClamp**
Obtained by calling `Part.LaunchClamp`.

Part **getPart**()
The part object for this launch clamp.

void **Release**()
Releases the docking clamp. Has no effect if the clamp has already been released.

Light

public class **Light**
Obtained by calling `Part.Light`.

Part **getPart**()
The part object for this light.

boolean **getActive**()

void **setActive**(boolean *value*)
Whether the light is switched on.

float **getPowerUsage**()
The current power usage, in units of charge per second.

Parachute

public class **Parachute**

Obtained by calling `Part.Parachute`.

Part **getPart**()

The part object for this parachute.

void **Deploy**()

Deploys the parachute. This has no effect if the parachute has already been deployed.

boolean **getDeployed**()

Whether the parachute has been deployed.

ParachuteState **getState**()

The current state of the parachute.

float **getDeployAltitude**()

void **setDeployAltitude**(float *value*)

The altitude at which the parachute will full deploy, in meters.

float **getDeployMinPressure**()

void **setDeployMinPressure**(float *value*)

The minimum pressure at which the parachute will semi-deploy, in atmospheres.

public enum **ParachuteState**

See `Parachute.State`.

public *ParachuteState* **Stowed**

The parachute is safely tucked away inside its housing.

public *ParachuteState* **Active**

The parachute is still stowed, but ready to semi-deploy.

public *ParachuteState* **SemiDeployed**

The parachute has been deployed and is providing some drag, but is not fully deployed yet.

public *ParachuteState* **Deployed**

The parachute is fully deployed.

public *ParachuteState* **Cut**

The parachute has been cut.

Radiator

public class **Radiator**

Obtained by calling `Part.Radiator`.

Part **getPart**()

The part object for this radiator.

boolean **getDeployed**()

void **setDeployed**(boolean *value*)

Whether the radiator is extended.

RadiatorState **getState**()

The current state of the radiator.

public enum **RadiatorState**

`RadiatorState`

public *RadiatorState* **Extended**
Radiator is fully extended.

public *RadiatorState* **Retracted**
Radiator is fully retracted.

public *RadiatorState* **Extending**
Radiator is being extended.

public *RadiatorState* **Retracting**
Radiator is being retracted.

public *RadiatorState* **Broken**
Radiator is being broken.

Resource Converter

public class **ResourceConverter**
Obtained by calling `Part.ResourceConverter`.

Part **getPart** ()
The part object for this converter.

int **getCount** ()
The number of converters in the part.

String **Name** (int *index*)
The name of the specified converter.

Parameters

- **index** (*int*) – Index of the converter.

boolean **Active** (int *index*)
True if the specified converter is active.

Parameters

- **index** (*int*) – Index of the converter.

void **Start** (int *index*)
Start the specified converter.

Parameters

- **index** (*int*) – Index of the converter.

void **Stop** (int *index*)
Stop the specified converter.

Parameters

- **index** (*int*) – Index of the converter.

ResourceConverterState **State** (int *index*)
The state of the specified converter.

Parameters

- **index** (*int*) – Index of the converter.

String **StatusInfo** (int *index*)
Status information for the specified converter. This is the full status message shown in the in-game UI.

Parameters

- **index** (*int*) – Index of the converter.

java.util.List<String> **Inputs** (int *index*)
List of the names of resources consumed by the specified converter.

Parameters

- **index** (*int*) – Index of the converter.

java.util.List<String> **Outputs** (int *index*)
List of the names of resources produced by the specified converter.

Parameters

- **index** (*int*) – Index of the converter.

public enum **ResourceConverterState**
See `ResourceConverter.State`.

public *ResourceConverterState* **Running**
Converter is running.

public *ResourceConverterState* **Idle**
Converter is idle.

public *ResourceConverterState* **MissingResource**
Converter is missing a required resource.

public *ResourceConverterState* **StorageFull**
No available storage for output resource.

public *ResourceConverterState* **Capacity**
At preset resource capacity.

public *ResourceConverterState* **Unknown**
Unknown state. Possible with modified resource converters. In this case, check `ResourceConverter.StatusInfo` for more information.

Resource Harvester

public class **ResourceHarvester**
Obtained by calling `Part.ResourceHarvester`.

Part **getPart** ()
The part object for this harvester.

ResourceHarvesterState **getState** ()
The state of the harvester.

boolean **getDeployed** ()

void **setDeployed** (boolean *value*)
Whether the harvester is deployed.

boolean **getActive** ()

void **setActive** (boolean *value*)
Whether the harvester is actively drilling.

float **getExtractionRate**()
The rate at which the drill is extracting ore, in units per second.

float **getThermalEfficiency**()
The thermal efficiency of the drill, as a percentage of its maximum.

float **getCoreTemperature**()
The core temperature of the drill, in Kelvin.

float **getOptimumCoreTemperature**()
The core temperature at which the drill will operate with peak efficiency, in Kelvin.

Reaction Wheel

public class **ReactionWheel**
Obtained by calling `Part.ReactionWheel`.

Part **getPart**()
The part object for this reaction wheel.

boolean **getActive**()

void **setActive**(boolean *value*)
Whether the reaction wheel is active.

boolean **getBroken**()
Whether the reaction wheel is broken.

float **getPitchTorque**()
The torque in the pitch axis, in Newton meters.

float **getYawTorque**()
The torque in the yaw axis, in Newton meters.

float **getRollTorque**()
The torque in the roll axis, in Newton meters.

Sensor

public class **Sensor**
Obtained by calling `Part.Sensor`.

Part **getPart**()
The part object for this sensor.

boolean **getActive**()

void **setActive**(boolean *value*)
Whether the sensor is active.

String **getValue**()
The current value of the sensor.

float **getPowerUsage**()
The current power usage of the sensor, in units of charge per second.

Solar Panel

public class **SolarPanel**
Obtained by calling `Part.SolarPanel`.

Part **getPart**()
The part object for this solar panel.

boolean **getDeployed**()

void **setDeployed**(boolean *value*)
Whether the solar panel is extended.

SolarPanelState **getState**()
The current state of the solar panel.

float **getEnergyFlow**()
The current amount of energy being generated by the solar panel, in units of charge per second.

float **getSunExposure**()
The current amount of sunlight that is incident on the solar panel, as a percentage. A value between 0 and 1.

public enum **SolarPanelState**
See `SolarPanel.State`.

public *SolarPanelState* **Extended**
Solar panel is fully extended.

public *SolarPanelState* **Retracted**
Solar panel is fully retracted.

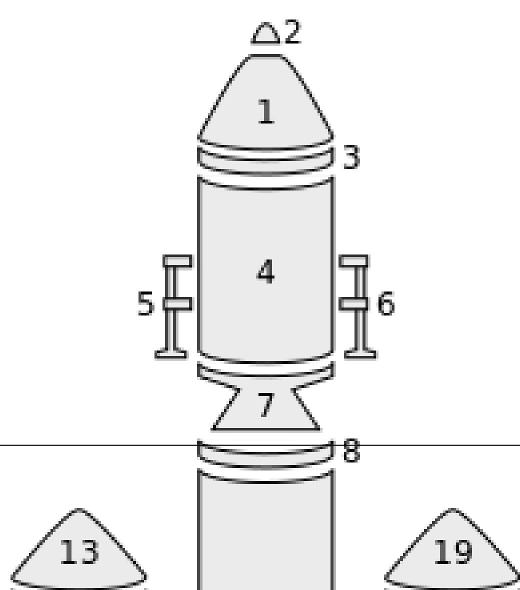
public *SolarPanelState* **Extending**
Solar panel is being extended.

public *SolarPanelState* **Retracting**
Solar panel is being retracted.

public *SolarPanelState* **Broken**
Solar panel is broken.

Trees of Parts

Vessels in KSP are comprised of a number of parts, connected to one another in a *tree* structure. An example vessel is shown in Figure 1, and the corresponding tree of parts in Figure 2. The craft file for this example can also be `downloaded here`.



Traversing the Tree

The tree of parts can be traversed using the attributes `SpaceCenter.Parts.Root`, `SpaceCenter.Part.Parent` and `SpaceCenter.Part.Children`.

The root of the tree is the same as the vessels *root part* (part number 1 in the example above) and can be obtained by calling `SpaceCenter.Parts.Root`.

A parts children can be obtained by calling `SpaceCenter.Part.Children`. If the part does not have any children, `SpaceCenter.Part.Children` returns an empty list. A parts parent can be obtained by calling `SpaceCenter.Part.Parent`. If the part does not have a parent (as is the case for the root part), `SpaceCenter.Part.Parent` returns `null`.

The following Java example uses these attributes to perform a depth-first traversal over all of the parts in a vessel:

```
import java.io.IOException;
import java.util.ArrayDeque;
import java.util.Deque;

import org.javatuples.Pair;

import krpc.client.Connection;
import krpc.client.RPCException;
import krpc.client.services.SpaceCenter;
import krpc.client.services.SpaceCenter.Part;
import krpc.client.services.SpaceCenter.Vessel;

public class TreeTraversal {
    public static void main(String[] args) throw
        Connection connection = Connection.newIn
        Vessel vessel = SpaceCenter.newInstance
        Part root = vessel.getParts().getRoot();
        Deque<Pair<Part, Integer>> stack = new A
        stack.push(new Pair<Part, Integer>(root,
        while (stack.size() > 0) {
            Pair<Part, Integer> item = stack.pop
            Part part = item.getValue0();
            int depth = item.getValue1();
            String prefix = "";
            for (int i = 0; i < depth; i++)
                prefix += " ";
            System.out.println(prefix + part.get
            for (Part child : part.getChildren()
                stack.push(new Pair<Part, Intege
        }
    }
}
```

When this code is execute using the craft file for the example vessel pictured above, the following is printed out:

```
Command Pod Mk1
 TR-18A Stack Decoupler
  FL-T400 Fuel Tank
   LV-909 Liquid Fuel Engine
    TR-18A Stack Decoupler
     FL-T800 Fuel Tank
```

```
                                            LV-909 Liquid Fuel Engine
                                            TT-70 Radial Decoupler
                                             FL-T400 Fuel Tank
                                              TT18-A Launch Stability Enhancer
                                              FTX-2 External Fuel Duct
                                              LV-909 Liquid Fuel Engine
                                              Aerodynamic Nose Cone
                                            TT-70 Radial Decoupler
                                             FL-T400 Fuel Tank
                                              TT18-A Launch Stability Enhancer
                                              FTX-2 External Fuel Duct
                                              LV-909 Liquid Fuel Engine
                                              Aerodynamic Nose Cone
                                         LT-1 Landing Struts
                                         LT-1 Landing Struts
                                       Mk16 Parachute
```

Attachment Modes

Parts can be attached to other parts either *radially* (on the side of the parent part) or *axially* (on the end of the parent part, to form a stack).

For example, in the vessel pictured above, the parachute (part 2) is *axially* connected to its parent (the command pod – part 1), and the landing leg (part 5) is *radially* connected to its parent (the fuel tank – part 4).

The root part of a vessel (for example the command pod – part 1) does not have a parent part, so does not have an attachment mode. However, the part is consider to be *axially* attached to nothing.

The following Java example does a depth-first traversal as before, but also prints out the attachment mode used by the part:

```java
import java.io.IOException;
import java.util.ArrayDeque;
import java.util.Deque;

import org.javatuples.Pair;

import krpc.client.Connection;
import krpc.client.RPCException;
import krpc.client.services.SpaceCenter;
import krpc.client.services.SpaceCenter.Part;
import krpc.client.services.SpaceCenter.Vessel;

public class AttachmentModes {
    public static void main(String[] args) throws IOException, RPCException {
        Connection connection = Connection.newInstance();
        Vessel vessel = SpaceCenter.newInstance(connection).getActiveVessel();
        Part root = vessel.getParts().getRoot();
        Deque<Pair<Part, Integer>> stack = new ArrayDeque<Pair<Part, Integer>>();
        stack.push(new Pair<Part, Integer>(root, 0));
```

```
        while (stack.size() > 0) {
            Pair<Part, Integer> item = stack.pop();
            Part part = item.getValue0();
            int depth = item.getValue1();
            String prefix = "";
            for (int i = 0; i < depth; i++)
                prefix += " ";
            String attachMode = part.getAxiallyAttached() ? "axial" : "radial";
            System.out.println(prefix + part.getTitle() + " - " + attachMode);
            for (Part child : part.getChildren())
                stack.push(new Pair<Part, Integer>(child, depth + 1));
        }
    }
}
```

When this code is execute using the craft file for the example vessel pictured above, the following is printed out:

```
Command Pod Mk1 - axial
 TR-18A Stack Decoupler - axial
  FL-T400 Fuel Tank - axial
   LV-909 Liquid Fuel Engine - axial
    TR-18A Stack Decoupler - axial
     FL-T800 Fuel Tank - axial
      LV-909 Liquid Fuel Engine - axial
      TT-70 Radial Decoupler - radial
       FL-T400 Fuel Tank - radial
        TT18-A Launch Stability Enhancer - radial
        FTX-2 External Fuel Duct - radial
        LV-909 Liquid Fuel Engine - axial
        Aerodynamic Nose Cone - axial
      TT-70 Radial Decoupler - radial
       FL-T400 Fuel Tank - radial
        TT18-A Launch Stability Enhancer - radial
        FTX-2 External Fuel Duct - radial
        LV-909 Liquid Fuel Engine - axial
        Aerodynamic Nose Cone - axial
   LT-1 Landing Struts - radial
   LT-1 Landing Struts - radial
 Mk16 Parachute - axial
```

Fuel Lines

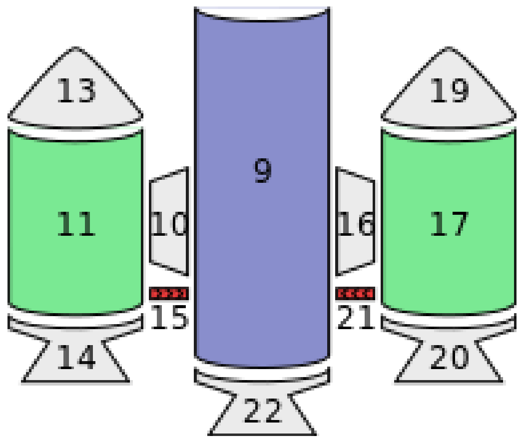


Fig. 5.12: **Figure 5** – Fuel lines from the example in Figure 1. Fuel flows from the parts highlighted in green, into the part highlighted in blue.

Fuel lines are considered parts, and are included in the parts tree (for example, as pictured in Figure 4). However, the parts tree does not contain information about which parts fuel lines connect to. The parent part of a fuel line is the part from which it will take fuel (as shown in Figure 4) however the part that it will send fuel to is not represented in the parts tree.

Figure 5 shows the fuel lines from the example vessel pictured earlier. Fuel line part 15 (in red) takes fuel from a fuel tank (part 11 – in green) and feeds it into another fuel tank (part 9 – in blue). The fuel line is therefore a child of part 11, but its connection to part 9 is not represented in the tree.

The attributes `SpaceCenter.Part.FuelLinesFrom` and `SpaceCenter.Part.FuelLinesTo` can be used to discover these connections. In the example in Figure 5, when `SpaceCenter.Part.FuelLinesTo` is called on fuel tank part 11, it will return a list of parts containing just fuel tank part 9 (the blue part). When `SpaceCenter.Part.FuelLinesFrom` is called on fuel tank part 9, it will return a list containing fuel tank parts 11 and 17 (the parts colored green).

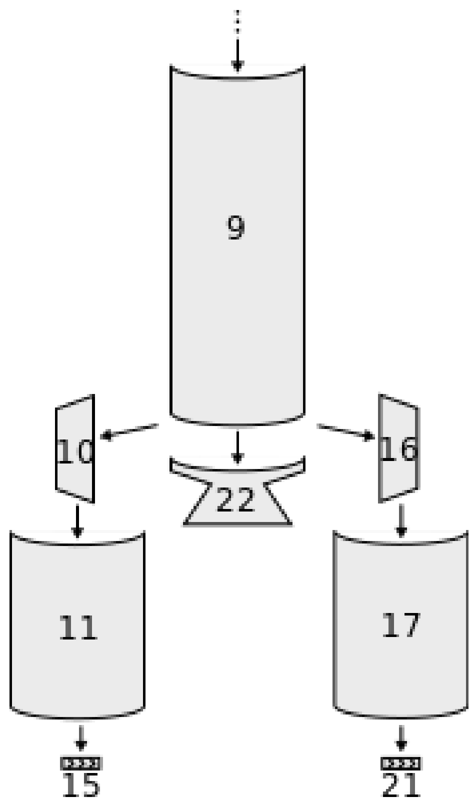
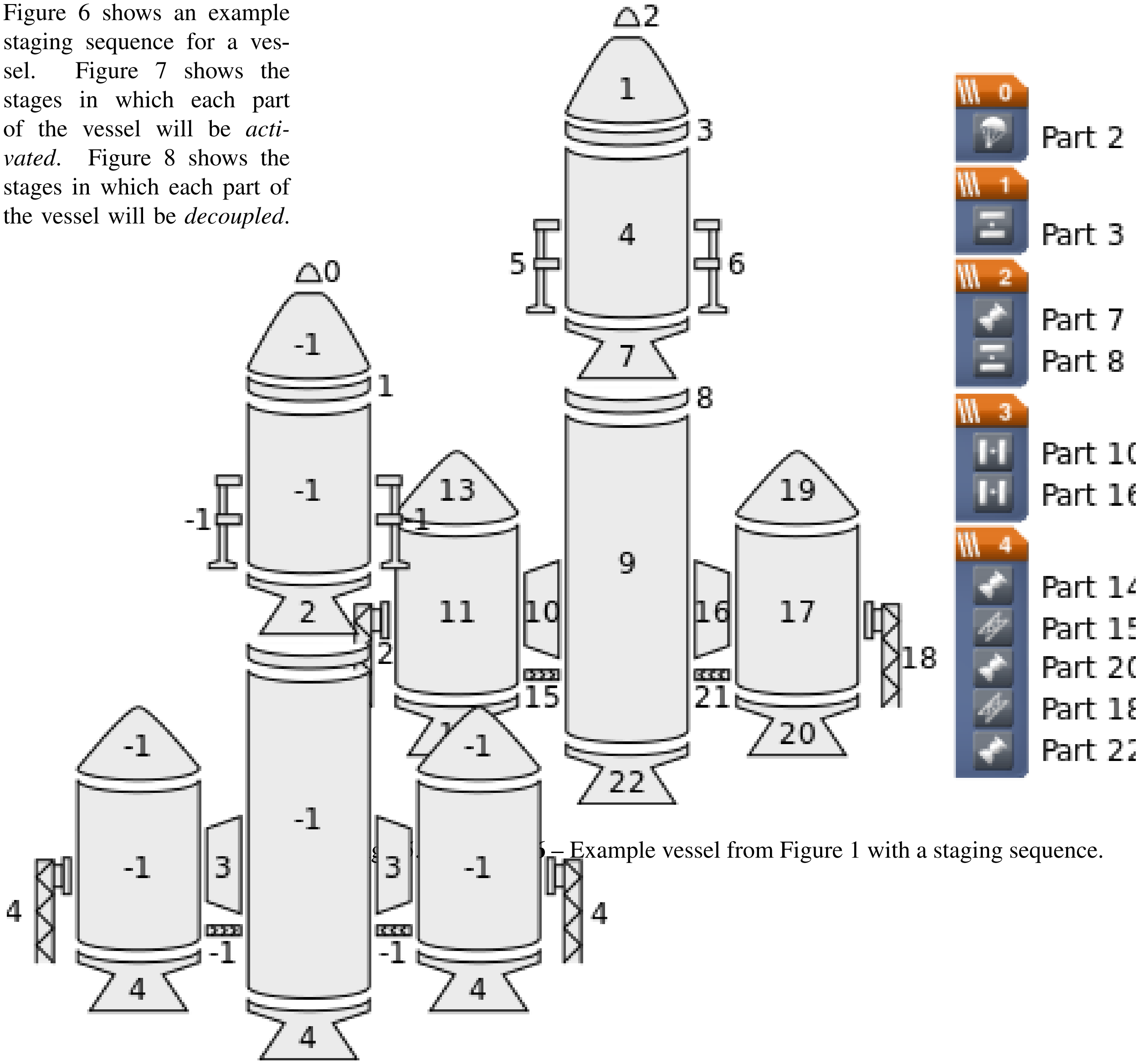


Fig. 5.13: **Figure 4** – A subset of the parts tree from Figure 2 above.

Staging

Each part has two staging numbers associated with it: the stage in which the part is *activated* and the stage in which the part is *decoupled*. These values can be obtained using `SpaceCenter.Part.Stage` and `SpaceCenter.Part.DecoupleStage` respectively. For parts that are not activated by staging, `SpaceCenter.Part.Stage` returns -1. For parts that are never decoupled, `SpaceCenter.Part.DecoupleStage` returns a value of -1.

Figure 6 shows an example staging sequence for a vessel. Figure 7 shows the stages in which each part of the vessel will be *activated*. Figure 8 shows the stages in which each part of the vessel will be *decoupled*.



– Example vessel from Figure 1 with a staging sequence.

Fig. 5.15: **Figure 7** – The stage in which each part is *activated*.

5.2.8 Resources

public class **Resources**

Created by calling `Vessel.Resources`, `Vessel.ResourcesInDecoupleStage` or `Part.Resources`.

java.util.List<String> **getNames** ()

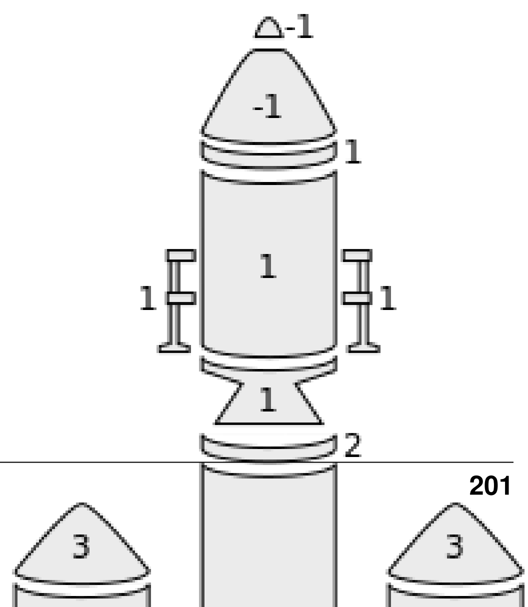
A list of resource names that can be stored.

boolean **HasResource** (String *name*)

Check whether the named resource can be stored.

Parameters

- **name** (*String*) – The name of the resource.



float **Max** (String *name*)
Returns the amount of a resource that can be stored.

Parameters

- **name** (*String*) – The name of the resource.

float **Amount** (String *name*)
Returns the amount of a resource that is currently stored.

Parameters

- **name** (*String*) – The name of the resource.

float **Density** (String *name*)
Returns the density of a resource, in kg/l.

Parameters

- **name** (*String*) – The name of the resource.

ResourceFlowMode **FlowMode** (String *name*)
Returns the flow mode of a resource.

Parameters

- **name** (*String*) – The name of the resource.

public enum **ResourceFlowMode**
See `Resources.FlowMode`.

public *ResourceFlowMode* **Vessel**
The resource flows to any part in the vessel. For example, electric charge.

public *ResourceFlowMode* **Stage**
The resource flows from parts in the first stage, followed by the second, and so on. For example, mono-propellant.

public *ResourceFlowMode* **Adjacent**
The resource flows between adjacent parts within the vessel. For example, liquid fuel or oxidizer.

public *ResourceFlowMode* **None**
The resource does not flow. For example, solid fuel.

5.2.9 Node

public class **Node**
Represents a maneuver node. Can be created using `Control.AddNode`.

float **getPrograde** ()

void **setPrograde** (float *value*)
The magnitude of the maneuver nodes delta-v in the prograde direction, in meters per second.

float **getNormal** ()

void **setNormal** (float *value*)
The magnitude of the maneuver nodes delta-v in the normal direction, in meters per second.

float **getRadial** ()

void **setRadial** (float *value*)
The magnitude of the maneuver nodes delta-v in the radial direction, in meters per second.

float **getDeltaV** ()

void **setDeltaV** (float *value*)
The delta-v of the maneuver node, in meters per second.

Note: Does not change when executing the maneuver node. See `Node.RemainingDeltaV`.

float **getRemainingDeltaV** ()
Gets the remaining delta-v of the maneuver node, in meters per second. Changes as the node is executed. This is equivalent to the delta-v reported in-game.

org.javatuples.Triplet<Double, Double, Double> **BurnVector** (*ReferenceFrame referenceFrame*)
Returns a vector whose direction the direction of the maneuver node burn, and whose magnitude is the delta-v of the burn in m/s.

Parameters

- **referenceFrame** (`ReferenceFrame`) –

Note: Does not change when executing the maneuver node. See `Node.RemainingBurnVector`.

org.javatuples.Triplet<Double, Double, Double> **RemainingBurnVector** (*ReferenceFrame referenceFrame*)
Returns a vector whose direction the direction of the maneuver node burn, and whose magnitude is the delta-v of the burn in m/s. The direction and magnitude change as the burn is executed.

Parameters

- **referenceFrame** (`ReferenceFrame`) –

double **getUT** ()

void **setUT** (double *value*)
The universal time at which the maneuver will occur, in seconds.

double **getTimeTo**()
The time until the maneuver node will be encountered, in seconds.

Orbit **getOrbit**()
The orbit that results from executing the maneuver node.

void **Remove**()
Removes the maneuver node.

ReferenceFrame **getReferenceFrame**()
Gets the reference frame that is fixed relative to the maneuver node's burn.

- The origin is at the position of the maneuver node.
- The y-axis points in the direction of the burn.
- The x-axis and z-axis point in arbitrary but fixed directions.

ReferenceFrame **getOrbitalReferenceFrame**()
Gets the reference frame that is fixed relative to the maneuver node, and orientated with the orbital prograde/normal/radial directions of the original orbit at the maneuver node's position.

- The origin is at the position of the maneuver node.
- The x-axis points in the orbital anti-radial direction of the original orbit, at the position of the maneuver node.
- The y-axis points in the orbital prograde direction of the original orbit, at the position of the maneuver node.
- The z-axis points in the orbital normal direction of the original orbit, at the position of the maneuver node.

org.javatuples.Triplet<Double, Double, Double> **Position**(*ReferenceFrame referenceFrame*)
Returns the position vector of the maneuver node in the given reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

org.javatuples.Triplet<Double, Double, Double> **Direction**(*ReferenceFrame referenceFrame*)
Returns the unit direction vector of the maneuver nodes burn in the given reference frame.

Parameters

- **referenceFrame** (ReferenceFrame) –

5.2.10 Comms

public class **Comms**
Used to interact with RemoteTech. Created using a

call to `Vessel.Comms`.

Note: This class requires RemoteTech to be installed.

boolean **getHasLocalControl**()
: Whether the vessel can be controlled locally.

boolean **getHasFlightComputer**()
: Whether the vessel has a RemoteTech flight computer on board.

boolean **getHasConnection**()
: Whether the vessel can receive commands from the KSC or a command station.

boolean **getHasConnectionToGroundStation**()
: Whether the vessel can transmit science data to a ground station.

double **getSignalDelay**()
: The signal delay when sending commands to the vessel, in seconds.

double **getSignalDelayToGroundStation**()
: The signal delay between the vessel and the closest ground station, in seconds.

double **SignalDelayToVessel**(*Vessel other*)
: Returns the signal delay between the current vessel and another vessel, in seconds.

Parameters

- **other** (`Vessel`) –

5.2.11 ReferenceFrame

public class **ReferenceFrame**
: Represents a reference frame for positions, rotations and velocities. Contains:

- The position of the origin.
- The directions of the x, y and z axes.
- The linear velocity of the frame.
- The angular velocity of the frame.

Note: This class does not contain any properties or methods. It is only used as a parameter to other functions.

5.2.12 AutoPilot

public class **AutoPilot**

Provides basic auto-piloting utilities for a vessel. Created by calling `Vessel.AutoPilot`.

void **Engage** ()

Engage the auto-pilot.

void **Disengage** ()

Disengage the auto-pilot.

void **Wait** ()

Blocks until the vessel is pointing in the target direction (if set) and has the target roll (if set).

float **getError** ()

The error, in degrees, between the direction the ship has been asked to point in and the direction it is pointing in. Returns zero if the auto-pilot has not been engaged, SAS is not enabled, SAS is in stability assist mode, or no target direction is set.

float **getRollError** ()

The error, in degrees, between the roll the ship has been asked to be in and the actual roll. Returns zero if the auto-pilot has not been engaged or no target roll is set.

ReferenceFrame **getReferenceFrame** ()

void **setReferenceFrame** (*ReferenceFrame value*)

The reference frame for the target direction (`AutoPilot.TargetDirection`).

org.javatuples.Triplet<Double, Double, Double> **getTargetDirection** ()

void **setTargetDirection** (org.javatuples.Triplet<Double, Double, Double> *value*)

The target direction. `null` if no target direction is set.

void **TargetPitchAndHeading** (float *pitch*, float *heading*)

Set (`AutoPilot.TargetDirection`) from a pitch and heading angle.

Parameters

- **pitch** (*float*) – Target pitch angle, in degrees between -90° and +90°.
- **heading** (*float*) – Target heading angle, in degrees between 0° and 360°.

float **getTargetRoll** ()

void **setTargetRoll** (float *value*)

The target roll, in degrees. `NaN` if no target roll is set.

boolean **getSAS** ()

void **setSAS** (boolean *value*)
The state of SAS.

Note: Equivalent to `Control.SAS`

SASMode **getSASMode** ()

void **setSASMode** (*SASMode value*)
The current *SASMode*. These modes are equivalent to the mode buttons to the left of the navball that appear when SAS is enabled.

Note: Equivalent to `Control.SASMode`

float **getRotationSpeedMultiplier** ()

void **setRotationSpeedMultiplier** (float *value*)
Target rotation speed multiplier. Defaults to 1.

float **getMaxRotationSpeed** ()

void **setMaxRotationSpeed** (float *value*)
Maximum target rotation speed. Defaults to 1.

float **getRollSpeedMultiplier** ()

void **setRollSpeedMultiplier** (float *value*)
Target roll speed multiplier. Defaults to 1.

float **getMaxRollSpeed** ()

void **setMaxRollSpeed** (float *value*)
Maximum target roll speed. Defaults to 1.

void **SetPIDParameters** (float *Kp*, float *Ki*, float *Kd*)
Sets the gains for the rotation rate PID controller.

Parameters

- **Kp** (*float*) – Proportional gain.
- **Ki** (*float*) – Integral gain.
- **Kd** (*float*) – Derivative gain.

5.2.13 Geometry Types

3-dimensional vectors are represented as a 3-tuple. For example:

```java
import java.io.IOException;

import org.javatuples.Triplet;

import krpc.client.Connection;
import krpc.client.RPCException;
import krpc.client.services.SpaceCenter;
import krpc.client.services.SpaceCenter.Vessel;

public class Vector3 {
    public static void main(String[] args) throws IOException, RPCException {
        Connection connection = Connection.newInstance();
        Vessel vessel = SpaceCenter.newInstance(connection).getActiveVessel();
        Triplet<Double, Double, Double> v = vessel.flight(null).getPrograde();
        System.out.println(v.getValue0() + "," + v.getValue1() + "," + v.getValue2());
    }
}
```

Quaternions (rotations in 3-dimensional space) are encoded as a 4-tuple containing the x, y, z and w components. For example:

```java
import java.io.IOException;

import org.javatuples.Quartet;

import krpc.client.Connection;
import krpc.client.RPCException;
import krpc.client.services.SpaceCenter;
import krpc.client.services.SpaceCenter.Vessel;

public class Quaternion {
    public static void main(String[] args) throws IOException, RPCException {
        Connection connection = Connection.newInstance();
        Vessel vessel = SpaceCenter.newInstance(connection).getActiveVessel();
        Quartet<Double, Double, Double, Double> q = vessel.flight(null).getRotation();
        System.out.println(q.getValue0() + "," + q.getValue1() + "," + q.getValue2() + "," + q.getVal
    }
}
```

5.3 InfernalRobotics API

Provides RPCs to interact with the InfernalRobotics mod. Provides the following classes:

5.3.1 InfernalRobotics

public class **InfernalRobotics**

This service provides functionality to interact with the InfernalRobotics mod.

java.util.List<*ControlGroup*> **getServoGroups**()

A list of all the servo groups in the active vessel.

ControlGroup **ServoGroupWithName** (String *name*)
Returns the servo group with the given *name* or `null` if none exists. If multiple servo groups have the same name, only one of them is returned.

Parameters

- **name** (*String*) – Name of servo group to find.

Servo **ServoWithName** (String *name*)
Returns the servo with the given *name*, from all servo groups, or `null` if none exists. If multiple servos have the same name, only one of them is returned.

Parameters

- **name** (*String*) – Name of the servo to find.

5.3.2 ControlGroup

public class **ControlGroup**
A group of servos, obtained by calling `ServoGroups` or *ServoGroupWithName*. Represents the "Servo Groups" in the InfernalRobotics UI.

String **getName** ()

void **setName** (String *value*)
The name of the group.

String **getForwardKey** ()

void **setForwardKey** (String *value*)
The key assigned to be the "forward" key for the group.

String **getReverseKey** ()

void **setReverseKey** (String *value*)
The key assigned to be the "reverse" key for the group.

float **getSpeed** ()

void **setSpeed** (float *value*)
The speed multiplier for the group.

boolean **getExpanded** ()

void **setExpanded** (boolean *value*)
Whether the group is expanded in the InfernalRobotics UI.

java.util.List<Servo> **getServos** ()
The servos that are in the group.

Servo **ServoWithName** (String *name*)
Returns the servo with the given *name* from this group, or `null` if none exists.

Parameters

- **name** (*String*) – Name of servo to find.

void **MoveRight** ()
Moves all of the servos in the group to the right.

void **MoveLeft** ()
Moves all of the servos in the group to the left.

void **MoveCenter** ()
Moves all of the servos in the group to the center.

void **MoveNextPreset** ()
Moves all of the servos in the group to the next preset.

void **MovePrevPreset** ()
Moves all of the servos in the group to the previous preset.

void **Stop** ()
Stops the servos in the group.

5.3.3 Servo

public class **Servo**
Represents a servo. Obtained using `ControlGroup.Servos`, `ControlGroup.ServoWithName` or *ServoWithName*.

String **getName** ()

void **setName** (String *value*)
The name of the servo.

void **setHighlight** (boolean *value*)
Whether the servo should be highlighted in-game.

float **getPosition** ()
The position of the servo.

float **getMinConfigPosition** ()
The minimum position of the servo, specified by the part configuration.

float **getMaxConfigPosition** ()
The maximum position of the servo, specified by the part configuration.

float **getMinPosition** ()

void **setMinPosition**(float *value*)
The minimum position of the servo, specified by the in-game tweak menu.

float **getMaxPosition**()

void **setMaxPosition**(float *value*)
The maximum position of the servo, specified by the in-game tweak menu.

float **getConfigSpeed**()
The speed multiplier of the servo, specified by the part configuration.

float **getSpeed**()

void **setSpeed**(float *value*)
The speed multiplier of the servo, specified by the in-game tweak menu.

float **getCurrentSpeed**()

void **setCurrentSpeed**(float *value*)
The current speed at which the servo is moving.

float **getAcceleration**()

void **setAcceleration**(float *value*)
The current speed multiplier set in the UI.

boolean **getIsMoving**()
Whether the servo is moving.

boolean **getIsFreeMoving**()
Whether the servo is freely moving.

boolean **getIsLocked**()

void **setIsLocked**(boolean *value*)
Whether the servo is locked.

boolean **getIsAxisInverted**()

void **setIsAxisInverted**(boolean *value*)
Whether the servos axis is inverted.

void **MoveRight**()
Moves the servo to the right.

void **MoveLeft**()
Moves the servo to the left.

void **MoveCenter**()
Moves the servo to the center.

void **MoveNextPreset**()
Moves the servo to the next preset.

void **MovePrevPreset** ()
Moves the servo to the previous preset.

void **MoveTo** (float *position*, float *speed*)
Moves the servo to *position* and sets the speed multiplier to *speed*.

Parameters

- **position** (*float*) – The position to move the servo to.
- **speed** (*float*) – Speed multiplier for the movement.

void **Stop** ()
Stops the servo.

5.3.4 Example

The following example gets the control group named "MyGroup", prints out the names and positions of all of the servos in the group, then moves all of the servos to the right for 1 second.

```
import java.io.IOException;

import krpc.client.Connection;
import krpc.client.RPCException;
import krpc.client.services.InfernalRobotics;
import krpc.client.services.InfernalRobotics.ControlGroup;
import krpc.client.services.InfernalRobotics.Servo;

public class InfernalRoboticsExample {
    public static void main(String[] args) throws IOException, RPCException, InterruptedException {

        Connection connection = Connection.newInstance("InfernalRobotics Example");
        InfernalRobotics ir = InfernalRobotics.newInstance(connection);

        ControlGroup group = ir.servoGroupWithName("MyGroup");
        if (group == null) {
            System.out.println("Group not found");
            return;
        }

        for (Servo servo : group.getServos())
            System.out.println(servo.getName() + " " + servo.getPosition());

        group.moveRight();
        Thread.sleep(1000);
        group.stop();
    }
}
```

5.4 Kerbal Alarm Clock API

Provides RPCs to interact with the Kerbal Alarm Clock mod. Provides the following classes:

5.4.1 KerbalAlarmClock

public class **KerbalAlarmClock**
This service provides functionality to interact with the Kerbal Alarm Clock mod.

java.util.List<*Alarm*> **getAlarms**()
A list of all the alarms.

Alarm **AlarmWithName**(String *name*)
Get the alarm with the given *name*, or `null` if no alarms have that name. If more than one alarm has the name, only returns one of them.

Parameters

- **name** (*String*) – Name of the alarm to search for.

java.util.List<*Alarm*> **AlarmsWithType**(*AlarmType* *type*)
Get a list of alarms of the specified *type*.

Parameters

- **type** (`AlarmType`) – Type of alarm to return.

Alarm **CreateAlarm**(*AlarmType* *type*, String *name*, double *ut*)
Create a new alarm and return it.

Parameters

- **type** (`AlarmType`) – Type of the new alarm.
- **name** (*String*) – Name of the new alarm.
- **ut** (*double*) – Time at which the new alarm should trigger.

5.4.2 Alarm

public class **Alarm**
Represents an alarm. Obtained by calling `Alarms`, *AlarmWithName* or *AlarmsWithType*.

AlarmAction **getAction**()

void **setAction**(*AlarmAction* *value*)
The action that the alarm triggers.

double **getMargin**()

void **setMargin**(double *value*)
The number of seconds before the event that the alarm will fire.

double **getTime** ()

void **setTime** (double *value*)
The time at which the alarm will fire.

AlarmType **getType** ()
The type of the alarm.

String **getID** ()
The unique identifier for the alarm.

String **getName** ()

void **setName** (String *value*)
The short name of the alarm.

String **getNotes** ()

void **setNotes** (String *value*)
The long description of the alarm.

double **getRemaining** ()
The number of seconds until the alarm will fire.

boolean **getRepeat** ()

void **setRepeat** (boolean *value*)
Whether the alarm will be repeated after it has fired.

double **getRepeatPeriod** ()

void **setRepeatPeriod** (double *value*)
The time delay to automatically create an alarm after it has fired.

SpaceCenter.Vessel **getVessel** ()

void **setVessel** (*SpaceCenter*.Vessel *value*)
The vessel that the alarm is attached to.

SpaceCenter.CelestialBody **getXferOriginBody** ()

void **setXferOriginBody** (*SpaceCenter*.CelestialBody *value*)
The celestial body the vessel is departing from.

SpaceCenter.CelestialBody **getXferTargetBody** ()

void **setXferTargetBody** (*SpaceCenter*.CelestialBody *value*)
The celestial body the vessel is arriving at.

void **Remove** ()
Removes the alarm.

5.4.3 AlarmType

public enum **AlarmType**
The type of an alarm.

public *AlarmType* **Raw**
An alarm for a specific date/time or a specific period in the future.

public *AlarmType* **Maneuver**
An alarm based on the next maneuver node on the current ships flight path. This node will be stored and can be restored when you come back to the ship.

public *AlarmType* **ManeuverAuto**
See `AlarmType.Maneuver`.

public *AlarmType* **Apoapsis**
An alarm for furthest part of the orbit from the planet.

public *AlarmType* **Periapsis**
An alarm for nearest part of the orbit from the planet.

public *AlarmType* **AscendingNode**
Ascending node for the targeted object, or equatorial ascending node.

public *AlarmType* **DescendingNode**
Descending node for the targeted object, or equatorial descending node.

public *AlarmType* **Closest**
An alarm based on the closest approach of this vessel to the targeted vessel, some number of orbits into the future.

public *AlarmType* **Contract**
An alarm based on the expiry or deadline of contracts in career modes.

public *AlarmType* **ContractAuto**
See `AlarmType.Contract`.

public *AlarmType* **Crew**
An alarm that is attached to a crew member.

public *AlarmType* **Distance**
An alarm that is triggered when a selected target comes within a chosen distance.

public *AlarmType* **EarthTime**
An alarm based on the time in the "Earth" alternative Universe (aka the Real World).

public *AlarmType* **LaunchRendevous**
An alarm that fires as your landed craft passes under the orbit of your target.

public *AlarmType* **SOIChange**
An alarm manually based on when the next SOI

point is on the flight path or set to continually monitor the active flight path and add alarms as it detects SOI changes.

public *AlarmType* **SOIChangeAuto**
See `AlarmType.SOIChange`.

public *AlarmType* **Transfer**
An alarm based on Interplanetary Transfer Phase Angles, i.e. when should I launch to planet X? Based on Kosmo Not's post and used in Olex's Calculator.

public *AlarmType* **TransferModelled**
See `AlarmType.Transfer`.

5.4.4 AlarmAction

public enum **AlarmAction**
The action performed by an alarm when it fires.

public *AlarmAction* **DoNothing**
Don't do anything at all...

public *AlarmAction* **DoNothingDeleteWhenPassed**
Don't do anything, and delete the alarm.

public *AlarmAction* **KillWarp**
Drop out of time warp.

public *AlarmAction* **KillWarpOnly**
Drop out of time warp.

public *AlarmAction* **MessageOnly**
Display a message.

public *AlarmAction* **PauseGame**
Pause the game.

5.4.5 Example

The following example creates a new alarm for the active vessel. The alarm is set to trigger after 10 seconds have passed, and display a message.

```
import java.io.IOException;

import krpc.client.Connection;
import krpc.client.RPCException;
import krpc.client.services.KerbalAlarmClock;
import krpc.client.services.KerbalAlarmClock.Alarm;
import krpc.client.services.KerbalAlarmClock.AlarmAction;
import krpc.client.services.KerbalAlarmClock.AlarmType;
import krpc.client.services.SpaceCenter;

public class KerbalAlarmClockExample {
    public static void main(String[] args) throws IOException, RPCException {
        Connection connection = Connection.newInstance("Kerbal Alarm Clock Example", "10.0.2.2");
```

```
        KerbalAlarmClock kac = KerbalAlarmClock.newInstance(connection);
        Alarm alarm = kac.createAlarm(AlarmType.RAW, "My New Alarm", SpaceCenter.newInstance(connect
        alarm.setNotes("10 seconds have now passed since the alarm was created.");
        alarm.setAction(AlarmAction.MESSAGE_ONLY);
    }
}
```

CHAPTER

SIX

LUA

6.1 Lua Client

The krpc module provides functionality to interact with a kRPC server from lua. It can be installed using luarocks.

6.1.1 Connecting to the Server

To connect to a server, use the *krpc.connect()* function. This returns a connection object through which you can interact with the server. For example to connect to a server running on the local machine:

```
local krpc = require 'krpc'
local conn = krpc.connect('Example')
print(conn.krpc:get_status().version)
```

This function also accepts arguments that specify what address and port numbers to connect to. For example:

```
local krpc = require 'krpc'
local conn = krpc.connect('Remote example', 'my.domain.name', 1000, 1001)
print(conn.krpc:get_status().version)
```

6.1.2 Interacting with the Server

Interaction with the server is performed via the client object (of type *krpc.Client*) returned when connecting to the server using *krpc.connect()*.

Upon connecting, the client interrogates the server to find out what functionality it provides and dynamically adds all of the classes, methods, properties to the client object.

For example, all of the functionality provided by the SpaceCenter service is accessible via conn.space_center and the functionality provided by the InfernalRobotics service is accessible via conn.infernal_robotics.

Calling methods, getting or setting properties, etc. are mapped to remote procedure calls and passed to the server by the lua client.

6.1.3 Streaming Data from the Server

Warning: Streams are not yet supported by the Lua client.

6.1.4 Reference

krpc.**connect** ([*name=nil*][, *address='127.0.0.1'*][, *rpc_port=50000*][, *stream_port=50001*])

This function creates a connection to a kRPC server. It returns a `krpc.Client` object, through which the server can be communicated with.

Parameters

- **name** (*string*) – A descriptive name for the connection. This is passed to the server and appears, for example, in the client connection dialog on the in-game server window.
- **address** (*string*) – The address of the server to connect to. Can either be a hostname or an IP address in dotted decimal notation. Defaults to '127.0.0.1'.
- **rpc_port** (*int*) – The port number of the RPC Server. Defaults to 50000.
- **stream_port** (*int*) – The port number of the Stream Server. Defaults to 50001.

class krpc.**Client**

This class provides the interface for communicating with the server. It is dynamically populated with all the functionality provided by the server. Instances of this class should be obtained by calling `krpc.connect()`.

close()

Closes the connection to the server.

krpc

The built-in KRPC class, providing basic interactions with the server.

Return type `krpc.KRPC`

class krpc.**KRPC**

This class provides access to the basic server functionality provided by the KRPC service. An instance can be obtained by calling `krpc.Client.krpc`. Most of this functionality is used internally by the lua client and therefore does not need to be used directly from application code. The only exception that may be useful is:

get_status()

Gets a status message from the server containing information including the server's version string and performance statistics.

For example, the following prints out the version string for the server:

```
print('Server version = ' .. conn.krpc:get_status().version)
```

Or to get the rate at which the server is sending and receiving data over the network:

```
local status = conn.krpc:get_status()
print('Data in = ' .. (status.bytes_read_rate/1024) .. ' KB/s')
print('Data out = ' .. (status.bytes_written_rate/1024) .. ' KB/s')
```

6.2 SpaceCenter API

6.2.1 SpaceCenter

class SpaceCenter.**SpaceCenter**

Provides functionality to interact with Kerbal Space Program. This includes controlling the active vessel, managing its resources, planning maneuver nodes and auto-piloting.

active_vessel

The currently active vessel.

Attribute Can be read or written

Return type *Vessel*

vessels
A list of all the vessels in the game.

Attribute Read-only, cannot be set

Return type List of *Vessel*

bodies
A dictionary of all celestial bodies (planets, moons, etc.) in the game, keyed by the name of the body.

Attribute Read-only, cannot be set

Return type Map from string to *CelestialBody*

target_body
The currently targeted celestial body.

Attribute Can be read or written

Return type *CelestialBody*

target_vessel
The currently targeted vessel.

Attribute Can be read or written

Return type *Vessel*

target_docking_port
The currently targeted docking port.

Attribute Can be read or written

Return type *DockingPort*

static **clear_target**()
Clears the current target.

static **launch_vessel_from_vab**(*name*)
Launch a new vessel from the VAB onto the launchpad.

Parameters **name** (*string*) – Name of the vessel's craft file.

static **launch_vessel_from_sph**(*name*)
Launch a new vessel from the SPH onto the runway.

Parameters **name** (*string*) – Name of the vessel's craft file.

ut
The current universal time in seconds.

Attribute Read-only, cannot be set

Return type number

g
The value of the gravitational constant G in $N(m/kg)^2$.

Attribute Read-only, cannot be set

Return type number

warp_mode

The current time warp mode. Returns *WarpMode.none* if time warp is not active, *WarpMode.rails* if regular "on-rails" time warp is active, or *WarpMode.physics* if physical time warp is active.

Attribute Read-only, cannot be set

Return type *WarpMode*

warp_rate

The current warp rate. This is the rate at which time is passing for either on-rails or physical time warp. For example, a value of 10 means time is passing 10x faster than normal. Returns 1 if time warp is not active.

Attribute Read-only, cannot be set

Return type number

warp_factor

The current warp factor. This is the index of the rate at which time is passing for either regular "on-rails" or physical time warp. Returns 0 if time warp is not active. When in on-rails time warp, this is equal to *rails_warp_factor*, and in physics time warp, this is equal to *physics_warp_factor*.

Attribute Read-only, cannot be set

Return type number

rails_warp_factor

The time warp rate, using regular "on-rails" time warp. A value between 0 and 7 inclusive. 0 means no time warp. Returns 0 if physical time warp is active. If requested time warp factor cannot be set, it will be set to the next lowest possible value. For example, if the vessel is too close to a planet. See the KSP wiki for details.

Attribute Can be read or written

Return type number

physics_warp_factor

The physical time warp rate. A value between 0 and 3 inclusive. 0 means no time warp. Returns 0 if regular "on-rails" time warp is active.

Attribute Can be read or written

Return type number

static **can_rails_warp_at** ([*factor = 1*])

Returns `True` if regular "on-rails" time warp can be used, at the specified warp *factor*. The maximum time warp rate is limited by various things, including how close the active vessel is to a planet. See the KSP wiki for details.

Parameters **factor** (*number*) – The warp factor to check.

Return type boolean

maximum_rails_warp_factor

The current maximum regular "on-rails" warp factor that can be set. A value between 0 and 7 inclusive. See the KSP wiki for details.

Attribute Read-only, cannot be set

Return type number

static **warp_to** (*ut*[, *max_rails_rate = 100000.0*][, *max_physics_rate = 2.0*])

Uses time acceleration to warp forward to a time in the future, specified by universal time *ut*. This call blocks until the desired time is reached. Uses regular "on-rails" or physical time warp as appropriate. For example, physical time warp is used when the active vessel is traveling through an atmosphere. When using regular "on-rails" time warp, the warp rate is limited by *max_rails_rate*, and when using physical time warp, the warp rate is limited by *max_physics_rate*.

Parameters

- **ut** (*number*) – The universal time to warp to, in seconds.
- **max_rails_rate** (*number*) – The maximum warp rate in regular "on-rails" time warp.
- **max_physics_rate** (*number*) – The maximum warp rate in physical time warp.

Returns When the time warp is complete.

static transform_position (*position*, *from*, *to*)
Converts a position vector from one reference frame to another.

Parameters

- **position** (*Tuple*) – Position vector in reference frame *from*.
- **from** (*ReferenceFrame*) – The reference frame that the position vector is in.
- **to** (*ReferenceFrame*) – The reference frame to covert the position vector to.

Returns The corresponding position vector in reference frame *to*.

Return type Tuple of (number, number, number)

static transform_direction (*direction*, *from*, *to*)
Converts a direction vector from one reference frame to another.

Parameters

- **direction** (*Tuple*) – Direction vector in reference frame *from*.
- **from** (*ReferenceFrame*) – The reference frame that the direction vector is in.
- **to** (*ReferenceFrame*) – The reference frame to covert the direction vector to.

Returns The corresponding direction vector in reference frame *to*.

Return type Tuple of (number, number, number)

static transform_rotation (*rotation*, *from*, *to*)
Converts a rotation from one reference frame to another.

Parameters

- **rotation** (*Tuple*) – Rotation in reference frame *from*.
- **from** (*ReferenceFrame*) – The reference frame that the rotation is in.
- **to** (*ReferenceFrame*) – The corresponding rotation in reference frame *to*.

Returns The corresponding rotation in reference frame *to*.

Return type Tuple of (number, number, number, number)

static transform_velocity (*position*, *velocity*, *from*, *to*)
Converts a velocity vector (acting at the specified position vector) from one reference frame to another. The position vector is required to take the relative angular velocity of the reference frames into account.

Parameters

- **position** (*Tuple*) – Position vector in reference frame *from*.
- **velocity** (*Tuple*) – Velocity vector in reference frame *from*.

- **from** (*ReferenceFrame*) – The reference frame that the position and velocity vectors are in.
- **to** (*ReferenceFrame*) – The reference frame to covert the velocity vector to.

Returns The corresponding velocity in reference frame *to*.

Return type Tuple of (number, number, number)

far_available
Whether Ferram Aerospace Research is installed.

Attribute Read-only, cannot be set

Return type boolean

remote_tech_available
Whether RemoteTech is installed.

Attribute Read-only, cannot be set

Return type boolean

static **draw_direction** (*direction*, *reference_frame*, *color*[, *length = 10.0*])
Draw a direction vector on the active vessel.

Parameters

- **direction** (*Tuple*) – Direction to draw the line in.
- **reference_frame** (*ReferenceFrame*) – Reference frame that the direction is in.
- **color** (*Tuple*) – The color to use for the line, as an RGB color.
- **length** (*number*) – The length of the line. Defaults to 10.

static **draw_line** (*start*, *end*, *reference_frame*, *color*)
Draw a line.

Parameters

- **start** (*Tuple*) – Position of the start of the line.
- **end** (*Tuple*) – Position of the end of the line.
- **reference_frame** (*ReferenceFrame*) – Reference frame that the position are in.
- **color** (*Tuple*) – The color to use for the line, as an RGB color.

static **clear_drawing** ()
Remove all directions and lines currently being drawn.

class SpaceCenter.**WarpMode**
Returned by warp_mode

rails
Time warp is active, and in regular “on-rails” mode.

physics
Time warp is active, and in physical time warp mode.

none
Time warp is not active.

6.2.2 Vessel

class SpaceCenter.**Vessel**

These objects are used to interact with vessels in KSP. This includes getting orbital and flight data, manipulating control inputs and managing resources.

name

The name of the vessel.

Attribute Can be read or written

Return type string

type

The type of the vessel.

Attribute Can be read or written

Return type *VesselType*

situation

The situation the vessel is in.

Attribute Read-only, cannot be set

Return type *VesselSituation*

met

The mission elapsed time in seconds.

Attribute Read-only, cannot be set

Return type number

flight ([*reference_frame = None*])

Returns a *Flight* object that can be used to get flight telemetry for the vessel, in the specified reference frame.

Parameters **reference_frame** (*ReferenceFrame*) – Reference frame. Defaults to the vessel's surface reference frame (*Vessel.surface_reference_frame*).

Return type *Flight*

target

The target vessel. `nil` if there is no target. When setting the target, the target cannot be the current vessel.

Attribute Can be read or written

Return type *Vessel*

orbit

The current orbit of the vessel.

Attribute Read-only, cannot be set

Return type *Orbit*

control

Returns a *Control* object that can be used to manipulate the vessel's control inputs. For example, its pitch/yaw/roll controls, RCS and thrust.

Attribute Read-only, cannot be set

Return type *Control*

auto_pilot
An *AutoPilot* object, that can be used to perform simple auto-piloting of the vessel.

Attribute Read-only, cannot be set

Return type *AutoPilot*

resources
A *Resources* object, that can used to get information about resources stored in the vessel.

Attribute Read-only, cannot be set

Return type *Resources*

resources_in_decouple_stage (*stage*[, *cumulative = True*])
Returns a *Resources* object, that can used to get information about resources stored in a given *stage*.

Parameters

- **stage** (*number*) – Get resources for parts that are decoupled in this stage.
- **cumulative** (*boolean*) – When False, returns the resources for parts decoupled in just the given stage. When True returns the resources decoupled in the given stage and all subsequent stages combined.

Return type *Resources*

Note: For details on stage numbering, see the discussion on *Staging*.

parts
A *Parts* object, that can used to interact with the parts that make up this vessel.

Attribute Read-only, cannot be set

Return type *Parts*

comms
A *Comms* object, that can used to interact with RemoteTech for this vessel.

Attribute Read-only, cannot be set

Return type *Comms*

Note: Requires RemoteTech to be installed.

mass
The total mass of the vessel, including resources, in kg.

Attribute Read-only, cannot be set

Return type number

dry_mass
The total mass of the vessel, excluding resources, in kg.

Attribute Read-only, cannot be set

Return type number

thrust
The total thrust currently being produced by the vessel's engines, in Newtons. This is computed by summing *Engine.thrust* for every engine in the vessel.

Attribute Read-only, cannot be set

Return type number

available_thrust

Gets the total available thrust that can be produced by the vessel's active engines, in Newtons. This is computed by summing *Engine.available_thrust* for every active engine in the vessel.

Attribute Read-only, cannot be set

Return type number

max_thrust

The total maximum thrust that can be produced by the vessel's active engines, in Newtons. This is computed by summing *Engine.max_thrust* for every active engine.

Attribute Read-only, cannot be set

Return type number

max_vacuum_thrust

The total maximum thrust that can be produced by the vessel's active engines when the vessel is in a vacuum, in Newtons. This is computed by summing *Engine.max_vacuum_thrust* for every active engine.

Attribute Read-only, cannot be set

Return type number

specific_impulse

The combined specific impulse of all active engines, in seconds. This is computed using the formula described here.

Attribute Read-only, cannot be set

Return type number

vacuum_specific_impulse

The combined vacuum specific impulse of all active engines, in seconds. This is computed using the formula described here.

Attribute Read-only, cannot be set

Return type number

kerbin_sea_level_specific_impulse

The combined specific impulse of all active engines at sea level on Kerbin, in seconds. This is computed using the formula described here.

Attribute Read-only, cannot be set

Return type number

reference_frame

The reference frame that is fixed relative to the vessel, and orientated with the vessel.

- The origin is at the center of mass of the vessel.
- The axes rotate with the vessel.
- The x-axis points out to the right of the vessel.
- The y-axis points in the forward direction of the vessel.
- The z-axis points out of the bottom off the vessel.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

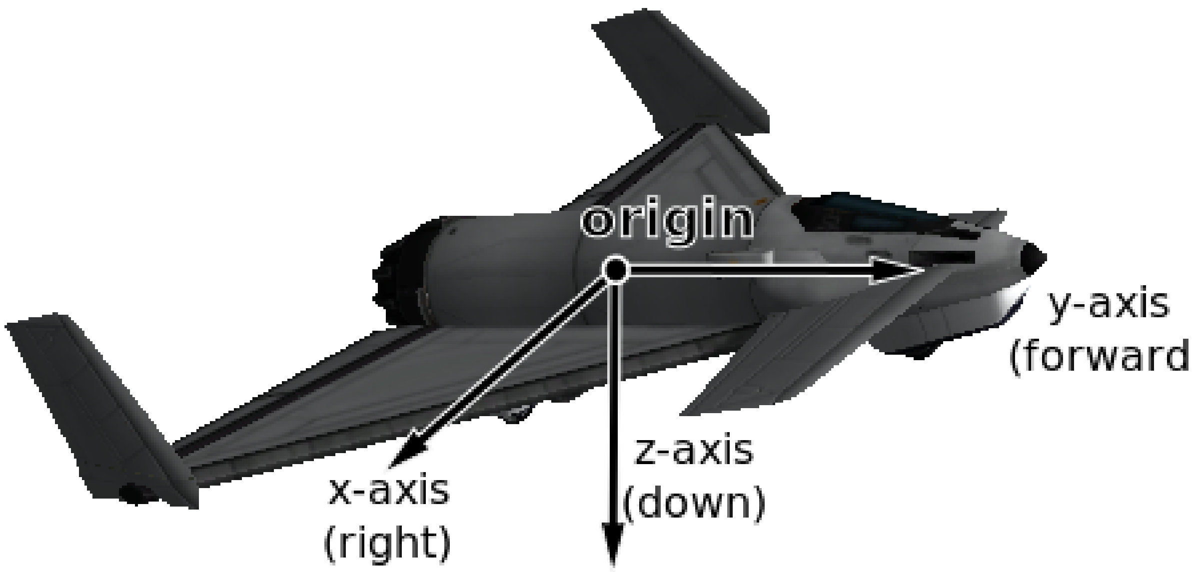


Fig. 6.1: Vessel reference frame origin and axes for the Aeris 3A aircraft

orbital_reference_frame

The reference frame that is fixed relative to the vessel, and orientated with the vessels orbital prograde/normal/radial directions.

- The origin is at the center of mass of the vessel.
- The axes rotate with the orbital prograde/normal/radial directions.
- The x-axis points in the orbital anti-radial direction.
- The y-axis points in the orbital prograde direction.
- The z-axis points in the orbital normal direction.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

Note: Be careful not to confuse this with 'orbit' mode on the navball.

surface_reference_frame

The reference frame that is fixed relative to the vessel, and orientated with the surface of the body being orbited.

- The origin is at the center of mass of the vessel.
- The axes rotate with the north and up directions on the surface of the body.
- The x-axis points in the zenith direction (upwards, normal to the body being orbited, from the center of the body towards the center of mass of the vessel).
- The y-axis points northwards towards the astronomical horizon (north, and tangential to the surface of the body – the direction in which a compass would point when on the surface).

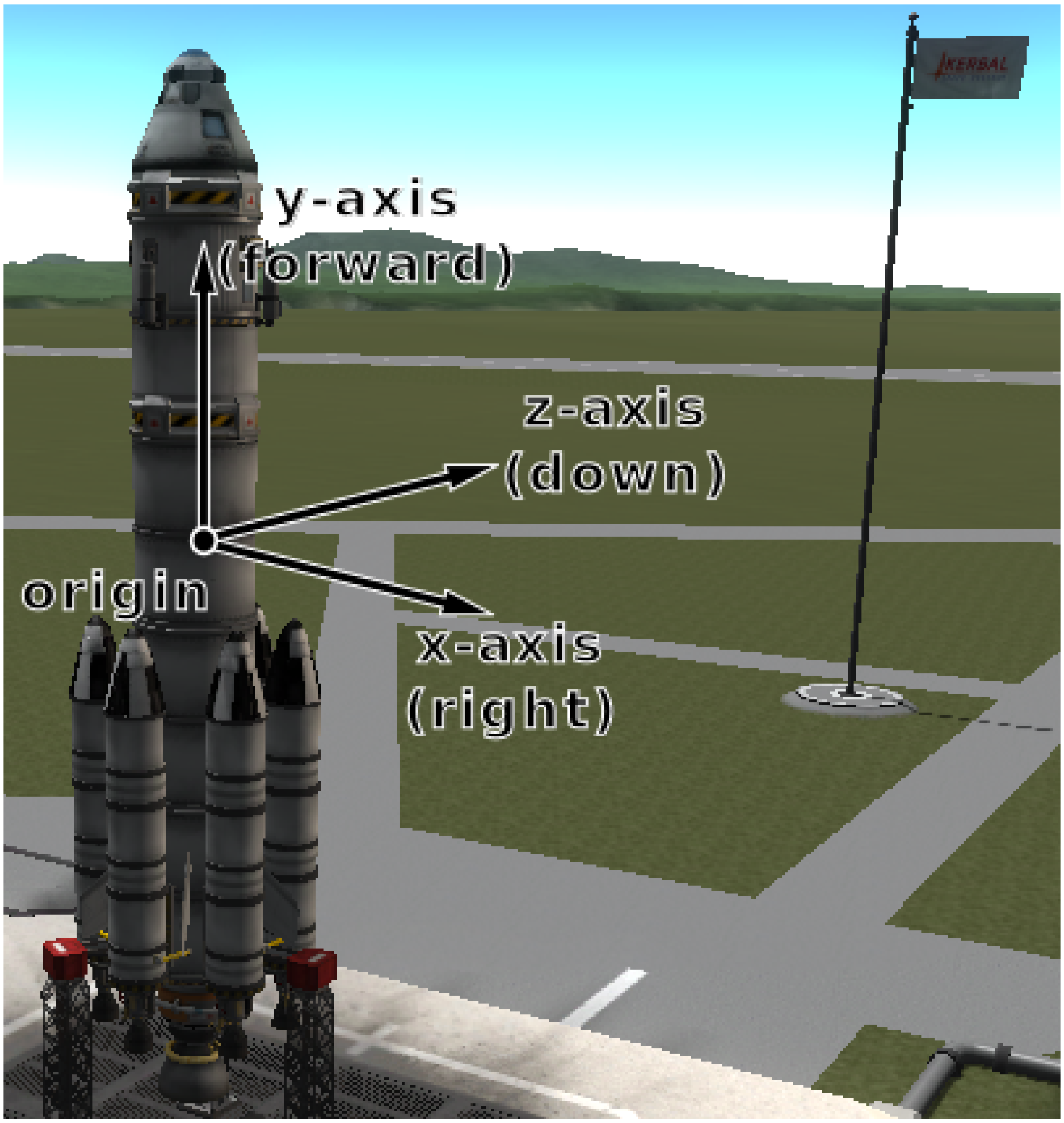


Fig. 6.2: Vessel reference frame origin and axes for the Kerbal-X rocket

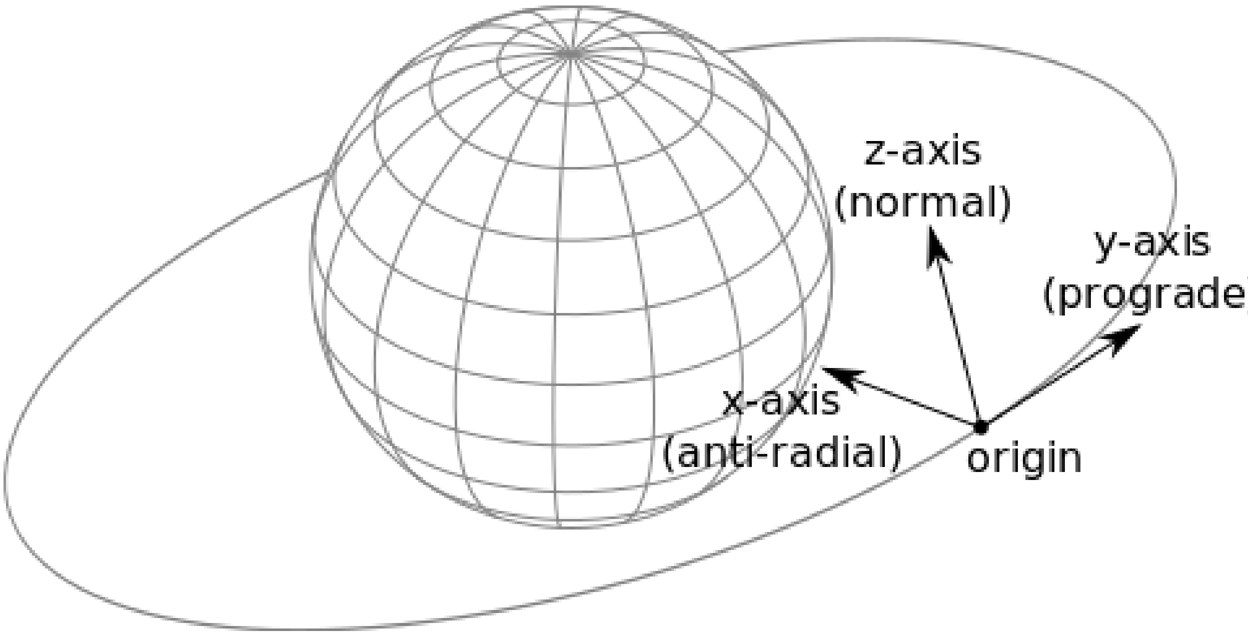


Fig. 6.3: Vessel orbital reference frame origin and axes

- The z-axis points eastwards towards the astronomical horizon (east, and tangential to the surface of the body – east on a compass when on the surface).

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

Note: Be careful not to confuse this with 'surface' mode on the navball.

surface_velocity_reference_frame

The reference frame that is fixed relative to the vessel, and orientated with the velocity vector of the vessel relative to the surface of the body being orbited.

- The origin is at the center of mass of the vessel.
- The axes rotate with the vessel's velocity vector.
- The y-axis points in the direction of the vessel's velocity vector, relative to the surface of the body being orbited.
- The z-axis is in the plane of the astronomical horizon.
- The x-axis is orthogonal to the other two axes.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

position (*reference_frame*)

Returns the position vector of the center of mass of the vessel in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

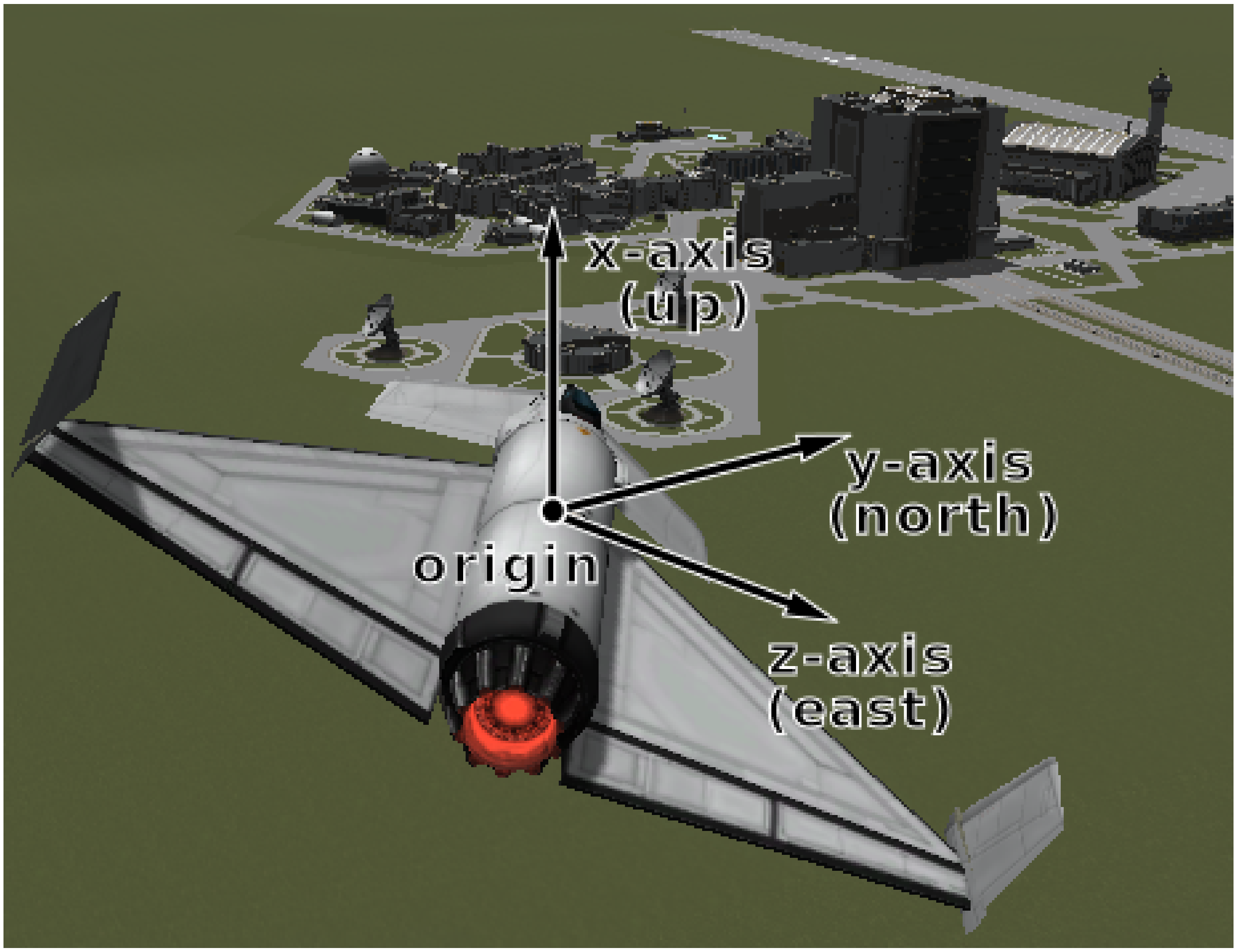


Fig. 6.4: Vessel surface reference frame origin and axes

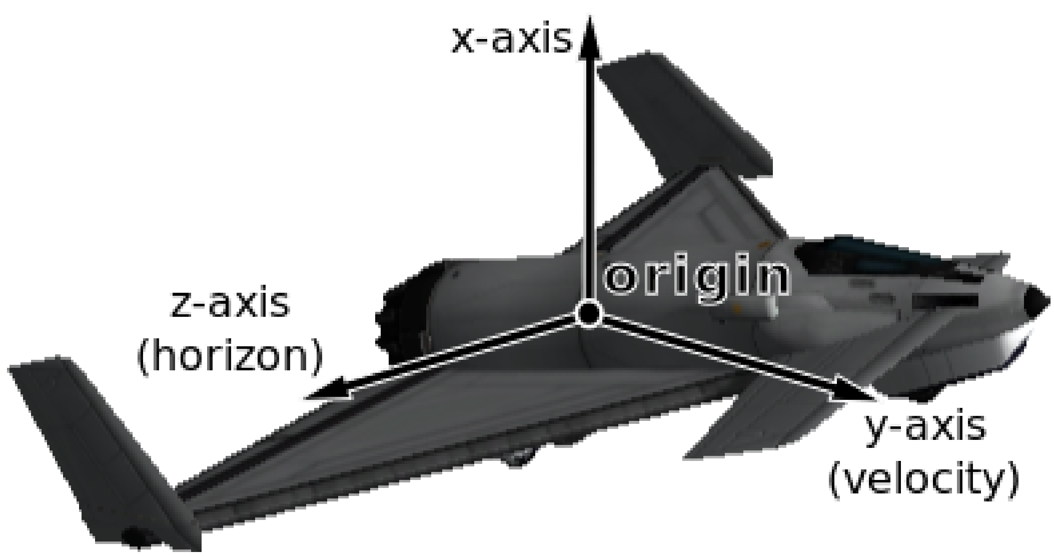


Fig. 6.5: Vessel surface velocity reference frame origin and axes

velocity (*reference_frame*)
Returns the velocity vector of the center of mass of the vessel in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

rotation (*reference_frame*)
Returns the rotation of the center of mass of the vessel in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number, number)

direction (*reference_frame*)
Returns the direction in which the vessel is pointing, as a unit vector, in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

angular_velocity (*reference_frame*)
Returns the angular velocity of the vessel in the given reference frame. The magnitude of the returned vector is the rotational speed in radians per second, and the direction of the vector indicates the axis of rotation (using the right hand rule).

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

class SpaceCenter.**VesselType**
See *Vessel.type*.

ship
Ship.

station
Station.

lander
Lander.

probe
Probe.

rover
Rover.

base
Base.

debris
Debris.

class SpaceCenter.**VesselSituation**
See *Vessel.situation*.

docked
Vessel is docked to another.

escaping
Escaping.

flying
Vessel is flying through an atmosphere.

landed
Vessel is landed on the surface of a body.

orbiting
Vessel is orbiting a body.

pre_launch
Vessel is awaiting launch.

splashed
Vessel has splashed down in an ocean.

sub_orbital
Vessel is on a sub-orbital trajectory.

6.2.3 CelestialBody

class SpaceCenter.**CelestialBody**
Represents a celestial body (such as a planet or moon).

name
The name of the body.

Attribute Read-only, cannot be set

Return type string

satellites
A list of celestial bodies that are in orbit around this celestial body.

Attribute Read-only, cannot be set

Return type List of *CelestialBody*

orbit
The orbit of the body.

Attribute Read-only, cannot be set

Return type *Orbit*

mass
The mass of the body, in kilograms.

Attribute Read-only, cannot be set

Return type number

gravitational_parameter
The standard gravitational parameter of the body in m^3s^{-2}.

Attribute Read-only, cannot be set

Return type number

surface_gravity
The acceleration due to gravity at sea level (mean altitude) on the body, in m/s^2.

Attribute Read-only, cannot be set

Return type number

rotational_period
The sidereal rotational period of the body, in seconds.

Attribute Read-only, cannot be set

Return type number

rotational_speed
The rotational speed of the body, in radians per second.

Attribute Read-only, cannot be set

Return type number

equatorial_radius
The equatorial radius of the body, in meters.

Attribute Read-only, cannot be set

Return type number

surface_height (*latitude*, *longitude*)
The height of the surface relative to mean sea level at the given position, in meters. When over water this is equal to 0.

Parameters

- **latitude** (*number*) – Latitude in degrees
- **longitude** (*number*) – Longitude in degrees

Return type number

bedrock_height (*latitude*, *longitude*)
The height of the surface relative to mean sea level at the given position, in meters. When over water, this is the height of the sea-bed and is therefore a negative value.

Parameters

- **latitude** (*number*) – Latitude in degrees
- **longitude** (*number*) – Longitude in degrees

Return type number

msl_position (*latitude*, *longitude*, *reference_frame*)
The position at mean sea level at the given latitude and longitude, in the given reference frame.

Parameters

- **latitude** (*number*) – Latitude in degrees
- **longitude** (*number*) – Longitude in degrees
- **reference_frame** (*ReferenceFrame*) – Reference frame for the returned position vector

Return type Tuple of (number, number, number)

surface_position (*latitude*, *longitude*, *reference_frame*)
The position of the surface at the given latitude and longitude, in the given reference frame. When over water, this is the position of the surface of the water.

Parameters

- **latitude** (*number*) – Latitude in degrees
- **longitude** (*number*) – Longitude in degrees
- **reference_frame** (*ReferenceFrame*) – Reference frame for the returned position vector

Return type Tuple of (number, number, number)

bedrock_position (*latitude*, *longitude*, *reference_frame*)

The position of the surface at the given latitude and longitude, in the given reference frame. When over water, this is the position at the bottom of the sea-bed.

Parameters

- **latitude** (*number*) – Latitude in degrees
- **longitude** (*number*) – Longitude in degrees
- **reference_frame** (*ReferenceFrame*) – Reference frame for the returned position vector

Return type Tuple of (number, number, number)

sphere_of_influence

The radius of the sphere of influence of the body, in meters.

Attribute Read-only, cannot be set

Return type number

has_atmosphere

`True` if the body has an atmosphere.

Attribute Read-only, cannot be set

Return type boolean

atmosphere_depth

The depth of the atmosphere, in meters.

Attribute Read-only, cannot be set

Return type number

has_atmospheric_oxygen

`True` if there is oxygen in the atmosphere, required for air-breathing engines.

Attribute Read-only, cannot be set

Return type boolean

reference_frame

The reference frame that is fixed relative to the celestial body.

- The origin is at the center of the body.
- The axes rotate with the body.
- The x-axis points from the center of the body towards the intersection of the prime meridian and equator (the position at 0° longitude, 0° latitude).
- The y-axis points from the center of the body towards the north pole.
- The z-axis points from the center of the body towards the equator at 90°E longitude.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

non_rotating_reference_frame

The reference frame that is fixed relative to this celestial body, and orientated in a fixed direction (it does not rotate with the body).

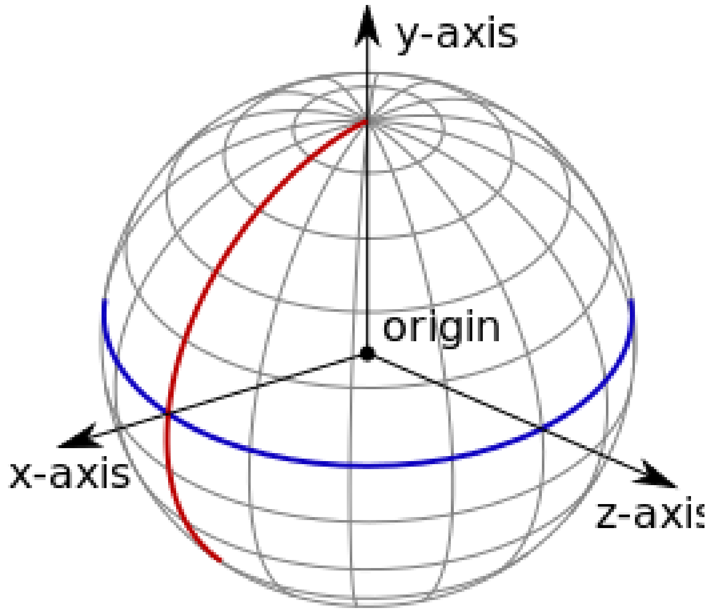


Fig. 6.6: Celestial body reference frame origin and axes. The equator is shown in blue, and the prime meridian in red.

- The origin is at the center of the body.
- The axes do not rotate.
- The x-axis points in an arbitrary direction through the equator.
- The y-axis points from the center of the body towards the north pole.
- The z-axis points in an arbitrary direction through the equator.

Attribute Read-only, cannot be set

Return type `ReferenceFrame`

`orbital_reference_frame`

Gets the reference frame that is fixed relative to this celestial body, but orientated with the body's orbital prograde/normal/radial directions.

- The origin is at the center of the body.
- The axes rotate with the orbital prograde/normal/radial directions.
- The x-axis points in the orbital anti-radial direction.
- The y-axis points in the orbital prograde direction.
- The z-axis points in the orbital normal direction.

Attribute Read-only, cannot be set

Return type `ReferenceFrame`

`position` (*reference_frame*)

Returns the position vector of the center of the body in the specified reference frame.

Parameters **`reference_frame`** (`ReferenceFrame`) –

Return type Tuple of (number, number, number)

velocity (*reference_frame*)
Returns the velocity vector of the body in the specified reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

rotation (*reference_frame*)
Returns the rotation of the body in the specified reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number, number)

direction (*reference_frame*)
Returns the direction in which the north pole of the celestial body is pointing, as a unit vector, in the specified reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

angular_velocity (*reference_frame*)
Returns the angular velocity of the body in the specified reference frame. The magnitude of the vector is the rotational speed of the body, in radians per second, and the direction of the vector indicates the axis of rotation, using the right-hand rule.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

6.2.4 Flight

class SpaceCenter.**Flight**
Used to get flight telemetry for a vessel, by calling *Vessel.flight()*. All of the information returned by this class is given in the reference frame passed to that method.

Note: To get orbital information, such as the apoapsis or inclination, see *Orbit*.

g_force
The current G force acting on the vessel in m/s^2.

Attribute Read-only, cannot be set

Return type number

mean_altitude
The altitude above sea level, in meters.

Attribute Read-only, cannot be set

Return type number

surface_altitude
The altitude above the surface of the body or sea level, whichever is closer, in meters.

Attribute Read-only, cannot be set

Return type number

bedrock_altitude

The altitude above the surface of the body, in meters. When over water, this is the altitude above the sea floor.

Attribute Read-only, cannot be set

Return type number

elevation

The elevation of the terrain under the vessel, in meters. This is the height of the terrain above sea level, and is negative when the vessel is over the sea.

Attribute Read-only, cannot be set

Return type number

latitude

The latitude of the vessel for the body being orbited, in degrees.

Attribute Read-only, cannot be set

Return type number

longitude

The longitude of the vessel for the body being orbited, in degrees.

Attribute Read-only, cannot be set

Return type number

velocity

The velocity vector of the vessel. The magnitude of the vector is the speed of the vessel in meters per second. The direction of the vector is the direction of the vessels motion.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

speed

The speed of the vessel in meters per second.

Attribute Read-only, cannot be set

Return type number

horizontal_speed

The horizontal speed of the vessel in meters per second.

Attribute Read-only, cannot be set

Return type number

vertical_speed

The vertical speed of the vessel in meters per second.

Attribute Read-only, cannot be set

Return type number

center_of_mass

The position of the center of mass of the vessel.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

rotation
The rotation of the vessel.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number, number)

direction
The direction vector that the vessel is pointing in.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

pitch
The pitch angle of the vessel relative to the horizon, in degrees. A value between -90° and +90°.

Attribute Read-only, cannot be set

Return type number

heading
The heading angle of the vessel relative to north, in degrees. A value between 0° and 360°.

Attribute Read-only, cannot be set

Return type number

roll
The roll angle of the vessel relative to the horizon, in degrees. A value between -180° and +180°.

Attribute Read-only, cannot be set

Return type number

prograde
The unit direction vector pointing in the prograde direction.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

retrograde
The unit direction vector pointing in the retrograde direction.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

normal
The unit direction vector pointing in the normal direction.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

anti_normal
The unit direction vector pointing in the anti-normal direction.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

radial
The unit direction vector pointing in the radial direction.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

anti_radial
The unit direction vector pointing in the anti-radial direction.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

atmosphere_density
The current density of the atmosphere around the vessel, in kg/m^3.

Attribute Read-only, cannot be set

Return type number

dynamic_pressure
The dynamic pressure acting on the vessel, in Pascals. This is a measure of the strength of the aerodynamic forces. It is equal to $\frac{1}{2}$.air density.velocity^2. It is commonly denoted as Q.

Attribute Read-only, cannot be set

Return type number

Note: Calculated using KSPs stock aerodynamic model, or Ferram Aerospace Research if it is installed.

static_pressure
The static atmospheric pressure acting on the vessel, in Pascals.

Attribute Read-only, cannot be set

Return type number

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

aerodynamic_force
The total aerodynamic forces acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

lift
The aerodynamic lift currently acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

drag

The aerodynamic drag currently acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Attribute Read-only, cannot be set

Return type Tuple of (number, number, number)

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

speed_of_sound

The speed of sound, in the atmosphere around the vessel, in m/s.

Attribute Read-only, cannot be set

Return type number

Note: Not available when Ferram Aerospace Research is installed.

mach

The speed of the vessel, in multiples of the speed of sound.

Attribute Read-only, cannot be set

Return type number

Note: Not available when Ferram Aerospace Research is installed.

equivalent_air_speed

The equivalent air speed of the vessel, in m/s.

Attribute Read-only, cannot be set

Return type number

Note: Not available when Ferram Aerospace Research is installed.

terminal_velocity

An estimate of the current terminal velocity of the vessel, in m/s. This is the speed at which the drag forces cancel out the force of gravity.

Attribute Read-only, cannot be set

Return type number

Note: Calculated using KSPs stock aerodynamic model, or Ferram Aerospace Research if it is installed.

angle_of_attack

Gets the pitch angle between the orientation of the vessel and its velocity vector, in degrees.

Attribute Read-only, cannot be set

Return type number

sideslip_angle
Gets the yaw angle between the orientation of the vessel and its velocity vector, in degrees.

Attribute Read-only, cannot be set

Return type number

total_air_temperature
The total air temperature of the atmosphere around the vessel, in Kelvin. This temperature includes the *Flight.static_air_temperature* and the vessel's kinetic energy.

Attribute Read-only, cannot be set

Return type number

static_air_temperature
The static (ambient) temperature of the atmosphere around the vessel, in Kelvin.

Attribute Read-only, cannot be set

Return type number

stall_fraction
Gets the current amount of stall, between 0 and 1. A value greater than 0.005 indicates a minor stall and a value greater than 0.5 indicates a large-scale stall.

Attribute Read-only, cannot be set

Return type number

Note: Requires Ferram Aerospace Research.

drag_coefficient
Gets the coefficient of drag. This is the amount of drag produced by the vessel. It depends on air speed, air density and wing area.

Attribute Read-only, cannot be set

Return type number

Note: Requires Ferram Aerospace Research.

lift_coefficient
Gets the coefficient of lift. This is the amount of lift produced by the vessel, and depends on air speed, air density and wing area.

Attribute Read-only, cannot be set

Return type number

Note: Requires Ferram Aerospace Research.

ballistic_coefficient
Gets the ballistic coefficient.

Attribute Read-only, cannot be set

Return type number

Note: Requires Ferram Aerospace Research.

thrust_specific_fuel_consumption
Gets the thrust specific fuel consumption for the jet engines on the vessel. This is a measure of the efficiency of the engines, with a lower value indicating a more efficient vessel. This value is the number of Newtons of fuel that are burned, per hour, to product one newton of thrust.

Attribute Read-only, cannot be set

Return type number

Note: Requires Ferram Aerospace Research.

6.2.5 Orbit

class `SpaceCenter.`**`Orbit`**
Describes an orbit. For example, the orbit of a vessel, obtained by calling `Vessel.orbit`, or a celestial body, obtained by calling `CelestialBody.orbit`.

body
The celestial body (e.g. planet or moon) around which the object is orbiting.

Attribute Read-only, cannot be set

Return type `CelestialBody`

apoapsis
Gets the apoapsis of the orbit, in meters, from the center of mass of the body being orbited.

Attribute Read-only, cannot be set

Return type number

Note: For the apoapsis altitude reported on the in-game map view, use `Orbit.apoapsis_altitude`.

periapsis
The periapsis of the orbit, in meters, from the center of mass of the body being orbited.

Attribute Read-only, cannot be set

Return type number

Note: For the periapsis altitude reported on the in-game map view, use `Orbit.periapsis_altitude`.

apoapsis_altitude
The apoapsis of the orbit, in meters, above the sea level of the body being orbited.

Attribute Read-only, cannot be set

Return type number

Note: This is equal to `Orbit.apoapsis` minus the equatorial radius of the body.

periapsis_altitude
The periapsis of the orbit, in meters, above the sea level of the body being orbited.

Attribute Read-only, cannot be set

Return type number

Note: This is equal to *Orbit.periapsis* minus the equatorial radius of the body.

semi_major_axis
The semi-major axis of the orbit, in meters.

Attribute Read-only, cannot be set

Return type number

semi_minor_axis
The semi-minor axis of the orbit, in meters.

Attribute Read-only, cannot be set

Return type number

radius
The current radius of the orbit, in meters. This is the distance between the center of mass of the object in orbit, and the center of mass of the body around which it is orbiting.

Attribute Read-only, cannot be set

Return type number

Note: This value will change over time if the orbit is elliptical.

speed
The current orbital speed of the object in meters per second.

Attribute Read-only, cannot be set

Return type number

Note: This value will change over time if the orbit is elliptical.

period
The orbital period, in seconds.

Attribute Read-only, cannot be set

Return type number

time_to_apoapsis
The time until the object reaches apoapsis, in seconds.

Attribute Read-only, cannot be set

Return type number

time_to_periapsis
The time until the object reaches periapsis, in seconds.

Attribute Read-only, cannot be set

Return type number

eccentricity
The eccentricity of the orbit.

Attribute Read-only, cannot be set

Return type number

inclination
The inclination of the orbit, in radians.

Attribute Read-only, cannot be set

Return type number

longitude_of_ascending_node
The longitude of the ascending node, in radians.

Attribute Read-only, cannot be set

Return type number

argument_of_periapsis
The argument of periapsis, in radians.

Attribute Read-only, cannot be set

Return type number

mean_anomaly_at_epoch
The mean anomaly at epoch.

Attribute Read-only, cannot be set

Return type number

epoch
The time since the epoch (the point at which the mean anomaly at epoch was measured, in seconds.

Attribute Read-only, cannot be set

Return type number

mean_anomaly
The mean anomaly.

Attribute Read-only, cannot be set

Return type number

eccentric_anomaly
The eccentric anomaly.

Attribute Read-only, cannot be set

Return type number

static **reference_plane_normal** (*reference_frame*)
The unit direction vector that is normal to the orbits reference plane, in the given reference frame. The reference plane is the plane from which the orbits inclination is measured.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

static **reference_plane_direction** (*reference_frame*)
The unit direction vector from which the orbits longitude of ascending node is measured, in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

time_to_soi_change
The time until the object changes sphere of influence, in seconds. Returns `NaN` if the object is not going to change sphere of influence.

Attribute Read-only, cannot be set

Return type number

next_orbit
If the object is going to change sphere of influence in the future, returns the new orbit after the change. Otherwise returns `nil`.

Attribute Read-only, cannot be set

Return type *Orbit*

6.2.6 Control

class SpaceCenter.**Control**
Used to manipulate the controls of a vessel. This includes adjusting the throttle, enabling/disabling systems such as SAS and RCS, or altering the direction in which the vessel is pointing.

Note: Control inputs (such as pitch, yaw and roll) are zeroed when all clients that have set one or more of these inputs are no longer connected.

sas
The state of SAS.

Attribute Can be read or written

Return type boolean

Note: Equivalent to *AutoPilot.sas*

sas_mode
The current *SASMode*. These modes are equivalent to the mode buttons to the left of the navball that appear when SAS is enabled.

Attribute Can be read or written

Return type *SASMode*

Note: Equivalent to *AutoPilot.sas_mode*

speed_mode
The current *SpeedMode* of the navball. This is the mode displayed next to the speed at the top of the navball.

Attribute Can be read or written

Return type *SpeedMode*

rcs
The state of RCS.

Attribute Can be read or written

Return type boolean

gear
The state of the landing gear/legs.

Attribute Can be read or written

Return type boolean

lights
The state of the lights.

Attribute Can be read or written

Return type boolean

brakes
The state of the wheel brakes.

Attribute Can be read or written

Return type boolean

abort
The state of the abort action group.

Attribute Can be read or written

Return type boolean

throttle
The state of the throttle. A value between 0 and 1.

Attribute Can be read or written

Return type number

pitch
The state of the pitch control. A value between -1 and 1. Equivalent to the w and s keys.

Attribute Can be read or written

Return type number

yaw
The state of the yaw control. A value between -1 and 1. Equivalent to the a and d keys.

Attribute Can be read or written

Return type number

roll
The state of the roll control. A value between -1 and 1. Equivalent to the q and e keys.

Attribute Can be read or written

Return type number

forward
The state of the forward translational control. A value between -1 and 1. Equivalent to the h and n keys.

Attribute Can be read or written

Return type number

up
The state of the up translational control. A value between -1 and 1. Equivalent to the i and k keys.

Attribute Can be read or written

Return type number

right
The state of the right translational control. A value between -1 and 1. Equivalent to the j and l keys.

Attribute Can be read or written

Return type number

wheel_throttle
The state of the wheel throttle. A value between -1 and 1. A value of 1 rotates the wheels forwards, a value of -1 rotates the wheels backwards.

Attribute Can be read or written

Return type number

wheel_steering
The state of the wheel steering. A value between -1 and 1. A value of 1 steers to the left, and a value of -1 steers to the right.

Attribute Can be read or written

Return type number

current_stage
The current stage of the vessel. Corresponds to the stage number in the in-game UI.

Attribute Read-only, cannot be set

Return type number

activate_next_stage()
Activates the next stage. Equivalent to pressing the space bar in-game.

Returns A list of vessel objects that are jettisoned from the active vessel.

Return type List of *Vessel*

get_action_group(*group*)
Returns `True` if the given action group is enabled.

Parameters **group** (*number*) – A number between 0 and 9 inclusive.

Return type boolean

set_action_group(*group*, *state*)
Sets the state of the given action group (a value between 0 and 9 inclusive).

Parameters

- **group** (*number*) – A number between 0 and 9 inclusive.
- **state** (*boolean*) –

toggle_action_group(*group*)
Toggles the state of the given action group.

Parameters **group** (*number*) – A number between 0 and 9 inclusive.

add_node (*ut*[, *prograde = 0.0*][, *normal = 0.0*][, *radial = 0.0*])
Creates a maneuver node at the given universal time, and returns a *Node* object that can be used to modify it. Optionally sets the magnitude of the delta-v for the maneuver node in the prograde, normal and radial directions.

Parameters

- **ut** (*number*) – Universal time of the maneuver node.
- **prograde** (*number*) – Delta-v in the prograde direction.
- **normal** (*number*) – Delta-v in the normal direction.
- **radial** (*number*) – Delta-v in the radial direction.

Return type *Node*

nodes
Returns a list of all existing maneuver nodes, ordered by time from first to last.

Attribute Read-only, cannot be set

Return type List of *Node*

remove_nodes ()
Remove all maneuver nodes.

class SpaceCenter.**SASMode**
The behavior of the SAS auto-pilot. See *AutoPilot.sas_mode*.

stability_assist
Stability assist mode. Dampen out any rotation.

maneuver
Point in the burn direction of the next maneuver node.

prograde
Point in the prograde direction.

retrograde
Point in the retrograde direction.

normal
Point in the orbit normal direction.

anti_normal
Point in the orbit anti-normal direction.

radial
Point in the orbit radial direction.

anti_radial
Point in the orbit anti-radial direction.

target
Point in the direction of the current target.

anti_target
Point away from the current target.

class SpaceCenter.**SpeedMode**
See *Control.speed_mode*.

orbit
Speed is relative to the vessel's orbit.

surface
Speed is relative to the surface of the body being orbited.

target
Speed is relative to the current target.

6.2.7 Parts

The following classes allow interaction with a vessels individual parts.

Parts

class `SpaceCenter.`**`Parts`**
Instances of this class are used to interact with the parts of a vessel. An instance can be obtained by calling `Vessel.parts`.

all
A list of all of the vessels parts.

Attribute Read-only, cannot be set

Return type List of `Part`

root
The vessels root part.

Attribute Read-only, cannot be set

Return type `Part`

Note: See the discussion on *Trees of Parts*.

controlling

The part from which the vessel is controlled.

Attribute Can be read or written

Return type `Part`

with_name (*name*)

A list of parts whose `Part.name` is *name*.

Parameters **name** (`string`) –

Return type List of `Part`

with_title (*title*)

A list of all parts whose `Part.title` is *title*.

Parameters **title** (`string`) –

Return type List of `Part`

with_module (*module_name*)

A list of all parts that contain a `Module` whose `Module.name` is *module_name*.

Parameters **module_name** (`string`) –

Return type List of `Part`

in_stage (*stage*)

A list of all parts that are activated in the given *stage*.

Parameters **stage** (`number`) –

Return type List of `Part`

Note: See the discussion on *Staging*.

in_decouple_stage (*stage*)

A list of all parts that are decoupled in the given *stage*.

Parameters **stage** (`number`) –

Return type List of `Part`

Note: See the discussion on *Staging*.

modules_with_name (*module_name*)

A list of modules (combined across all parts in the vessel) whose `Module.name` is *module_name*.

Parameters **module_name** (`string`) –

Return type List of `Module`

decouplers

A list of all decouplers in the vessel.

Attribute Read-only, cannot be set

Return type List of `Decoupler`

docking_ports
A list of all docking ports in the vessel.

Attribute Read-only, cannot be set

Return type List of *DockingPort*

docking_port_with_name (*name*)
The first docking port in the vessel with the given port name, as returned by *DockingPort.name*. Returns `nil` if there are no such docking ports.

Parameters **name** (*string*) –

Return type *DockingPort*

engines
A list of all engines in the vessel.

Attribute Read-only, cannot be set

Return type List of *Engine*

landing_gear
A list of all landing gear attached to the vessel.

Attribute Read-only, cannot be set

Return type List of *LandingGear*

landing_legs
A list of all landing legs attached to the vessel.

Attribute Read-only, cannot be set

Return type List of *LandingLeg*

launch_clamps
A list of all launch clamps attached to the vessel.

Attribute Read-only, cannot be set

Return type List of *LaunchClamp*

lights
A list of all lights in the vessel.

Attribute Read-only, cannot be set

Return type List of *Light*

parachutes
A list of all parachutes in the vessel.

Attribute Read-only, cannot be set

Return type List of *Parachute*

radiators
A list of all radiators in the vessel.

Attribute Read-only, cannot be set

Return type List of *Radiator*

resource_converters
A list of all resource converters in the vessel.

Attribute Read-only, cannot be set

Return type List of *ResourceConverter*

resource_harvesters
A list of all resource harvesters in the vessel.

Attribute Read-only, cannot be set

Return type List of *ResourceHarvester*

reaction_wheels
A list of all reaction wheels in the vessel.

Attribute Read-only, cannot be set

Return type List of *ReactionWheel*

sensors
A list of all sensors in the vessel.

Attribute Read-only, cannot be set

Return type List of *Sensor*

solar_panels
A list of all solar panels in the vessel.

Attribute Read-only, cannot be set

Return type List of *SolarPanel*

Part

class SpaceCenter.**Part**
Instances of this class represents a part. A vessel is made of multiple parts. Instances can be obtained by various methods in *Parts*.

name
Internal name of the part, as used in part cfg files. For example “Mark1-2Pod”.

Attribute Read-only, cannot be set

Return type string

title
Title of the part, as shown when the part is right clicked in-game. For example “Mk1-2 Command Pod”.

Attribute Read-only, cannot be set

Return type string

cost
The cost of the part, in units of funds.

Attribute Read-only, cannot be set

Return type number

vessel
The vessel that contains this part.

Attribute Read-only, cannot be set

Return type *Vessel*

parent

The parts parent. Returns `nil` if the part does not have a parent. This, in combination with `Part.children`, can be used to traverse the vessels parts tree.

Attribute Read-only, cannot be set

Return type `Part`

Note: See the discussion on *Trees of Parts*.

children

The parts children. Returns an empty list if the part has no children. This, in combination with `Part.parent`, can be used to traverse the vessels parts tree.

Attribute Read-only, cannot be set

Return type List of `Part`

Note: See the discussion on *Trees of Parts*.

axially_attached

Whether the part is axially attached to its parent, i.e. on the top or bottom of its parent. If the part has no parent, returns `False`.

Attribute Read-only, cannot be set

Return type boolean

Note: See the discussion on *Attachment Modes*.

radially_attached

Whether the part is radially attached to its parent, i.e. on the side of its parent. If the part has no parent, returns `False`.

Attribute Read-only, cannot be set

Return type boolean

Note: See the discussion on *Attachment Modes*.

stage

The stage in which this part will be activated. Returns -1 if the part is not activated by staging.

Attribute Read-only, cannot be set

Return type number

Note: See the discussion on *Staging*.

decouple_stage

The stage in which this part will be decoupled. Returns -1 if the part is never decoupled from the vessel.

Attribute Read-only, cannot be set

Return type number

Note: See the discussion on *Staging*.

massless
Whether the part is massless.

Attribute Read-only, cannot be set

Return type boolean

mass
The current mass of the part, including resources it contains, in kilograms. Returns zero if the part is massless.

Attribute Read-only, cannot be set

Return type number

dry_mass
The mass of the part, not including any resources it contains, in kilograms. Returns zero if the part is massless.

Attribute Read-only, cannot be set

Return type number

impact_tolerance
The impact tolerance of the part, in meters per second.

Attribute Read-only, cannot be set

Return type number

temperature
Temperature of the part, in Kelvin.

Attribute Read-only, cannot be set

Return type number

skin_temperature
Temperature of the skin of the part, in Kelvin.

Attribute Read-only, cannot be set

Return type number

max_temperature
Maximum temperature that the part can survive, in Kelvin.

Attribute Read-only, cannot be set

Return type number

max_skin_temperature
Maximum temperature that the skin of the part can survive, in Kelvin.

Attribute Read-only, cannot be set

Return type number

external_temperature
Temperature of the atmosphere/vacuum surrounding the part, in Kelvin. This does not include heating from direct sunlight.

Attribute Read-only, cannot be set

Return type number

thermal_mass
How much it takes to heat up the part.

Attribute Read-only, cannot be set

Return type number

thermal_skin_mass
How much it takes to heat up the part's skin.

Attribute Read-only, cannot be set

Return type number

thermal_resource_mass
How much it takes to heat up resources in the part.

Attribute Read-only, cannot be set

Return type number

thermal_conduction_flux
The speed that heat is conducting into or out of the part through contact with other parts. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

Attribute Read-only, cannot be set

Return type number

thermal_convection_flux
The speed that heat is convecting into or out of the part from the surrounding atmosphere. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

Attribute Read-only, cannot be set

Return type number

thermal_radiation_flux
The speed that heat is radiating into or out of the part from the surrounding vacuum. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

Attribute Read-only, cannot be set

Return type number

thermal_internal_flux
The speed that heat is generated by the part. For example, engines generate heat by burning fuel. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

Attribute Read-only, cannot be set

Return type number

thermal_skin_to_internal_flux
The speed that heat is conducting between the part's skin and its internals.

Attribute Read-only, cannot be set

Return type number

resources
A `Resources` object for the part.

Attribute Read-only, cannot be set

Return type *Resources*

crossfeed
Whether this part is crossfeed capable.

Attribute Read-only, cannot be set

Return type boolean

is_fuel_line
Whether this part is a fuel line.

Attribute Read-only, cannot be set

Return type boolean

fuel_lines_from
The parts that are connected to this part via fuel lines, where the direction of the fuel line is into this part.

Attribute Read-only, cannot be set

Return type List of *Part*

Note: See the discussion on *Fuel Lines*.

fuel_lines_to
The parts that are connected to this part via fuel lines, where the direction of the fuel line is out of this part.

Attribute Read-only, cannot be set

Return type List of *Part*

Note: See the discussion on *Fuel Lines*.

modules
The modules for this part.

Attribute Read-only, cannot be set

Return type List of *Module*

decoupler
A *Decoupler* if the part is a decoupler, otherwise `nil`.

Attribute Read-only, cannot be set

Return type *Decoupler*

docking_port
A *DockingPort* if the part is a docking port, otherwise `nil`.

Attribute Read-only, cannot be set

Return type *DockingPort*

engine
An *Engine* if the part is an engine, otherwise `nil`.

Attribute Read-only, cannot be set

Return type *Engine*

landing_gear
A *LandingGear* if the part is a landing gear , otherwise nil.

Attribute Read-only, cannot be set

Return type *LandingGear*

landing_leg
A *LandingLeg* if the part is a landing leg, otherwise nil.

Attribute Read-only, cannot be set

Return type *LandingLeg*

launch_clamp
A *LaunchClamp* if the part is a launch clamp, otherwise nil.

Attribute Read-only, cannot be set

Return type *LaunchClamp*

light
A *Light* if the part is a light, otherwise nil.

Attribute Read-only, cannot be set

Return type *Light*

parachute
A *Parachute* if the part is a parachute, otherwise nil.

Attribute Read-only, cannot be set

Return type *Parachute*

radiator
A *Radiator* if the part is a radiator, otherwise nil.

Attribute Read-only, cannot be set

Return type *Radiator*

reaction_wheel
A *ReactionWheel* if the part is a reaction wheel, otherwise nil.

Attribute Read-only, cannot be set

Return type *ReactionWheel*

resource_converter
A *ResourceConverter* if the part is a resource converter, otherwise nil.

Attribute Read-only, cannot be set

Return type *ResourceConverter*

resource_harvester
A *ResourceHarvester* if the part is a resource harvester, otherwise nil.

Attribute Read-only, cannot be set

Return type *ResourceHarvester*

sensor
A *Sensor* if the part is a sensor, otherwise nil.

Attribute Read-only, cannot be set

Return type *Sensor*

solar_panel

A *SolarPanel* if the part is a solar panel, otherwise nil.

Attribute Read-only, cannot be set

Return type *SolarPanel*

position (*reference_frame*)

The position of the part in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

direction (*reference_frame*)

The direction of the part in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

velocity (*reference_frame*)

The velocity of the part in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

rotation (*reference_frame*)

The rotation of the part in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number, number)

reference_frame

The reference frame that is fixed relative to this part.

- The origin is at the position of the part.
- The axes rotate with the part.
- The x, y and z axis directions depend on the design of the part.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

Note: For docking port parts, this reference frame is not necessarily equivalent to the reference frame for the docking port, returned by *DockingPort.reference_frame*.

Module

class SpaceCenter.**Module**

In KSP, each part has zero or more PartModules associated with it. Each one contains some of the functionality of the part. For example, an engine has a “ModuleEngines” PartModule that contains all the functionality of an engine. This class allows you to interact with KSPs PartModules, and any PartModules that have been added by other mods.

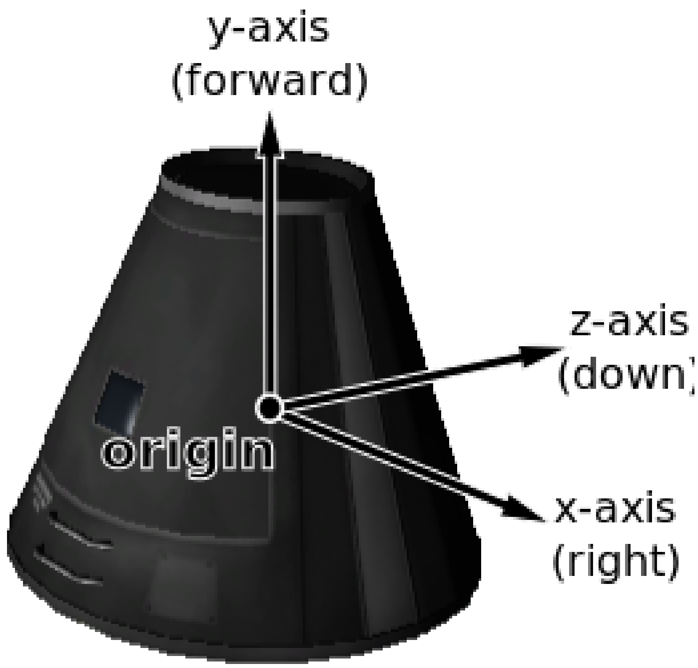


Fig. 6.7: Mk1 Command Pod reference frame origin and axes

name
Name of the PartModule. For example, "ModuleEngines".

Attribute Read-only, cannot be set

Return type string

part
The part that contains this module.

Attribute Read-only, cannot be set

Return type *Part*

fields
The modules field names and their associated values, as a dictionary. These are the values visible in the right-click menu of the part.

Attribute Read-only, cannot be set

Return type Map from string to string

has_field(*name*)
Returns `True` if the module has a field with the given name.

Parameters **name** (*string*) – Name of the field.

Return type boolean

get_field(*name*)
Returns the value of a field.

Parameters **name** (*string*) – Name of the field.

Return type string

events

A list of the names of all of the modules events. Events are the clickable buttons visible in the right-click menu of the part.

Attribute Read-only, cannot be set

Return type List of string

has_event (*name*)

`True` if the module has an event with the given name.

Parameters **name** (*string*) –

Return type boolean

trigger_event (*name*)

Trigger the named event. Equivalent to clicking the button in the right-click menu of the part.

Parameters **name** (*string*) –

actions

A list of all the names of the modules actions. These are the parts actions that can be assigned to action groups in the in-game editor.

Attribute Read-only, cannot be set

Return type List of string

has_action (*name*)

`True` if the part has an action with the given name.

Parameters **name** (*string*) –

Return type boolean

set_action (*name*[, *value = True*])

Set the value of an action with the given name.

Parameters

- **name** (*string*) –
- **value** (*boolean*) –

Specific Types of Part

The following classes provide functionality for specific types of part.

Decoupler

class `SpaceCenter.`**`Decoupler`**

Obtained by calling `Part.decoupler`

`part`

The part object for this decoupler.

Attribute Read-only, cannot be set

Return type `Part`

`decouple``()`

Fires the decoupler. Has no effect if the decoupler has already fired.

`decoupled`

Whether the decoupler has fired.

Attribute Read-only, cannot be set

Return type boolean

`impulse`

The impulse that the decoupler imparts when it is fired, in Newton seconds.

Attribute Read-only, cannot be set

Return type number

Docking Port

class `SpaceCenter.`**`DockingPort`**

Obtained by calling `Part.docking_port`

`part`

The part object for this docking port.

Attribute Read-only, cannot be set

Return type `Part`

`name`

The port name of the docking port. This is the name of the port that can be set in the right click menu, when the Docking Port Alignment Indicator mod is installed. If this mod is not installed, returns the title of the part (*Part.title*).

Attribute Can be read or written

Return type string

state
The current state of the docking port.

Attribute Read-only, cannot be set

Return type *DockingPortState*

docked_part
The part that this docking port is docked to. Returns `nil` if this docking port is not docked to anything.

Attribute Read-only, cannot be set

Return type *Part*

undock()
Undocks the docking port and returns the vessel that was undocked from. After undocking, the active vessel may change (`active_vessel`). This method can be called for either docking port in a docked pair - both calls will have the same effect. Returns `nil` if the docking port is not docked to anything.

Return type *Vessel*

reengage_distance
The distance a docking port must move away when it undocks before it becomes ready to dock with another port, in meters.

Attribute Read-only, cannot be set

Return type number

has_shield
Whether the docking port has a shield.

Attribute Read-only, cannot be set

Return type boolean

shielded
The state of the docking ports shield, if it has one. Returns `True` if the docking port has a shield, and the shield is closed. Otherwise returns `False`. When set to `True`, the shield is closed, and when set to `False` the shield is opened. If the docking port does not have a shield, setting this attribute has no effect.

Attribute Can be read or written

Return type boolean

position(*reference_frame*)
The position of the docking port in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

direction(*reference_frame*)
The direction that docking port points in, in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

rotation (*reference_frame*)

The rotation of the docking port, in the given reference frame.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number, number)

reference_frame

The reference frame that is fixed relative to this docking port, and oriented with the port.

- The origin is at the position of the docking port.
- The axes rotate with the docking port.
- The x-axis points out to the right side of the docking port.
- The y-axis points in the direction the docking port is facing.
- The z-axis points out of the bottom off the docking port.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

Note: This reference frame is not necessarily equivalent to the reference frame for the part, returned by *Part.reference_frame*.

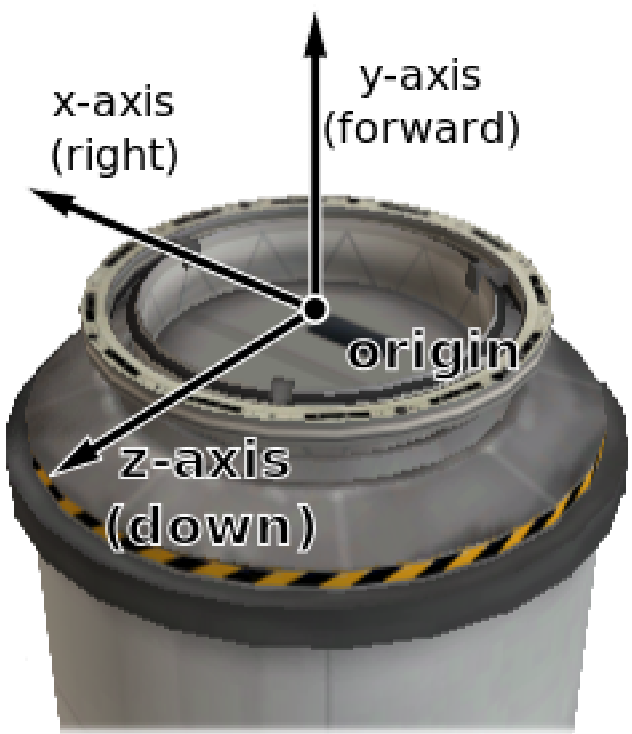


Fig. 6.8: Docking port reference frame origin and axes

class SpaceCenter.**DockingPortState**

See *DockingPort.state*.

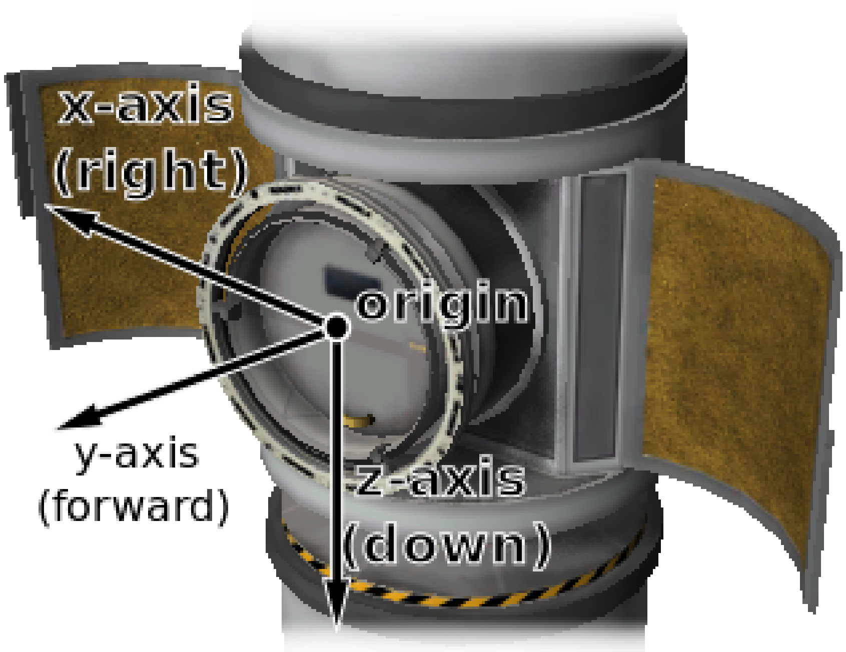


Fig. 6.9: Inline docking port reference frame origin and axes

ready
The docking port is ready to dock to another docking port.

docked
The docking port is docked to another docking port, or docked to another part (from the VAB/SPH).

docking
The docking port is very close to another docking port, but has not docked. It is using magnetic force to acquire a solid dock.

undocking
The docking port has just been undocked from another docking port, and is disabled until it moves away by a sufficient distance (*DockingPort.reengage_distance*).

shielded
The docking port has a shield, and the shield is closed.

moving
The docking ports shield is currently opening/closing.

Engine

class SpaceCenter.**Engine**
Obtained by calling *Part.engine*.

part
The part object for this engine.

Attribute Read-only, cannot be set

Return type *Part*

active

Whether the engine is active. Setting this attribute may have no effect, depending on `Engine.can_shutdown` and `Engine.can_restart`.

Attribute Can be read or written

Return type boolean

thrust

The current amount of thrust being produced by the engine, in Newtons. Returns zero if the engine is not active or if it has no fuel.

Attribute Read-only, cannot be set

Return type number

available_thrust

The maximum available amount of thrust that can be produced by the engine, in Newtons. This takes `Engine.thrust_limit` into account, and is the amount of thrust produced by the engine when activated and the main throttle is set to 100%. Returns zero if the engine does not have any fuel.

Attribute Read-only, cannot be set

Return type number

max_thrust

Gets the maximum amount of thrust that can be produced by the engine, in Newtons. This is the amount of thrust produced by the engine when activated, `Engine.thrust_limit` is set to 100% and the main vessel's throttle is set to 100%.

Attribute Read-only, cannot be set

Return type number

max_vacuum_thrust

The maximum amount of thrust that can be produced by the engine in a vacuum, in Newtons. This is the amount of thrust produced by the engine when activated, `Engine.thrust_limit` is set to 100%, the main vessel's throttle is set to 100% and the engine is in a vacuum.

Attribute Read-only, cannot be set

Return type number

thrust_limit

The thrust limiter of the engine. A value between 0 and 1. Setting this attribute may have no effect, for example the thrust limit for a solid rocket booster cannot be changed in flight.

Attribute Can be read or written

Return type number

specific_impulse

The current specific impulse of the engine, in seconds. Returns zero if the engine is not active.

Attribute Read-only, cannot be set

Return type number

vacuum_specific_impulse

The vacuum specific impulse of the engine, in seconds.

Attribute Read-only, cannot be set

Return type number

kerbin_sea_level_specific_impulse

The specific impulse of the engine at sea level on Kerbin, in seconds.

Attribute Read-only, cannot be set

Return type number

propellants

The names of resources that the engine consumes.

Attribute Read-only, cannot be set

Return type List of string

propellant_ratios

The ratios of resources that the engine consumes. A dictionary mapping resource names to the ratios at which they are consumed by the engine.

Attribute Read-only, cannot be set

Return type Map from string to number

has_fuel

Whether the engine has run out of fuel (or flamed out).

Attribute Read-only, cannot be set

Return type boolean

throttle

The current throttle setting for the engine. A value between 0 and 1. This is not necessarily the same as the vessel's main throttle setting, as some engines take time to adjust their throttle (such as jet engines).

Attribute Read-only, cannot be set

Return type number

throttle_locked

Whether the `Control.throttle` affects the engine. For example, this is `True` for liquid fueled rockets, and `False` for solid rocket boosters.

Attribute Read-only, cannot be set

Return type boolean

can_restart

Whether the engine can be restarted once shutdown. If the engine cannot be shutdown, returns `False`. For example, this is `True` for liquid fueled rockets and `False` for solid rocket boosters.

Attribute Read-only, cannot be set

Return type boolean

can_shutdown

Gets whether the engine can be shutdown once activated. For example, this is `True` for liquid fueled rockets and `False` for solid rocket boosters.

Attribute Read-only, cannot be set

Return type boolean

gimballed

Whether the engine nozzle is gimballed, i.e. can provide a turning force.

Attribute Read-only, cannot be set

Return type boolean

gimbal_range
The range over which the gimbal can move, in degrees.

Attribute Read-only, cannot be set

Return type number

gimbal_locked
Whether the engines gimbal is locked in place. Setting this attribute has no effect if the engine is not gimballed.

Attribute Can be read or written

Return type boolean

gimbal_limit
The gimbal limiter of the engine. A value between 0 and 1. Returns 0 if the gimbal is locked or the engine is not gimballed. Setting this attribute has no effect if the engine is not gimballed.

Attribute Can be read or written

Return type number

Landing Gear

class SpaceCenter.**LandingGear**
Obtained by calling *Part.landing_gear*.

part
The part object for this landing gear.

Attribute Read-only, cannot be set

Return type *Part*

state
Gets the current state of the landing gear.

Attribute Read-only, cannot be set

Return type *LandingGearState*

deployed
Whether the landing gear is deployed.

Attribute Can be read or written

Return type boolean

class SpaceCenter.**LandingGearState**
See *LandingGear.state*.

deployed
Landing gear is fully deployed.

retracted
Landing gear is fully retracted.

deploying
Landing gear is being deployed.

retracting
Landing gear is being retracted.

Landing Leg

class SpaceCenter.**LandingLeg**

Obtained by calling *Part.landing_leg*.

part

The part object for this landing leg.

Attribute Read-only, cannot be set

Return type *Part*

state

The current state of the landing leg.

Attribute Read-only, cannot be set

Return type *LandingLegState*

deployed

Whether the landing leg is deployed.

Attribute Can be read or written

Return type boolean

class SpaceCenter.**LandingLegState**

See *LandingLeg.state*.

deployed

Landing leg is fully deployed.

retracted

Landing leg is fully retracted.

deploying

Landing leg is being deployed.

retracting

Landing leg is being retracted.

broken

Landing leg is broken.

repairing

Landing leg is being repaired.

Launch Clamp

class SpaceCenter.**LaunchClamp**

Obtained by calling *Part.launch_clamp*.

part

The part object for this launch clamp.

Attribute Read-only, cannot be set

Return type *Part*

release()

Releases the docking clamp. Has no effect if the clamp has already been released.

Light

class `SpaceCenter.`**`Light`**

Obtained by calling *`Part.light`*.

`part`

The part object for this light.

Attribute Read-only, cannot be set

Return type *`Part`*

`active`

Whether the light is switched on.

Attribute Can be read or written

Return type boolean

`power_usage`

The current power usage, in units of charge per second.

Attribute Read-only, cannot be set

Return type number

Parachute

class `SpaceCenter.`**`Parachute`**

Obtained by calling *`Part.parachute`*.

`part`

The part object for this parachute.

Attribute Read-only, cannot be set

Return type *`Part`*

`deploy``()`

Deploys the parachute. This has no effect if the parachute has already been deployed.

`deployed`

Whether the parachute has been deployed.

Attribute Read-only, cannot be set

Return type boolean

`state`

The current state of the parachute.

Attribute Read-only, cannot be set

Return type *`ParachuteState`*

`deploy_altitude`

The altitude at which the parachute will full deploy, in meters.

Attribute Can be read or written

Return type number

`deploy_min_pressure`

The minimum pressure at which the parachute will semi-deploy, in atmospheres.

Attribute Can be read or written

Return type number

class SpaceCenter.**ParachuteState**

See *Parachute.state*.

stowed

The parachute is safely tucked away inside its housing.

active

The parachute is still stowed, but ready to semi-deploy.

semi_deployed

The parachute has been deployed and is providing some drag, but is not fully deployed yet.

deployed

The parachute is fully deployed.

cut

The parachute has been cut.

Radiator

class SpaceCenter.**Radiator**

Obtained by calling *Part.radiator*.

part

The part object for this radiator.

Attribute Read-only, cannot be set

Return type *Part*

deployed

Whether the radiator is extended.

Attribute Can be read or written

Return type boolean

state

The current state of the radiator.

Attribute Read-only, cannot be set

Return type *RadiatorState*

class SpaceCenter.**RadiatorState**

RadiatorState

extended

Radiator is fully extended.

retracted

Radiator is fully retracted.

extending

Radiator is being extended.

retracting

Radiator is being retracted.

broken
Radiator is being broken.

Resource Converter

class SpaceCenter.**ResourceConverter**
Obtained by calling *Part.resource_converter*.

part
The part object for this converter.

Attribute Read-only, cannot be set

Return type *Part*

count
The number of converters in the part.

Attribute Read-only, cannot be set

Return type number

name (*index*)
The name of the specified converter.

Parameters **index** (*number*) – Index of the converter.

Return type string

active (*index*)
True if the specified converter is active.

Parameters **index** (*number*) – Index of the converter.

Return type boolean

start (*index*)
Start the specified converter.

Parameters **index** (*number*) – Index of the converter.

stop (*index*)
Stop the specified converter.

Parameters **index** (*number*) – Index of the converter.

state (*index*)
The state of the specified converter.

Parameters **index** (*number*) – Index of the converter.

Return type *ResourceConverterState*

status_info (*index*)
Status information for the specified converter. This is the full status message shown in the in-game UI.

Parameters **index** (*number*) – Index of the converter.

Return type string

inputs (*index*)
List of the names of resources consumed by the specified converter.

Parameters **index** (*number*) – Index of the converter.

Return type List of string

outputs (*index*)
List of the names of resources produced by the specified converter.

Parameters **index** (*number*) – Index of the converter.

Return type List of string

class SpaceCenter.**ResourceConverterState**
See *ResourceConverter.state()*.

running
Converter is running.

idle
Converter is idle.

missing_resource
Converter is missing a required resource.

storage_full
No available storage for output resource.

capacity
At preset resource capacity.

unknown
Unknown state. Possible with modified resource converters. In this case, check *ResourceConverter.status_info()* for more information.

Resource Harvester

class SpaceCenter.**ResourceHarvester**
Obtained by calling *Part.resource_harvester*.

part
The part object for this harvester.

Attribute Read-only, cannot be set

Return type *Part*

state
The state of the harvester.

Attribute Read-only, cannot be set

Return type ResourceHarvesterState

deployed
Whether the harvester is deployed.

Attribute Can be read or written

Return type boolean

active
Whether the harvester is actively drilling.

Attribute Can be read or written

Return type boolean

extraction_rate
The rate at which the drill is extracting ore, in units per second.

Attribute Read-only, cannot be set

Return type number

thermal_efficiency
The thermal efficiency of the drill, as a percentage of its maximum.

Attribute Read-only, cannot be set

Return type number

core_temperature
The core temperature of the drill, in Kelvin.

Attribute Read-only, cannot be set

Return type number

optimum_core_temperature
The core temperature at which the drill will operate with peak efficiency, in Kelvin.

Attribute Read-only, cannot be set

Return type number

Reaction Wheel

class SpaceCenter.**ReactionWheel**
Obtained by calling *Part.reaction_wheel*.

part
The part object for this reaction wheel.

Attribute Read-only, cannot be set

Return type *Part*

active
Whether the reaction wheel is active.

Attribute Can be read or written

Return type boolean

broken
Whether the reaction wheel is broken.

Attribute Read-only, cannot be set

Return type boolean

pitch_torque
The torque in the pitch axis, in Newton meters.

Attribute Read-only, cannot be set

Return type number

yaw_torque
The torque in the yaw axis, in Newton meters.

Attribute Read-only, cannot be set

Return type number

roll_torque
The torque in the roll axis, in Newton meters.

Attribute Read-only, cannot be set

Return type number

Sensor

class SpaceCenter.**Sensor**
Obtained by calling *Part.sensor*.

part
The part object for this sensor.

Attribute Read-only, cannot be set

Return type *Part*

active
Whether the sensor is active.

Attribute Can be read or written

Return type boolean

value
The current value of the sensor.

Attribute Read-only, cannot be set

Return type string

power_usage
The current power usage of the sensor, in units of charge per second.

Attribute Read-only, cannot be set

Return type number

Solar Panel

class SpaceCenter.**SolarPanel**
Obtained by calling *Part.solar_panel*.

part
The part object for this solar panel.

Attribute Read-only, cannot be set

Return type *Part*

deployed
Whether the solar panel is extended.

Attribute Can be read or written

Return type boolean

state
The current state of the solar panel.

Attribute Read-only, cannot be set

Return type *SolarPanelState*

energy_flow

The current amount of energy being generated by the solar panel, in units of charge per second.

Attribute Read-only, cannot be set

Return type number

sun_exposure

The current amount of sunlight that is incident on the solar panel, as a percentage. A value between 0 and 1.

Attribute Read-only, cannot be set

Return type number

class `SpaceCenter.`**`SolarPanelState`**

See *SolarPanel.state*.

extended

Solar panel is fully extended.

retracted

Solar panel is fully retracted.

extending

Solar panel is being extended.

retracting

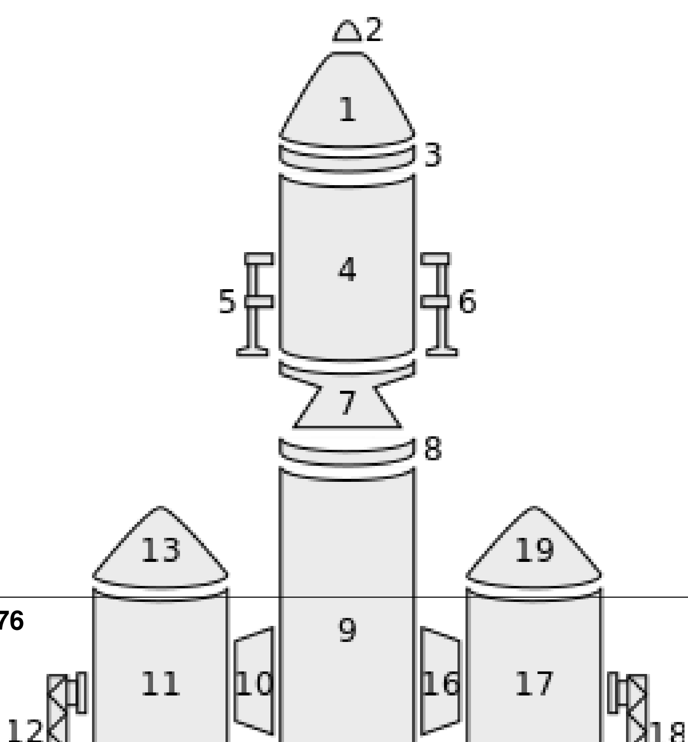
Solar panel is being retracted.

broken

Solar panel is broken.

Trees of Parts

Vessels in KSP are comprised of a number of parts, connected to one another in a *tree* structure. An example vessel is shown in Figure 1, and the corresponding tree of parts in Figure 2. The craft file for this example can also be `downloaded here`.



Traversing the Tree

The tree of parts can be traversed using the attributes *SpaceCenter.Parts.root*, *SpaceCenter.Part.parent* and *SpaceCenter.Part.children*.

The root of the tree is the same as the vessels *root part* (part number 1 in the example above) and can be obtained by calling *SpaceCenter.Parts.root*. A parts children can be obtained by calling *SpaceCenter.Part.children*. If the part does not have any children, *SpaceCenter.Part.children* returns an empty list. A parts parent can be obtained by calling *SpaceCenter.Part.parent*. If the part does not have a parent (as is the case for the root part), *SpaceCenter.Part.parent* returns nil.

The following Lua example uses these attributes to perform a depth-first traversal over all of the parts in a vessel:

```lua
local root = vessel.parts.root
local stack = {{root,0}}
while #stack > 0 do
  local part,depth = unpack(table.remove(stack))
  print(string.rep(' ', depth) .. part.title)
  for _,child in ipairs(part.children) do
    table.insert(stack, {child, depth+1})
  end
end
```

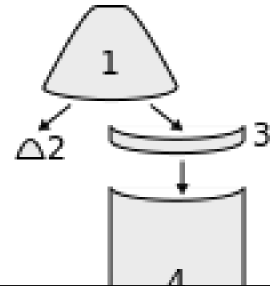
When this code is execute using the craft file for the example vessel pictured above, the following is printed out:

```
Command Pod Mk1
 TR-18A Stack Decoupler
  FL-T400 Fuel Tank
   LV-909 Liquid Fuel Engine
    TR-18A Stack Decoupler
     FL-T800 Fuel Tank
      LV-909 Liquid Fuel Engine
      TT-70 Radial Decoupler
       FL-T400 Fuel Tank
        TT18-A Launch Stability Enhancer
        FTX-2 External Fuel Duct
        LV-909 Liquid Fuel Engine
        Aerodynamic Nose Cone
      TT-70 Radial Decoupler
       FL-T400 Fuel Tank
        TT18-A Launch Stability Enhancer
        FTX-2 External Fuel Duct
        LV-909 Liquid Fuel Engine
        Aerodynamic Nose Cone
   LT-1 Landing Struts
   LT-1 Landing Struts
 Mk16 Parachute
```

Attachment Modes

Parts can be attached to other parts either *radially* (on the side of the parent part) or *axially* (on the end of the parent part, to form a stack).

For example, in the vessel pictured above, the parachute (part 2) is *axially* connected to its parent (the command pod – part 1), and the landing leg (part 5) is *radially* connected to its parent (the fuel tank – part 4).



The root part of a vessel (for example the command pod – part 1) does not have a parent part, so does not have an attachment mode. However, the part is consider to be *axially* attached to nothing.

The following Lua example does a depth-first traversal as before, but also prints out the attachment mode used by the part:

```
local root = vessel.parts.root
local stack = {{root, 0}}
while #stack > 0 do
  local part,depth = unpack(table.remove(stack))
  local attach_mode
  if part.axially_attached then
    attach_mode = 'axial'
  else -- radially_attached
    attach_mode = 'radial'
  end
  print(string.rep(' ', depth) .. part.title .. ' - ' .. attach_mode)
  for _,child in ipairs(part.children) do
    table.insert(stack, {child, depth+1})
  end
end
```

When this code is execute using the craft file for the example vessel pictured above, the following is printed out:

```
Command Pod Mk1 - axial
 TR-18A Stack Decoupler - axial
  FL-T400 Fuel Tank - axial
   LV-909 Liquid Fuel Engine - axial
    TR-18A Stack Decoupler - axial
     FL-T800 Fuel Tank - axial
      LV-909 Liquid Fuel Engine - axial
      TT-70 Radial Decoupler - radial
       FL-T400 Fuel Tank - radial
        TT18-A Launch Stability Enhancer - radial
        FTX-2 External Fuel Duct - radial
        LV-909 Liquid Fuel Engine - axial
        Aerodynamic Nose Cone - axial
      TT-70 Radial Decoupler - radial
       FL-T400 Fuel Tank - radial
        TT18-A Launch Stability Enhancer - radial
        FTX-2 External Fuel Duct - radial
        LV-909 Liquid Fuel Engine - axial
        Aerodynamic Nose Cone - axial
   LT-1 Landing Struts - radial
   LT-1 Landing Struts - radial
 Mk16 Parachute - axial
```

Fuel Lines

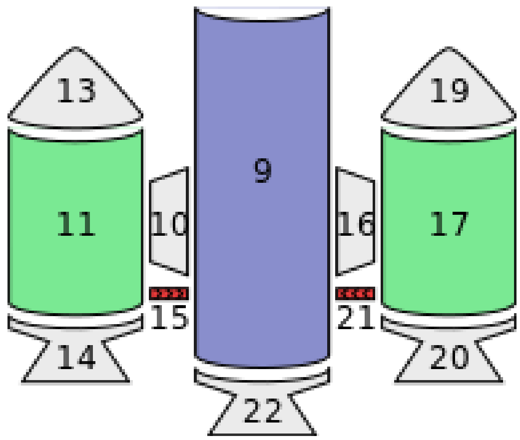


Fig. 6.12: **Figure 5** – Fuel lines from the example in Figure 1. Fuel flows from the parts highlighted in green, into the part highlighted in blue.

Fuel lines are considered parts, and are included in the parts tree (for example, as pictured in Figure 4). However, the parts tree does not contain information about which parts fuel lines connect to. The parent part of a fuel line is the part from which it will take fuel (as shown in Figure 4) however the part that it will send fuel to is not represented in the parts tree.

Figure 5 shows the fuel lines from the example vessel pictured earlier. Fuel line part 15 (in red) takes fuel from a fuel tank (part 11 – in green) and feeds it into another fuel tank (part 9 – in blue). The fuel line is therefore a child of part 11, but its connection to part 9 is not represented in the tree.

The attributes `SpaceCenter.Part.fuel_lines_from` and `SpaceCenter.Part.fuel_lines_to` can be used to discover these connections. In the example in Figure 5, when `SpaceCenter.Part.fuel_lines_to` is called on fuel tank part 11, it will return a list of parts containing just fuel tank part 9 (the blue part). When `SpaceCenter.Part.fuel_lines_from` is called on fuel tank part 9, it will return a list containing fuel tank parts 11 and 17 (the parts colored green).

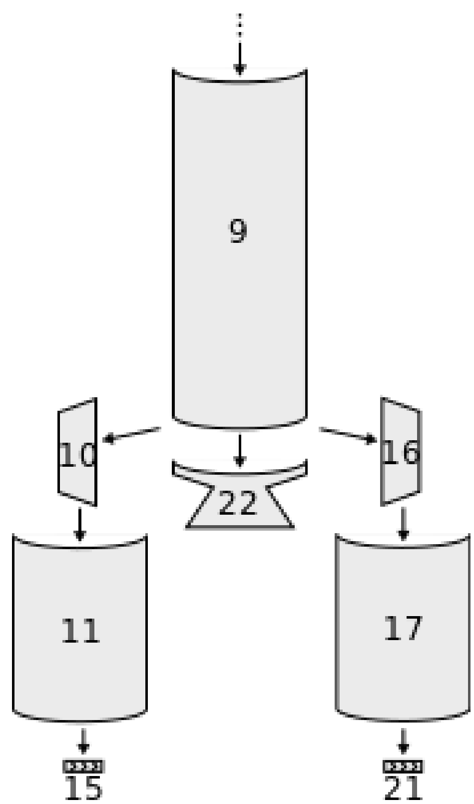
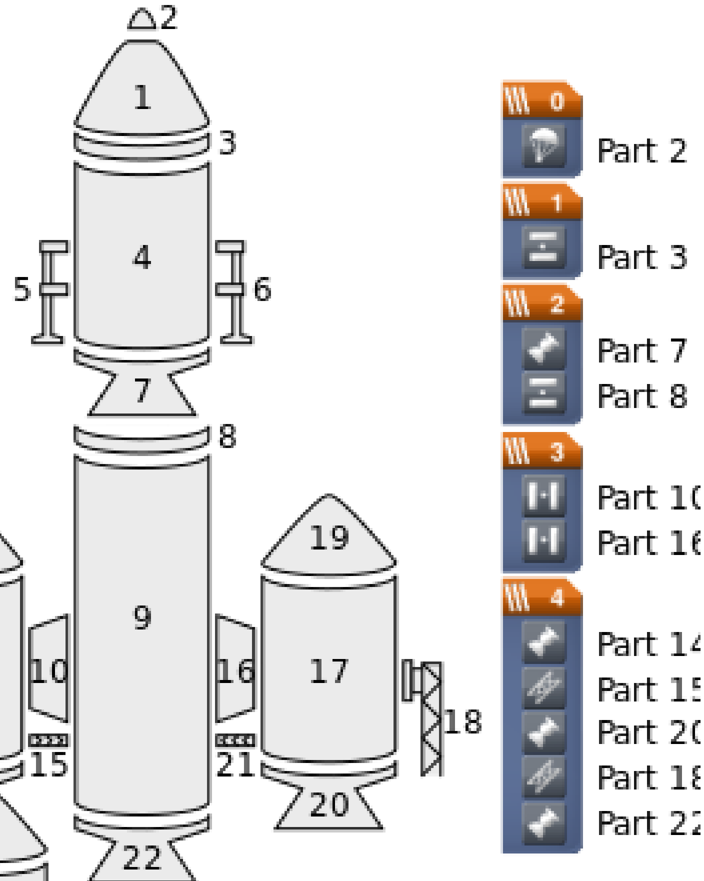


Fig. 6.13: **Figure 4** – A subset of the parts tree from Figure 2 above.

Staging

Each part has two staging numbers associated with it: the stage in which the part is *activated* and the stage in which the part is *decoupled*. These values can be obtained using `SpaceCenter.Part.stage` and `SpaceCenter.Part.decouple_stage` respectively. For parts that are not activated by staging, `SpaceCenter.Part.stage` returns -1. For parts that are never decoupled, `SpaceCenter.Part.decouple_stage` returns a value of -1.

Figure 6 shows an example staging sequence for a vessel. Figure 7 shows the stages in which each part of the vessel will be *activated*. Figure 8 shows the stages in which each part of the vessel will be *decoupled*.



– Example vessel from Figure 1 with a staging sequence.

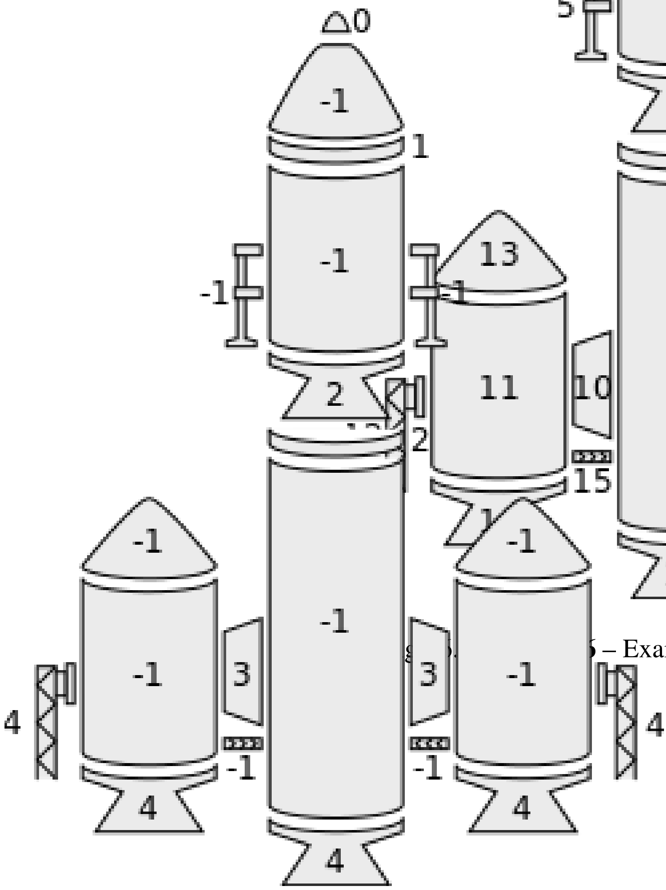


Fig. 6.15: **Figure 7** – The stage in which each part is *activated*.

6.2.8 Resources

class `SpaceCenter.`**`Resources`**

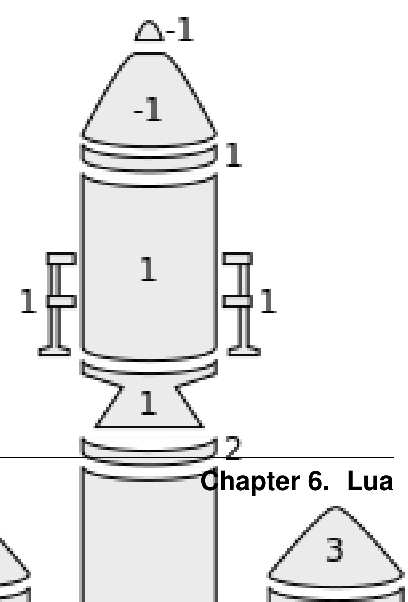
Created by calling `Vessel.resources`, `Vessel.resources_in_decouple_stage()` or `Part.resources`.

`names`

A list of resource names that can be stored.

Attribute Read-only, cannot be set

Return type List of string



has_resource (*name*)
Check whether the named resource can be stored.

Parameters **name** (*string*) – The name of the resource.

Return type boolean

max (*name*)
Returns the amount of a resource that can be stored.

Parameters **name** (*string*) – The name of the resource.

Return type number

amount (*name*)
Returns the amount of a resource that is currently stored.

Parameters **name** (*string*) – The name of the resource.

Return type number

static **density** (*name*)
Returns the density of a resource, in kg/l.

Parameters **name** (*string*) – The name of the resource.

Return type number

static **flow_mode** (*name*)
Returns the flow mode of a resource.

Parameters **name** (*string*) – The name of the resource.

Return type *ResourceFlowMode*

class SpaceCenter.**ResourceFlowMode**
See *Resources.flow_mode()*.

vessel
The resource flows to any part in the vessel. For example, electric charge.

stage
The resource flows from parts in the first stage, followed by the second, and so on. For example, mono-propellant.

adjacent
The resource flows between adjacent parts within the vessel. For example, liquid fuel or oxidizer.

none
The resource does not flow. For example, solid fuel.

6.2.9 Node

class SpaceCenter.**Node**

Represents a maneuver node. Can be created using *Control.add_node()*.

prograde

The magnitude of the maneuver nodes delta-v in the prograde direction, in meters per second.

Attribute Can be read or written

Return type number

normal

The magnitude of the maneuver nodes delta-v in the normal direction, in meters per second.

Attribute Can be read or written

Return type number

radial

The magnitude of the maneuver nodes delta-v in the radial direction, in meters per second.

Attribute Can be read or written

Return type number

delta_v

The delta-v of the maneuver node, in meters per second.

Attribute Can be read or written

Return type number

Note: Does not change when executing the maneuver node. See *Node.remaining_delta_v*.

remaining_delta_v

Gets the remaining delta-v of the maneuver node, in meters per second. Changes as the node is executed. This is equivalent to the delta-v reported in-game.

Attribute Read-only, cannot be set

Return type number

burn_vector ([*reference_frame = None*])

Returns a vector whose direction the direction of the maneuver node burn, and whose magnitude is the delta-v of the burn in m/s.

Parameters **reference_frame** (*ReferenceFrame*) –

Return type Tuple of (number, number, number)

Note: Does not change when executing the maneuver node. See `Node.remaining_burn_vector()`.

remaining_burn_vector([*reference_frame = None*])

Returns a vector whose direction the direction of the maneuver node burn, and whose magnitude is the delta-v of the burn in m/s. The direction and magnitude change as the burn is executed.

Parameters **reference_frame** (`ReferenceFrame`) –

Return type Tuple of (number, number, number)

ut

The universal time at which the maneuver will occur, in seconds.

Attribute Can be read or written

Return type number

time_to

The time until the maneuver node will be encountered, in seconds.

Attribute Read-only, cannot be set

Return type number

orbit

The orbit that results from executing the maneuver node.

Attribute Read-only, cannot be set

Return type `Orbit`

remove()

Removes the maneuver node.

reference_frame

Gets the reference frame that is fixed relative to the maneuver node's burn.

- The origin is at the position of the maneuver node.
- The y-axis points in the direction of the burn.
- The x-axis and z-axis point in arbitrary but fixed directions.

Attribute Read-only, cannot be set

Return type `ReferenceFrame`

orbital_reference_frame

Gets the reference frame that is fixed relative to the maneuver node, and orientated with the orbital prograde/normal/radial directions of the original orbit at the maneuver node's position.

- The origin is at the position of the maneuver node.
- The x-axis points in the orbital anti-radial direction of the original orbit, at the position of the maneuver node.
- The y-axis points in the orbital prograde direction of the original orbit, at the position of the maneuver node.
- The z-axis points in the orbital normal direction of the original orbit, at the position of the maneuver node.

Attribute Read-only, cannot be set

Return type `ReferenceFrame`

`position`(*reference_frame*)
Returns the position vector of the maneuver node in the given reference frame.

Parameters **`reference_frame`** (`ReferenceFrame`) –

Return type Tuple of (number, number, number)

`direction`(*reference_frame*)
Returns the unit direction vector of the maneuver nodes burn in the given reference frame.

Parameters **`reference_frame`** (`ReferenceFrame`) –

Return type Tuple of (number, number, number)

6.2.10 Comms

class `SpaceCenter.`**`Comms`**
Used to interact with RemoteTech. Created using a call to `Vessel.comms`.

Note: This class requires RemoteTech to be installed.

`has_local_control`
Whether the vessel can be controlled locally.

Attribute Read-only, cannot be set

Return type boolean

`has_flight_computer`
Whether the vessel has a RemoteTech flight computer on board.

Attribute Read-only, cannot be set

Return type boolean

has_connection
Whether the vessel can receive commands from the KSC or a command station.

Attribute Read-only, cannot be set

Return type boolean

has_connection_to_ground_station
Whether the vessel can transmit science data to a ground station.

Attribute Read-only, cannot be set

Return type boolean

signal_delay
The signal delay when sending commands to the vessel, in seconds.

Attribute Read-only, cannot be set

Return type number

signal_delay_to_ground_station
The signal delay between the vessel and the closest ground station, in seconds.

Attribute Read-only, cannot be set

Return type number

signal_delay_to_vessel (*other*)
Returns the signal delay between the current vessel and another vessel, in seconds.

Parameters **other** (*Vessel*) –

Return type number

6.2.11 ReferenceFrame

class SpaceCenter.**ReferenceFrame**
Represents a reference frame for positions, rotations and velocities. Contains:

- The position of the origin.
- The directions of the x, y and z axes.
- The linear velocity of the frame.
- The angular velocity of the frame.

Note: This class does not contain any properties or methods. It is only used as a parameter to other functions.

6.2.12 AutoPilot

class SpaceCenter.**AutoPilot**

Provides basic auto-piloting utilities for a vessel. Created by calling *Vessel.auto_pilot*.

engage()

Engage the auto-pilot.

disengage()

Disengage the auto-pilot.

wait()

Blocks until the vessel is pointing in the target direction (if set) and has the target roll (if set).

error

The error, in degrees, between the direction the ship has been asked to point in and the direction it is pointing in. Returns zero if the auto-pilot has not been engaged, SAS is not enabled, SAS is in stability assist mode, or no target direction is set.

Attribute Read-only, cannot be set

Return type number

roll_error

The error, in degrees, between the roll the ship has been asked to be in and the actual roll. Returns zero if the auto-pilot has not been engaged or no target roll is set.

Attribute Read-only, cannot be set

Return type number

reference_frame

The reference frame for the target direction (*AutoPilot.target_direction*).

Attribute Can be read or written

Return type *ReferenceFrame*

target_direction

The target direction. `nil` if no target direction is set.

Attribute Can be read or written

Return type Tuple of (number, number, number)

target_pitch_and_heading(*pitch*, *heading*)

Set (*AutoPilot.target_direction*) from a pitch and heading angle.

Parameters

- **pitch** (*number*) – Target pitch angle, in degrees between -90° and +90°.

- **heading** (*number*) – Target heading angle, in degrees between 0° and 360°.

target_roll
The target roll, in degrees. `NaN` if no target roll is set.

Attribute Can be read or written

Return type number

sas
The state of SAS.

Attribute Can be read or written

Return type boolean

Note: Equivalent to *Control.sas*

sas_mode
The current *SASMode*. These modes are equivalent to the mode buttons to the left of the navball that appear when SAS is enabled.

Attribute Can be read or written

Return type *SASMode*

Note: Equivalent to *Control.sas_mode*

rotation_speed_multiplier
Target rotation speed multiplier. Defaults to 1.

Attribute Can be read or written

Return type number

max_rotation_speed
Maximum target rotation speed. Defaults to 1.

Attribute Can be read or written

Return type number

roll_speed_multiplier
Target roll speed multiplier. Defaults to 1.

Attribute Can be read or written

Return type number

max_roll_speed
Maximum target roll speed. Defaults to 1.

Attribute Can be read or written

Return type number

set_pid_parameters ([*kp = 1.0*][, *ki = 0.0*][, *kd = 0.0*])
Sets the gains for the rotation rate PID controller.

Parameters

- **kp** (*number*) – Proportional gain.
- **ki** (*number*) – Integral gain.
- **kd** (*number*) – Derivative gain.

6.2.13 Geometry Types

class SpaceCenter.**Vector3**

3-dimensional vectors are represented as a 3-tuple. For example:

```
local krpc = require 'krpc.init'
local conn = krpc.connect()
local v = conn.space_center.active_vessel:flight().prograde
print(v[1], v[2], v[3])
```

class SpaceCenter.**Quaternion**

Quaternions (rotations in 3-dimensional space) are encoded as a 4-tuple containing the x, y, z and w components. For example:

```
local krpc = require 'krpc.init'
local conn = krpc.connect()
local q = conn.space_center.active_vessel:flight().rotation
print(q[1], q[2], q[3], q[4])
```

6.3 InfernalRobotics API

Provides RPCs to interact with the InfernalRobotics mod. Provides the following classes:

6.3.1 InfernalRobotics

class InfernalRobotics.**InfernalRobotics**

This service provides functionality to interact with the InfernalRobotics mod.

servo_groups

A list of all the servo groups in the active vessel.

Attribute Read-only, cannot be set

Return type List of *ControlGroup*

static **servo_group_with_name**(*name*)

Returns the servo group with the given *name* or `nil` if none exists. If multiple servo groups have the same name, only one of them is returned.

Parameters **name** (*string*) – Name of servo group to find.

Return type *ControlGroup*

static **`servo_with_name`**(*name*)
Returns the servo with the given *name*, from all servo groups, or `nil` if none exists. If multiple servos have the same name, only one of them is returned.

Parameters **name** (*string*) – Name of the servo to find.

Return type *Servo*

6.3.2 ControlGroup

class `InfernalRobotics.`**`ControlGroup`**
A group of servos, obtained by calling `servo_groups` or `servo_group_with_name()`. Represents the "Servo Groups" in the InfernalRobotics UI.

`name`
The name of the group.

Attribute Can be read or written

Return type string

`forward_key`
The key assigned to be the "forward" key for the group.

Attribute Can be read or written

Return type string

`reverse_key`
The key assigned to be the "reverse" key for the group.

Attribute Can be read or written

Return type string

`speed`
The speed multiplier for the group.

Attribute Can be read or written

Return type number

`expanded`
Whether the group is expanded in the InfernalRobotics UI.

Attribute Can be read or written

Return type boolean

`servos`
The servos that are in the group.

Attribute Read-only, cannot be set

Return type List of *Servo*

servo_with_name (*name*)
Returns the servo with the given *name* from this group, or `nil` if none exists.

Parameters **name** (*string*) – Name of servo to find.

Return type *Servo*

move_right ()
Moves all of the servos in the group to the right.

move_left ()
Moves all of the servos in the group to the left.

move_center ()
Moves all of the servos in the group to the center.

move_next_preset ()
Moves all of the servos in the group to the next preset.

move_prev_preset ()
Moves all of the servos in the group to the previous preset.

stop ()
Stops the servos in the group.

6.3.3 Servo

class `InfernalRobotics.`**Servo**
Represents a servo. Obtained using *ControlGroup.servos*, *ControlGroup.servo_with_name()* or `servo_with_name()`.

name
The name of the servo.

Attribute Can be read or written

Return type string

highlight
Whether the servo should be highlighted in-game.

Attribute Write-only, cannot be read

Return type boolean

position
The position of the servo.

Attribute Read-only, cannot be set

Return type number

min_config_position
The minimum position of the servo, specified by the part configuration.

Attribute Read-only, cannot be set

Return type number

max_config_position
The maximum position of the servo, specified by the part configuration.

Attribute Read-only, cannot be set

Return type number

min_position
The minimum position of the servo, specified by the in-game tweak menu.

Attribute Can be read or written

Return type number

max_position
The maximum position of the servo, specified by the in-game tweak menu.

Attribute Can be read or written

Return type number

config_speed
The speed multiplier of the servo, specified by the part configuration.

Attribute Read-only, cannot be set

Return type number

speed
The speed multiplier of the servo, specified by the in-game tweak menu.

Attribute Can be read or written

Return type number

current_speed
The current speed at which the servo is moving.

Attribute Can be read or written

Return type number

acceleration
The current speed multiplier set in the UI.

Attribute Can be read or written

Return type number

is_moving
Whether the servo is moving.

Attribute Read-only, cannot be set

Return type boolean

is_free_moving
Whether the servo is freely moving.

Attribute Read-only, cannot be set

Return type boolean

is_locked
Whether the servo is locked.

Attribute Can be read or written

Return type boolean

is_axis_inverted
Whether the servos axis is inverted.

Attribute Can be read or written

Return type boolean

move_right()
Moves the servo to the right.

move_left()
Moves the servo to the left.

move_center()
Moves the servo to the center.

move_next_preset()
Moves the servo to the next preset.

move_prev_preset()
Moves the servo to the previous preset.

move_to(*position*, *speed*)
Moves the servo to *position* and sets the speed multiplier to *speed*.

Parameters

- **position** (*number*) – The position to move the servo to.
- **speed** (*number*) – Speed multiplier for the movement.

stop()
Stops the servo.

6.3.4 Example

The following example gets the control group named "MyGroup", prints out the names and positions of all of the servos in the group, then moves all of the servos to the right for 1 second.

```
local krpc = require 'krpc.init'
local platform = require 'krpc.platform'
local Types = require 'krpc.types'

local conn = krpc.connect(nil, nil, nil, 'InfernalRobotics Example')

local group = conn.infernal_robotics.servo_group_with_name('MyGroup')
if group == Types.none then
  print('Group not found')
```

```
  os.exit(1)
end

for _,servo in ipairs(group.servos) do
  print(servo.name, servo.position)
end

group:move_right()
platform.sleep(1)
group:stop()
```

6.4 Kerbal Alarm Clock API

Provides RPCs to interact with the Kerbal Alarm Clock mod. Provides the following classes:

6.4.1 KerbalAlarmClock

class `KerbalAlarmClock.`**`KerbalAlarmClock`**

This service provides functionality to interact with the Kerbal Alarm Clock mod.

`alarms`

A list of all the alarms.

Attribute Read-only, cannot be set

Return type List of *`Alarm`*

static `alarm_with_name` (*name*)

Get the alarm with the given *name*, or `nil` if no alarms have that name. If more than one alarm has the name, only returns one of them.

Parameters **`name`** (*`string`*) – Name of the alarm to search for.

Return type *`Alarm`*

static `alarms_with_type` (*type*)

Get a list of alarms of the specified *type*.

Parameters **`type`** (*`AlarmType`*) – Type of alarm to return.

Return type List of *`Alarm`*

static `create_alarm` (*type*, *name*, *ut*)

Create a new alarm and return it.

Parameters

- **`type`** (*`AlarmType`*) – Type of the new alarm.
- **`name`** (*`string`*) – Name of the new alarm.
- **`ut`** (*`number`*) – Time at which the new alarm should trigger.

Return type *Alarm*

6.4.2 Alarm

class KerbalAlarmClock.**Alarm**

Represents an alarm. Obtained by calling `alarms`, `alarm_with_name()` or `alarms_with_type()`.

action

The action that the alarm triggers.

Attribute Can be read or written

Return type *AlarmAction*

margin

The number of seconds before the event that the alarm will fire.

Attribute Can be read or written

Return type number

time

The time at which the alarm will fire.

Attribute Can be read or written

Return type number

type

The type of the alarm.

Attribute Read-only, cannot be set

Return type *AlarmType*

id

The unique identifier for the alarm.

Attribute Read-only, cannot be set

Return type string

name

The short name of the alarm.

Attribute Can be read or written

Return type string

notes

The long description of the alarm.

Attribute Can be read or written

Return type string

remaining

The number of seconds until the alarm will fire.

Attribute Read-only, cannot be set

Return type number

repeat
Whether the alarm will be repeated after it has fired.

Attribute Can be read or written

Return type boolean

repeat_period
The time delay to automatically create an alarm after it has fired.

Attribute Can be read or written

Return type number

vessel
The vessel that the alarm is attached to.

Attribute Can be read or written

Return type *SpaceCenter.Vessel*

xfer_origin_body
The celestial body the vessel is departing from.

Attribute Can be read or written

Return type *SpaceCenter.CelestialBody*

xfer_target_body
The celestial body the vessel is arriving at.

Attribute Can be read or written

Return type *SpaceCenter.CelestialBody*

remove()
Removes the alarm.

6.4.3 AlarmType

class KerbalAlarmClock.**AlarmType**
The type of an alarm.

raw
An alarm for a specific date/time or a specific period in the future.

maneuver
An alarm based on the next maneuver node on the current ships flight path. This node will be stored and can be restored when you come back to the ship.

maneuver_auto
See *AlarmType.maneuver*.

apoapsis
An alarm for furthest part of the orbit from the planet.

periapsis
An alarm for nearest part of the orbit from the planet.

ascending_node
Ascending node for the targeted object, or equatorial ascending node.

descending_node
Descending node for the targeted object, or equatorial descending node.

closest
An alarm based on the closest approach of this vessel to the targeted vessel, some number of orbits into the future.

contract
An alarm based on the expiry or deadline of contracts in career modes.

contract_auto
See *AlarmType.contract*.

crew
An alarm that is attached to a crew member.

distance
An alarm that is triggered when a selected target comes within a chosen distance.

earth_time
An alarm based on the time in the "Earth" alternative Universe (aka the Real World).

launch_rendevous
An alarm that fires as your landed craft passes under the orbit of your target.

soi_change
An alarm manually based on when the next SOI point is on the flight path or set to continually monitor the active flight path and add alarms as it detects SOI changes.

soi_change_auto
See *AlarmType.soi_change*.

transfer
An alarm based on Interplanetary Transfer Phase Angles, i.e. when should I launch to planet X? Based on Kosmo Not's post and used in Olex's Calculator.

transfer_modelled
See *AlarmType.transfer*.

6.4.4 AlarmAction

class KerbalAlarmClock.**AlarmAction**
The action performed by an alarm when it fires.

do_nothing
Don't do anything at all...

do_nothing_delete_when_passed
Don't do anything, and delete the alarm.

kill_warp
Drop out of time warp.

kill_warp_only
Drop out of time warp.

message_only
Display a message.

pause_game
Pause the game.

6.4.5 Example

The following example creates a new alarm for the active vessel. The alarm is set to trigger after 10 seconds have passed, and display a message.

```
local krpc = require 'krpc.init'
local conn = krpc.connect(nil, nil, nil, 'Kerbal Alarm Clock Example')

local alarm = conn.kerbal_alarm_clock.create_alarm(
  conn.kerbal_alarm_clock.AlarmType.raw,
  'My New Alarm',
  conn.space_center.ut+10)

alarm.notes = '10 seconds have now passed since the alarm was created.'
alarm.action = conn.kerbal_alarm_clock.AlarmAction.message_only
```

CHAPTER

SEVEN

PYTHON

7.1 Python Client

The krpc module provides functionality to interact with a kRPC server from python. It can be installed from pypi.

7.1.1 Connecting to the Server

To connect to a server, use the *krpc.connect()* function. This returns a connection object through which you can interact with the server. For example to connect to a server running on the local machine:

```
import krpc
conn = krpc.connect(name='Example')
print(conn.krpc.get_status().version)
```

This function also accepts arguments that specify what address and port numbers to connect to. For example:

```
import krpc
conn = krpc.connect(address='my.domain.name', rpc_port=1000, stream_port=1001, name = 'Remote example
print(conn.krpc.get_status().version)
```

7.1.2 Interacting with the Server

Interaction with the server is performed via the client object (of type *krpc.client.Client*) returned when connecting to the server using *krpc.connect()*.

Upon connecting, the client interrogates the server to find out what functionality it provides and dynamically adds all of the classes, methods, properties to the client object.

For example, all of the functionality provided by the SpaceCenter service is accessible via conn.space_center and the functionality provided by the InfernalRobotics service is accessible via conn.infernal_robotics. To explore the functionality provided by a service, you can use the help() function from an interactive terminal. For example, running help(conn.space_center) will list all of the classes, enumerations, procedures and properties provides by the SpaceCenter service. Or for a class, such as the vessel class provided by the SpaceCenter service by calling help(conn.space_center.Vessel).

Calling methods, getting or setting properties, etc. are mapped to remote procedure calls and passed to the server by the python client.

7.1.3 Streaming Data from the Server

A stream repeatedly executes a function on the server, with a fixed set of argument values. It provides a more efficient way of repeatedly getting the result of calling function on the server, without having to invoke it directly – which incurs communication overheads.

For example, consider the following loop that continuously prints out the position of the active vessel. This loop incurs significant communication overheads, as the `vessel.position` function is called repeatedly.

```
vessel = conn.space_center.active_vessel
refframe = vessel.orbit.body.reference_frame
while True:
    print vessel.position(refframe)
```

The following code achieves the same thing, but is far more efficient. It makes a single call to `Client.add_stream()` to create the stream, which avoids the communication overhead in the previous example.

```
vessel = conn.space_center.active_vessel
refframe = vessel.orbit.body.reference_frame
position = conn.add_stream(vessel.position, refframe)
while True:
    print position()
```

Streams are created by calling `Client.add_stream()` or using the `with` statement applied to `Client.stream()`. Both of these methods return an instance of the *`krpc.stream.Stream`* class.

Both methods and attributes can be streamed. The example given above demonstrates how to stream methods. The following example shows how to stream an attribute (in this case `vessel.control.abort`):

```
abort = conn.add_stream(getattr, vessel.control, 'abort')
while not abort():
    ...
```

7.1.4 Reference

`krpc.`**`connect`**([*address='127.0.0.1'*][, *rpc_port=50000*][, *stream_port=50001*][, *name=None*])

This function creates a connection to a kRPC server. It returns a *`krpc.client.Client`* object, through which the server can be communicated with.

Parameters

- **address** (*string*) – The address of the server to connect to. Can either be a hostname or an IP address in dotted decimal notation. Defaults to '127.0.0.1'.
- **rpc_port** (*int*) – The port number of the RPC Server. Defaults to 50000.
- **stream_port** (*int*) – The port number of the Stream Server. Defaults to 50001.
- **name** (*string*) – A descriptive name for the connection. This is passed to the server and appears, for example, in the client connection dialog on the in-game server window.

class `krpc.client.`**`Client`**

This class provides the interface for communicating with the server. It is dynamically populated with all the functionality provided by the server. Instances of this class should be obtained by calling *`krpc.connect()`*.

`add_stream`(*func*, **args*, ***kwargs*)

Create a stream for the function *func* called with arguments *args* and *kwargs*. Returns a `krpc.streams.Stream` object.

stream(*func*, **args*, ***kwargs*)

Allows use of the `with` statement to create a stream and automatically remove it from the server when it goes out of scope. The function to be streamed should be passed as *func*, and its arguments as *args* and *kwargs*.

For example, to stream the result of method call `vessel.position(refframe)`:

```
vessel = conn.space_center.active_vessel
refframe = vessel.orbit.body.reference_frame
with conn.stream(vessel.position, refframe) as pos:
    print('Position =', pos())
```

Or to stream the property `conn.space_center.ut`:

```
with conn.stream(getattr(conn.space_center, 'ut')) as ut:
    print('Universal Time =', ut())
```

close()

Closes the connection to the server.

krpc

The built-in KRPC class, providing basic interactions with the server.

Return type *krpc.client.KRPC*

class `krpc.client.`**KRPC**

This class provides access to the basic server functionality provided by the `KRPC` service. An instance can be obtained by calling *krpc.client.Client.krpc*. Most of this functionality is used internally by the python client (for example to create and remove streams) and therefore does not need to be used directly from application code. The only exception that may be useful is:

get_status()

Gets a status message from the server containing information including the server's version string and performance statistics.

For example, the following prints out the version string for the server:

```
print('Server version =', conn.krpc.get_status().version)
```

Or to get the rate at which the server is sending and receiving data over the network:

```
status = conn.krpc.get_status()
print('Data in =', (status.bytes_read_rate/1024.0), 'KB/s')
print('Data out =', (status.bytes_written_rate/1024.0), 'KB/s')
```

class `krpc.stream.`**Stream**

__call__()

Gets the most recently received value for the stream.

remove()

Remove the stream from the server.

7.2 SpaceCenter API

7.2.1 SpaceCenter

class SpaceCenter.**SpaceCenter**

Provides functionality to interact with Kerbal Space Program. This includes controlling the active vessel, managing its resources, planning maneuver nodes and auto-piloting.

active_vessel

The currently active vessel.

Attribute Can be read or written

Return type *Vessel*

vessels

A list of all the vessels in the game.

Attribute Read-only, cannot be set

Return type list of *Vessel*

bodies

A dictionary of all celestial bodies (planets, moons, etc.) in the game, keyed by the name of the body.

Attribute Read-only, cannot be set

Return type dict from str to *CelestialBody*

target_body

The currently targeted celestial body.

Attribute Can be read or written

Return type *CelestialBody*

target_vessel

The currently targeted vessel.

Attribute Can be read or written

Return type *Vessel*

target_docking_port

The currently targeted docking port.

Attribute Can be read or written

Return type *DockingPort*

static clear_target()

Clears the current target.

static launch_vessel_from_vab(*name*)

Launch a new vessel from the VAB onto the launchpad.

Parameters **name** (*str*) – Name of the vessel's craft file.

static launch_vessel_from_sph(*name*)

Launch a new vessel from the SPH onto the runway.

Parameters **name** (*str*) – Name of the vessel's craft file.

ut

The current universal time in seconds.

Attribute Read-only, cannot be set

Return type float

g

The value of the gravitational constant G in $N(m/kg)^2$.

Attribute Read-only, cannot be set

Return type float

warp_mode

The current time warp mode. Returns `WarpMode.none` if time warp is not active, `WarpMode.rails` if regular "on-rails" time warp is active, or `WarpMode.physics` if physical time warp is active.

Attribute Read-only, cannot be set

Return type `WarpMode`

warp_rate

The current warp rate. This is the rate at which time is passing for either on-rails or physical time warp. For example, a value of 10 means time is passing 10x faster than normal. Returns 1 if time warp is not active.

Attribute Read-only, cannot be set

Return type float

warp_factor

The current warp factor. This is the index of the rate at which time is passing for either regular "on-rails" or physical time warp. Returns 0 if time warp is not active. When in on-rails time warp, this is equal to `rails_warp_factor`, and in physics time warp, this is equal to `physics_warp_factor`.

Attribute Read-only, cannot be set

Return type float

rails_warp_factor

The time warp rate, using regular "on-rails" time warp. A value between 0 and 7 inclusive. 0 means no time warp. Returns 0 if physical time warp is active. If requested time warp factor cannot be set, it will be set to the next lowest possible value. For example, if the vessel is too close to a planet. See the KSP wiki for details.

Attribute Can be read or written

Return type int

physics_warp_factor

The physical time warp rate. A value between 0 and 3 inclusive. 0 means no time warp. Returns 0 if regular "on-rails" time warp is active.

Attribute Can be read or written

Return type int

static **can_rails_warp_at**([*factor = 1*])

Returns `True` if regular "on-rails" time warp can be used, at the specified warp *factor*. The maximum time warp rate is limited by various things, including how close the active vessel is to a planet. See the KSP wiki for details.

Parameters **factor** (*int*) – The warp factor to check.

Return type bool

maximum_rails_warp_factor
The current maximum regular "on-rails" warp factor that can be set. A value between 0 and 7 inclusive. See the KSP wiki for details.

Attribute Read-only, cannot be set

Return type int

static **warp_to** (*ut*[, *max_rails_rate = 100000.0*][, *max_physics_rate = 2.0*])
Uses time acceleration to warp forward to a time in the future, specified by universal time *ut*. This call blocks until the desired time is reached. Uses regular "on-rails" or physical time warp as appropriate. For example, physical time warp is used when the active vessel is traveling through an atmosphere. When using regular "on-rails" time warp, the warp rate is limited by *max_rails_rate*, and when using physical time warp, the warp rate is limited by *max_physics_rate*.

Parameters

- **ut** (`float`) – The universal time to warp to, in seconds.
- **max_rails_rate** (`float`) – The maximum warp rate in regular "on-rails" time warp.
- **max_physics_rate** (`float`) – The maximum warp rate in physical time warp.

Returns When the time warp is complete.

static **transform_position** (*position*, *from*, *to*)
Converts a position vector from one reference frame to another.

Parameters

- **position** (`tuple`) – Position vector in reference frame *from*.
- **from** (`ReferenceFrame`) – The reference frame that the position vector is in.
- **to** (`ReferenceFrame`) – The reference frame to covert the position vector to.

Returns The corresponding position vector in reference frame *to*.

Return type tuple of (float, float, float)

static **transform_direction** (*direction*, *from*, *to*)
Converts a direction vector from one reference frame to another.

Parameters

- **direction** (`tuple`) – Direction vector in reference frame *from*.
- **from** (`ReferenceFrame`) – The reference frame that the direction vector is in.
- **to** (`ReferenceFrame`) – The reference frame to covert the direction vector to.

Returns The corresponding direction vector in reference frame *to*.

Return type tuple of (float, float, float)

static **transform_rotation** (*rotation*, *from*, *to*)
Converts a rotation from one reference frame to another.

Parameters

- **rotation** (`tuple`) – Rotation in reference frame *from*.
- **from** (`ReferenceFrame`) – The reference frame that the rotation is in.
- **to** (`ReferenceFrame`) – The corresponding rotation in reference frame *to*.

Returns The corresponding rotation in reference frame *to*.

Return type tuple of (float, float, float, float)

static **transform_velocity** (*position*, *velocity*, *from*, *to*)
Converts a velocity vector (acting at the specified position vector) from one reference frame to another. The position vector is required to take the relative angular velocity of the reference frames into account.

Parameters

- **position** (*tuple*) – Position vector in reference frame *from*.
- **velocity** (*tuple*) – Velocity vector in reference frame *from*.
- **from** (ReferenceFrame) – The reference frame that the position and velocity vectors are in.
- **to** (ReferenceFrame) – The reference frame to covert the velocity vector to.

Returns The corresponding velocity in reference frame *to*.

Return type tuple of (float, float, float)

far_available
Whether Ferram Aerospace Research is installed.

Attribute Read-only, cannot be set

Return type bool

remote_tech_available
Whether RemoteTech is installed.

Attribute Read-only, cannot be set

Return type bool

static **draw_direction** (*direction*, *reference_frame*, *color*[, *length = 10.0*])
Draw a direction vector on the active vessel.

Parameters

- **direction** (*tuple*) – Direction to draw the line in.
- **reference_frame** (ReferenceFrame) – Reference frame that the direction is in.
- **color** (*tuple*) – The color to use for the line, as an RGB color.
- **length** (*float*) – The length of the line. Defaults to 10.

static **draw_line** (*start*, *end*, *reference_frame*, *color*)
Draw a line.

Parameters

- **start** (*tuple*) – Position of the start of the line.
- **end** (*tuple*) – Position of the end of the line.
- **reference_frame** (ReferenceFrame) – Reference frame that the position are in.
- **color** (*tuple*) – The color to use for the line, as an RGB color.

static **clear_drawing** ()
Remove all directions and lines currently being drawn.

class SpaceCenter.**WarpMode**
Returned by warp_mode

rails
Time warp is active, and in regular "on-rails" mode.

physics
Time warp is active, and in physical time warp mode.

none
Time warp is not active.

7.2.2 Vessel

class SpaceCenter.**Vessel**
These objects are used to interact with vessels in KSP. This includes getting orbital and flight data, manipulating control inputs and managing resources.

name
The name of the vessel.

Attribute Can be read or written

Return type str

type
The type of the vessel.

Attribute Can be read or written

Return type *VesselType*

situation
The situation the vessel is in.

Attribute Read-only, cannot be set

Return type *VesselSituation*

met
The mission elapsed time in seconds.

Attribute Read-only, cannot be set

Return type float

flight ([*reference_frame = None*])
Returns a *Flight* object that can be used to get flight telemetry for the vessel, in the specified reference frame.

Parameters **reference_frame** (ReferenceFrame) – Reference frame. Defaults to the vessel's surface reference frame (*Vessel.surface_reference_frame*).

Return type *Flight*

target
The target vessel. None if there is no target. When setting the target, the target cannot be the current vessel.

Attribute Can be read or written

Return type *Vessel*

orbit
The current orbit of the vessel.

Attribute Read-only, cannot be set

Return type *Orbit*

control

Returns a *Control* object that can be used to manipulate the vessel's control inputs. For example, its pitch/yaw/roll controls, RCS and thrust.

Attribute Read-only, cannot be set

Return type *Control*

auto_pilot

An *AutoPilot* object, that can be used to perform simple auto-piloting of the vessel.

Attribute Read-only, cannot be set

Return type *AutoPilot*

resources

A *Resources* object, that can used to get information about resources stored in the vessel.

Attribute Read-only, cannot be set

Return type *Resources*

resources_in_decouple_stage (*stage*[, *cumulative = True*])

Returns a *Resources* object, that can used to get information about resources stored in a given *stage*.

Parameters

- **stage** (*int*) – Get resources for parts that are decoupled in this stage.
- **cumulative** (*bool*) – When `False`, returns the resources for parts decoupled in just the given stage. When `True` returns the resources decoupled in the given stage and all subsequent stages combined.

Return type *Resources*

Note: For details on stage numbering, see the discussion on *Staging*.

---

parts

A *Parts* object, that can used to interact with the parts that make up this vessel.

Attribute Read-only, cannot be set

Return type *Parts*

comms

A *Comms* object, that can used to interact with RemoteTech for this vessel.

Attribute Read-only, cannot be set

Return type *Comms*

Note: Requires RemoteTech to be installed.

---

mass

The total mass of the vessel, including resources, in kg.

Attribute Read-only, cannot be set

Return type float

dry_mass
The total mass of the vessel, excluding resources, in kg.

Attribute Read-only, cannot be set

Return type float

thrust
The total thrust currently being produced by the vessel's engines, in Newtons. This is computed by summing *Engine.thrust* for every engine in the vessel.

Attribute Read-only, cannot be set

Return type float

available_thrust
Gets the total available thrust that can be produced by the vessel's active engines, in Newtons. This is computed by summing *Engine.available_thrust* for every active engine in the vessel.

Attribute Read-only, cannot be set

Return type float

max_thrust
The total maximum thrust that can be produced by the vessel's active engines, in Newtons. This is computed by summing *Engine.max_thrust* for every active engine.

Attribute Read-only, cannot be set

Return type float

max_vacuum_thrust
The total maximum thrust that can be produced by the vessel's active engines when the vessel is in a vacuum, in Newtons. This is computed by summing *Engine.max_vacuum_thrust* for every active engine.

Attribute Read-only, cannot be set

Return type float

specific_impulse
The combined specific impulse of all active engines, in seconds. This is computed using the formula described here.

Attribute Read-only, cannot be set

Return type float

vacuum_specific_impulse
The combined vacuum specific impulse of all active engines, in seconds. This is computed using the formula described here.

Attribute Read-only, cannot be set

Return type float

kerbin_sea_level_specific_impulse
The combined specific impulse of all active engines at sea level on Kerbin, in seconds. This is computed using the formula described here.

Attribute Read-only, cannot be set

Return type float

reference_frame
The reference frame that is fixed relative to the vessel, and orientated with the vessel.

- The origin is at the center of mass of the vessel.
- The axes rotate with the vessel.
- The x-axis points out to the right of the vessel.
- The y-axis points in the forward direction of the vessel.
- The z-axis points out of the bottom off the vessel.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

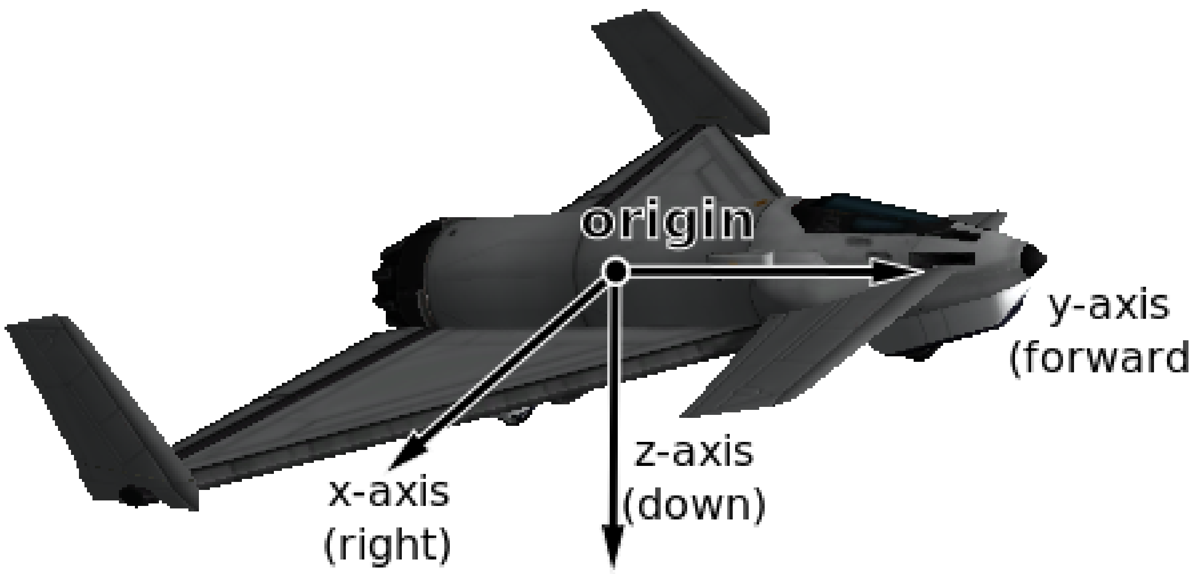


Fig. 7.1: Vessel reference frame origin and axes for the Aeris 3A aircraft

orbital_reference_frame

The reference frame that is fixed relative to the vessel, and orientated with the vessels orbital prograde/normal/radial directions.

- The origin is at the center of mass of the vessel.
- The axes rotate with the orbital prograde/normal/radial directions.
- The x-axis points in the orbital anti-radial direction.
- The y-axis points in the orbital prograde direction.
- The z-axis points in the orbital normal direction.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

Note: Be careful not to confuse this with 'orbit' mode on the navball.

surface_reference_frame

The reference frame that is fixed relative to the vessel, and orientated with the surface of the body being orbited.

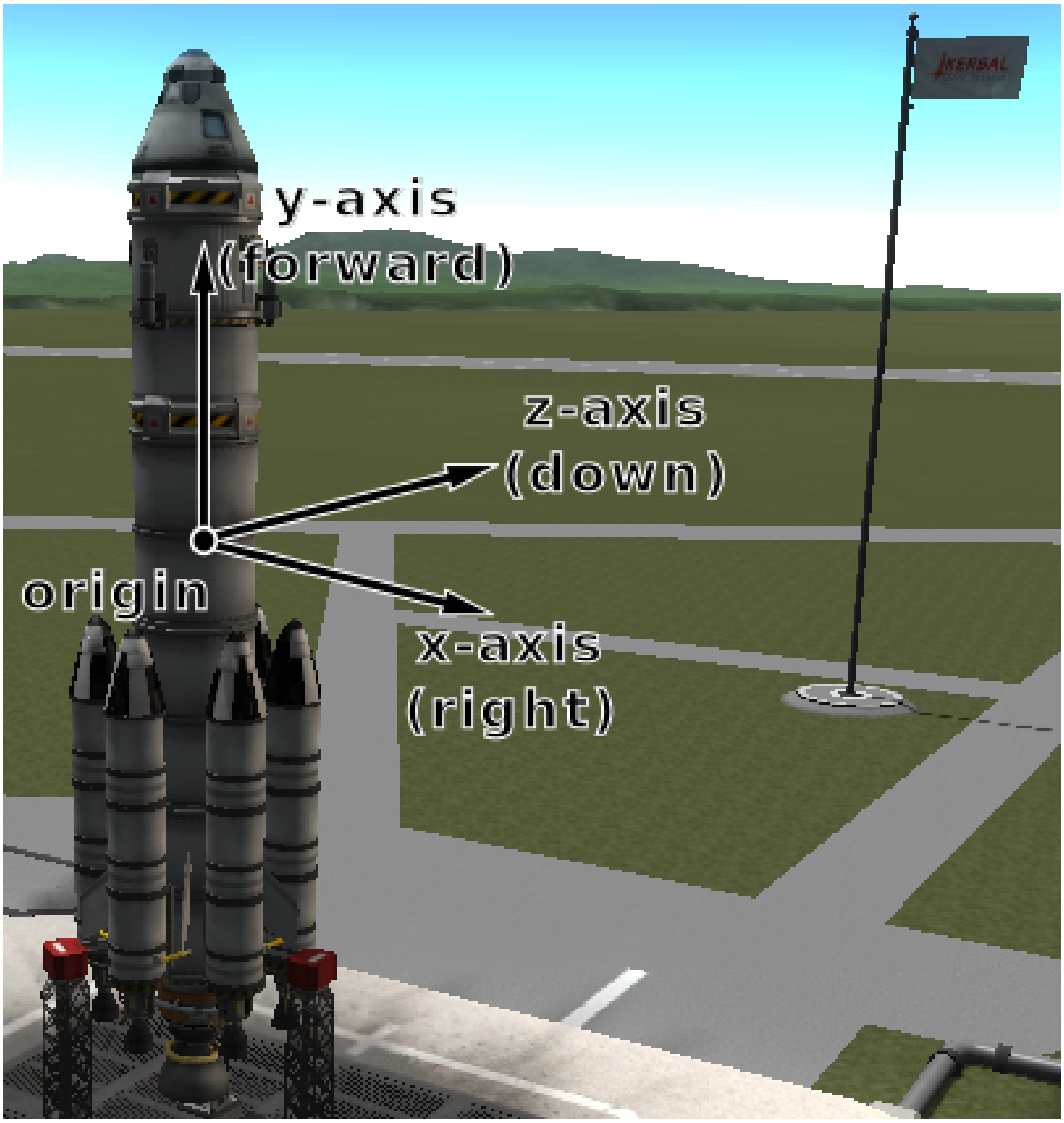


Fig. 7.2: Vessel reference frame origin and axes for the Kerbal-X rocket

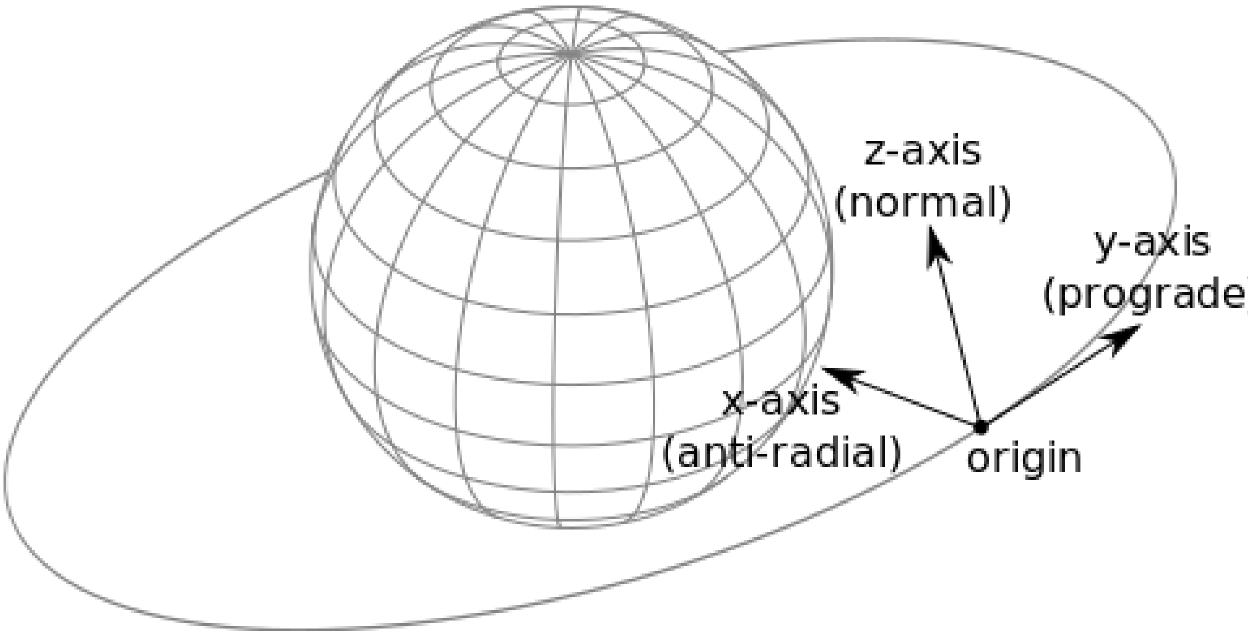


Fig. 7.3: Vessel orbital reference frame origin and axes

- The origin is at the center of mass of the vessel.
- The axes rotate with the north and up directions on the surface of the body.
- The x-axis points in the zenith direction (upwards, normal to the body being orbited, from the center of the body towards the center of mass of the vessel).
- The y-axis points northwards towards the astronomical horizon (north, and tangential to the surface of the body – the direction in which a compass would point when on the surface).
- The z-axis points eastwards towards the astronomical horizon (east, and tangential to the surface of the body – east on a compass when on the surface).

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

Note: Be careful not to confuse this with 'surface' mode on the navball.

surface_velocity_reference_frame

The reference frame that is fixed relative to the vessel, and orientated with the velocity vector of the vessel relative to the surface of the body being orbited.

- The origin is at the center of mass of the vessel.
- The axes rotate with the vessel's velocity vector.
- The y-axis points in the direction of the vessel's velocity vector, relative to the surface of the body being orbited.
- The z-axis is in the plane of the astronomical horizon.
- The x-axis is orthogonal to the other two axes.

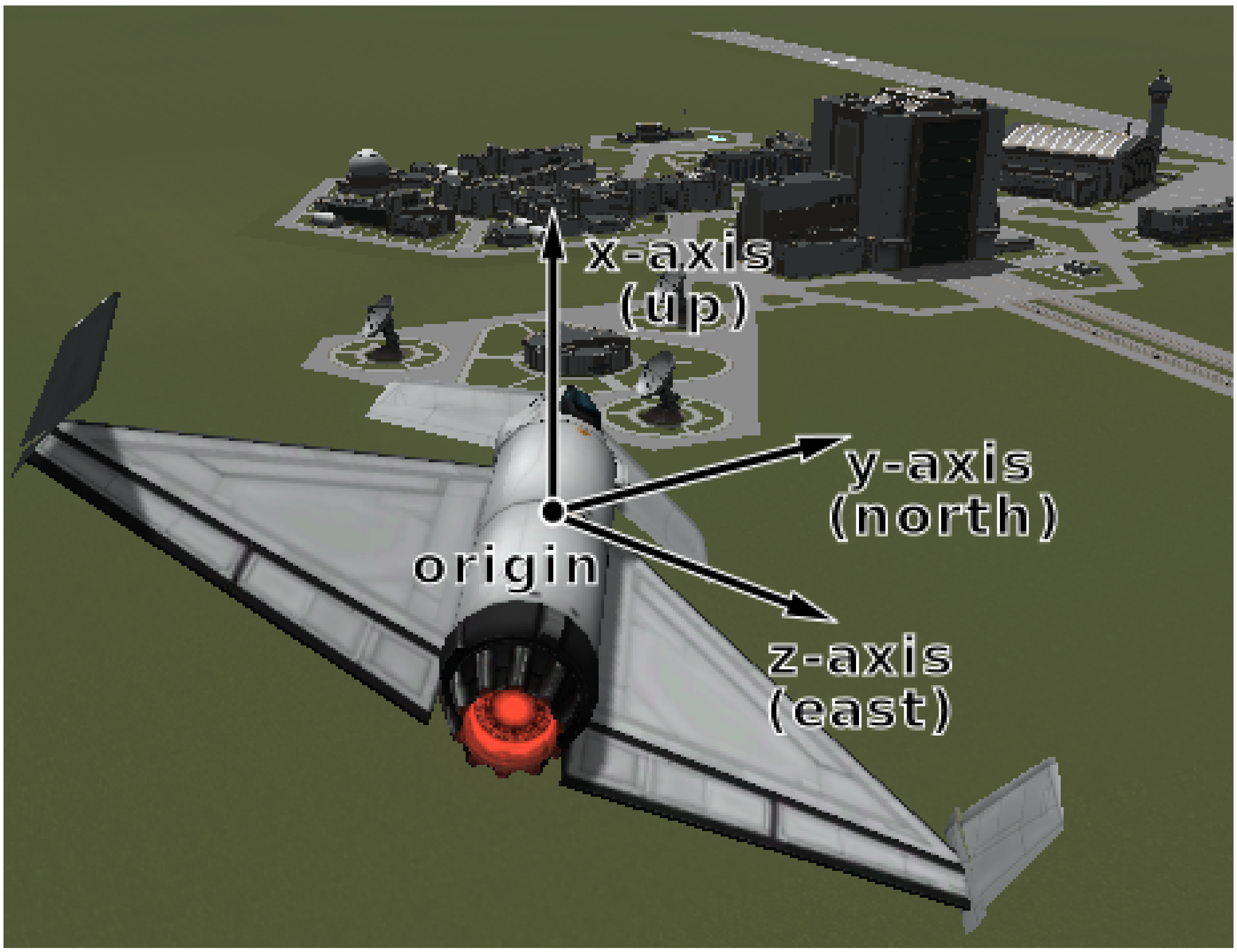


Fig. 7.4: Vessel surface reference frame origin and axes

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

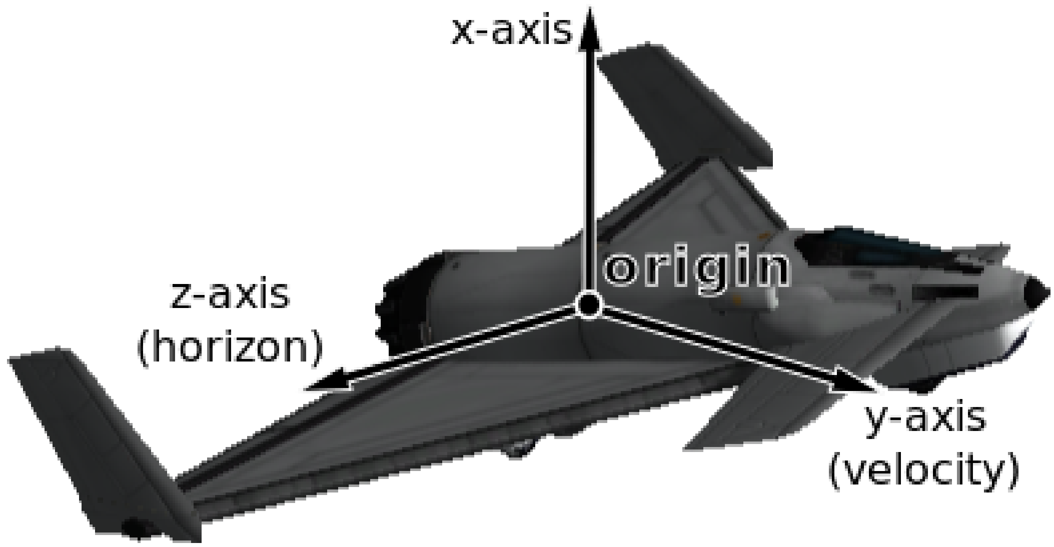


Fig. 7.5: Vessel surface velocity reference frame origin and axes

position (*reference_frame*)
Returns the position vector of the center of mass of the vessel in the given reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

velocity (*reference_frame*)
Returns the velocity vector of the center of mass of the vessel in the given reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

rotation (*reference_frame*)
Returns the rotation of the center of mass of the vessel in the given reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float, float)

direction (*reference_frame*)
Returns the direction in which the vessel is pointing, as a unit vector, in the given reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

angular_velocity (*reference_frame*)
Returns the angular velocity of the vessel in the given reference frame. The magnitude of the returned vector is the rotational speed in radians per second, and the direction of the vector indicates the axis of rotation (using the right hand rule).

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

class SpaceCenter.**VesselType**
See *Vessel.type*.

ship
Ship.

station
Station.

lander
Lander.

probe
Probe.

rover
Rover.

base
Base.

debris
Debris.

class SpaceCenter.**VesselSituation**
See *Vessel.situation*.

docked
Vessel is docked to another.

escaping
Escaping.

flying
Vessel is flying through an atmosphere.

landed
Vessel is landed on the surface of a body.

orbiting
Vessel is orbiting a body.

pre_launch
Vessel is awaiting launch.

splashed
Vessel has splashed down in an ocean.

sub_orbital
Vessel is on a sub-orbital trajectory.

7.2.3 CelestialBody

class SpaceCenter.**CelestialBody**
Represents a celestial body (such as a planet or moon).

name
The name of the body.

Attribute Read-only, cannot be set

Return type str

satellites
A list of celestial bodies that are in orbit around this celestial body.

Attribute Read-only, cannot be set

Return type list of *CelestialBody*

orbit
The orbit of the body.

Attribute Read-only, cannot be set

Return type *Orbit*

mass
The mass of the body, in kilograms.

Attribute Read-only, cannot be set

Return type float

gravitational_parameter
The standard gravitational parameter of the body in $m^3 s^{-2}$.

Attribute Read-only, cannot be set

Return type float

surface_gravity
The acceleration due to gravity at sea level (mean altitude) on the body, in m/s^2.

Attribute Read-only, cannot be set

Return type float

rotational_period
The sidereal rotational period of the body, in seconds.

Attribute Read-only, cannot be set

Return type float

rotational_speed
The rotational speed of the body, in radians per second.

Attribute Read-only, cannot be set

Return type float

equatorial_radius
The equatorial radius of the body, in meters.

Attribute Read-only, cannot be set

Return type float

surface_height (*latitude*, *longitude*)
The height of the surface relative to mean sea level at the given position, in meters. When over water this is equal to 0.

Parameters

- **latitude** (*float*) – Latitude in degrees
- **longitude** (*float*) – Longitude in degrees

Return type float

bedrock_height (*latitude*, *longitude*)
The height of the surface relative to mean sea level at the given position, in meters. When over water, this is the height of the sea-bed and is therefore a negative value.

Parameters

- **latitude** (*float*) – Latitude in degrees
- **longitude** (*float*) – Longitude in degrees

Return type float

msl_position (*latitude*, *longitude*, *reference_frame*)
The position at mean sea level at the given latitude and longitude, in the given reference frame.

Parameters

- **latitude** (*float*) – Latitude in degrees
- **longitude** (*float*) – Longitude in degrees
- **reference_frame** (ReferenceFrame) – Reference frame for the returned position vector

Return type tuple of (float, float, float)

surface_position (*latitude*, *longitude*, *reference_frame*)
The position of the surface at the given latitude and longitude, in the given reference frame. When over water, this is the position of the surface of the water.

Parameters

- **latitude** (*float*) – Latitude in degrees
- **longitude** (*float*) – Longitude in degrees
- **reference_frame** (ReferenceFrame) – Reference frame for the returned position vector

Return type tuple of (float, float, float)

bedrock_position (*latitude*, *longitude*, *reference_frame*)
The position of the surface at the given latitude and longitude, in the given reference frame. When over water, this is the position at the bottom of the sea-bed.

Parameters

- **latitude** (*float*) – Latitude in degrees
- **longitude** (*float*) – Longitude in degrees
- **reference_frame** (ReferenceFrame) – Reference frame for the returned position vector

Return type tuple of (float, float, float)

sphere_of_influence
The radius of the sphere of influence of the body, in meters.

Attribute Read-only, cannot be set

Return type float

has_atmosphere
`True` if the body has an atmosphere.

Attribute Read-only, cannot be set

Return type bool

atmosphere_depth

The depth of the atmosphere, in meters.

Attribute Read-only, cannot be set

Return type float

has_atmospheric_oxygen

`True` if there is oxygen in the atmosphere, required for air-breathing engines.

Attribute Read-only, cannot be set

Return type bool

reference_frame

The reference frame that is fixed relative to the celestial body.

- The origin is at the center of the body.
- The axes rotate with the body.
- The x-axis points from the center of the body towards the intersection of the prime meridian and equator (the position at 0° longitude, 0° latitude).
- The y-axis points from the center of the body towards the north pole.
- The z-axis points from the center of the body towards the equator at 90°E longitude.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

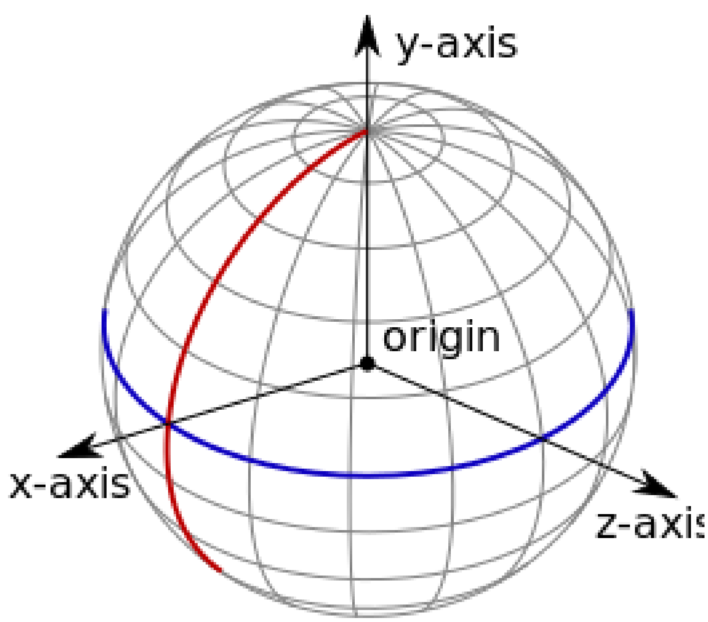


Fig. 7.6: Celestial body reference frame origin and axes. The equator is shown in blue, and the prime meridian in red.

non_rotating_reference_frame

The reference frame that is fixed relative to this celestial body, and orientated in a fixed direction (it does not rotate with the body).

- The origin is at the center of the body.

- The axes do not rotate.
- The x-axis points in an arbitrary direction through the equator.
- The y-axis points from the center of the body towards the north pole.
- The z-axis points in an arbitrary direction through the equator.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

orbital_reference_frame

Gets the reference frame that is fixed relative to this celestial body, but orientated with the body's orbital prograde/normal/radial directions.

- The origin is at the center of the body.
- The axes rotate with the orbital prograde/normal/radial directions.
- The x-axis points in the orbital anti-radial direction.
- The y-axis points in the orbital prograde direction.
- The z-axis points in the orbital normal direction.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

position(*reference_frame*)

Returns the position vector of the center of the body in the specified reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

velocity(*reference_frame*)

Returns the velocity vector of the body in the specified reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

rotation(*reference_frame*)

Returns the rotation of the body in the specified reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float, float)

direction(*reference_frame*)

Returns the direction in which the north pole of the celestial body is pointing, as a unit vector, in the specified reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

angular_velocity(*reference_frame*)

Returns the angular velocity of the body in the specified reference frame. The magnitude of the vector is the rotational speed of the body, in radians per second, and the direction of the vector indicates the axis of rotation, using the right-hand rule.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

7.2.4 Flight

class SpaceCenter.**Flight**

Used to get flight telemetry for a vessel, by calling *Vessel.flight()*. All of the information returned by this class is given in the reference frame passed to that method.

Note: To get orbital information, such as the apoapsis or inclination, see *Orbit*.

g_force

The current G force acting on the vessel in m/s^2.

Attribute Read-only, cannot be set

Return type float

mean_altitude

The altitude above sea level, in meters.

Attribute Read-only, cannot be set

Return type float

surface_altitude

The altitude above the surface of the body or sea level, whichever is closer, in meters.

Attribute Read-only, cannot be set

Return type float

bedrock_altitude

The altitude above the surface of the body, in meters. When over water, this is the altitude above the sea floor.

Attribute Read-only, cannot be set

Return type float

elevation

The elevation of the terrain under the vessel, in meters. This is the height of the terrain above sea level, and is negative when the vessel is over the sea.

Attribute Read-only, cannot be set

Return type float

latitude

The latitude of the vessel for the body being orbited, in degrees.

Attribute Read-only, cannot be set

Return type float

longitude

The longitude of the vessel for the body being orbited, in degrees.

Attribute Read-only, cannot be set

Return type float

velocity
The velocity vector of the vessel. The magnitude of the vector is the speed of the vessel in meters per second. The direction of the vector is the direction of the vessels motion.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

speed
The speed of the vessel in meters per second.

Attribute Read-only, cannot be set

Return type float

horizontal_speed
The horizontal speed of the vessel in meters per second.

Attribute Read-only, cannot be set

Return type float

vertical_speed
The vertical speed of the vessel in meters per second.

Attribute Read-only, cannot be set

Return type float

center_of_mass
The position of the center of mass of the vessel.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

rotation
The rotation of the vessel.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float, float)

direction
The direction vector that the vessel is pointing in.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

pitch
The pitch angle of the vessel relative to the horizon, in degrees. A value between -90° and +90°.

Attribute Read-only, cannot be set

Return type float

heading
The heading angle of the vessel relative to north, in degrees. A value between 0° and 360°.

Attribute Read-only, cannot be set

Return type float

roll
The roll angle of the vessel relative to the horizon, in degrees. A value between -180° and +180°.

Attribute Read-only, cannot be set

Return type float

prograde
The unit direction vector pointing in the prograde direction.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

retrograde
The unit direction vector pointing in the retrograde direction.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

normal
The unit direction vector pointing in the normal direction.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

anti_normal
The unit direction vector pointing in the anti-normal direction.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

radial
The unit direction vector pointing in the radial direction.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

anti_radial
The unit direction vector pointing in the anti-radial direction.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

atmosphere_density
The current density of the atmosphere around the vessel, in kg/m^3.

Attribute Read-only, cannot be set

Return type float

dynamic_pressure
The dynamic pressure acting on the vessel, in Pascals. This is a measure of the strength of the aerodynamic forces. It is equal to $\frac{1}{2}$.air density.velocity^2. It is commonly denoted as Q.

Attribute Read-only, cannot be set

Return type float

Note: Calculated using KSPs stock aerodynamic model, or Ferram Aerospace Research if it is installed.

static_pressure
The static atmospheric pressure acting on the vessel, in Pascals.

Attribute Read-only, cannot be set

Return type float

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

aerodynamic_force

The total aerodynamic forces acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

lift

The aerodynamic lift currently acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

drag

The aerodynamic drag currently acting on the vessel, as a vector pointing in the direction of the force, with its magnitude equal to the strength of the force in Newtons.

Attribute Read-only, cannot be set

Return type tuple of (float, float, float)

Note: Calculated using KSPs stock aerodynamic model. Not available when Ferram Aerospace Research is installed.

speed_of_sound

The speed of sound, in the atmosphere around the vessel, in m/s.

Attribute Read-only, cannot be set

Return type float

Note: Not available when Ferram Aerospace Research is installed.

mach

The speed of the vessel, in multiples of the speed of sound.

Attribute Read-only, cannot be set

Return type float

Note: Not available when Ferram Aerospace Research is installed.

equivalent_air_speed

The equivalent air speed of the vessel, in m/s.

Attribute Read-only, cannot be set

Return type float

Note: Not available when Ferram Aerospace Research is installed.

terminal_velocity

An estimate of the current terminal velocity of the vessel, in m/s. This is the speed at which the drag forces cancel out the force of gravity.

Attribute Read-only, cannot be set

Return type float

Note: Calculated using KSPs stock aerodynamic model, or Ferram Aerospace Research if it is installed.

angle_of_attack

Gets the pitch angle between the orientation of the vessel and its velocity vector, in degrees.

Attribute Read-only, cannot be set

Return type float

sideslip_angle

Gets the yaw angle between the orientation of the vessel and its velocity vector, in degrees.

Attribute Read-only, cannot be set

Return type float

total_air_temperature

The total air temperature of the atmosphere around the vessel, in Kelvin. This temperature includes the *Flight.static_air_temperature* and the vessel's kinetic energy.

Attribute Read-only, cannot be set

Return type float

static_air_temperature

The static (ambient) temperature of the atmosphere around the vessel, in Kelvin.

Attribute Read-only, cannot be set

Return type float

stall_fraction

Gets the current amount of stall, between 0 and 1. A value greater than 0.005 indicates a minor stall and a value greater than 0.5 indicates a large-scale stall.

Attribute Read-only, cannot be set

Return type float

Note: Requires Ferram Aerospace Research.

drag_coefficient
Gets the coefficient of drag. This is the amount of drag produced by the vessel. It depends on air speed, air density and wing area.

Attribute Read-only, cannot be set

Return type float

Note: Requires Ferram Aerospace Research.

lift_coefficient
Gets the coefficient of lift. This is the amount of lift produced by the vessel, and depends on air speed, air density and wing area.

Attribute Read-only, cannot be set

Return type float

Note: Requires Ferram Aerospace Research.

ballistic_coefficient
Gets the ballistic coefficient.

Attribute Read-only, cannot be set

Return type float

Note: Requires Ferram Aerospace Research.

thrust_specific_fuel_consumption
Gets the thrust specific fuel consumption for the jet engines on the vessel. This is a measure of the efficiency of the engines, with a lower value indicating a more efficient vessel. This value is the number of Newtons of fuel that are burned, per hour, to product one newton of thrust.

Attribute Read-only, cannot be set

Return type float

Note: Requires Ferram Aerospace Research.

7.2.5 Orbit

class SpaceCenter.**Orbit**
Describes an orbit. For example, the orbit of a vessel, obtained by calling *Vessel.orbit*, or a celestial body, obtained by calling *CelestialBody.orbit*.

body
The celestial body (e.g. planet or moon) around which the object is orbiting.

Attribute Read-only, cannot be set

Return type `CelestialBody`

apoapsis
Gets the apoapsis of the orbit, in meters, from the center of mass of the body being orbited.

Attribute Read-only, cannot be set

Return type float

Note: For the apoapsis altitude reported on the in-game map view, use `Orbit.apoapsis_altitude`.

periapsis
The periapsis of the orbit, in meters, from the center of mass of the body being orbited.

Attribute Read-only, cannot be set

Return type float

Note: For the periapsis altitude reported on the in-game map view, use `Orbit.periapsis_altitude`.

apoapsis_altitude
The apoapsis of the orbit, in meters, above the sea level of the body being orbited.

Attribute Read-only, cannot be set

Return type float

Note: This is equal to `Orbit.apoapsis` minus the equatorial radius of the body.

periapsis_altitude
The periapsis of the orbit, in meters, above the sea level of the body being orbited.

Attribute Read-only, cannot be set

Return type float

Note: This is equal to `Orbit.periapsis` minus the equatorial radius of the body.

semi_major_axis
The semi-major axis of the orbit, in meters.

Attribute Read-only, cannot be set

Return type float

semi_minor_axis
The semi-minor axis of the orbit, in meters.

Attribute Read-only, cannot be set

Return type float

radius
The current radius of the orbit, in meters. This is the distance between the center of mass of the object in orbit, and the center of mass of the body around which it is orbiting.

Attribute Read-only, cannot be set

Return type float

Note: This value will change over time if the orbit is elliptical.

speed
The current orbital speed of the object in meters per second.

Attribute Read-only, cannot be set

Return type float

Note: This value will change over time if the orbit is elliptical.

period
The orbital period, in seconds.

Attribute Read-only, cannot be set

Return type float

time_to_apoapsis
The time until the object reaches apoapsis, in seconds.

Attribute Read-only, cannot be set

Return type float

time_to_periapsis
The time until the object reaches periapsis, in seconds.

Attribute Read-only, cannot be set

Return type float

eccentricity
The eccentricity of the orbit.

Attribute Read-only, cannot be set

Return type float

inclination
The inclination of the orbit, in radians.

Attribute Read-only, cannot be set

Return type float

longitude_of_ascending_node
The longitude of the ascending node, in radians.

Attribute Read-only, cannot be set

Return type float

argument_of_periapsis
The argument of periapsis, in radians.

Attribute Read-only, cannot be set

Return type float

mean_anomaly_at_epoch
The mean anomaly at epoch.

Attribute Read-only, cannot be set

Return type float

epoch
The time since the epoch (the point at which the mean anomaly at epoch was measured, in seconds.

Attribute Read-only, cannot be set

Return type float

mean_anomaly
The mean anomaly.

Attribute Read-only, cannot be set

Return type float

eccentric_anomaly
The eccentric anomaly.

Attribute Read-only, cannot be set

Return type float

static reference_plane_normal(*reference_frame*)
The unit direction vector that is normal to the orbits reference plane, in the given reference frame. The reference plane is the plane from which the orbits inclination is measured.

Parameters **reference_frame** (`ReferenceFrame`) –

Return type tuple of (float, float, float)

static reference_plane_direction(*reference_frame*)
The unit direction vector from which the orbits longitude of ascending node is measured, in the given reference frame.

Parameters **reference_frame** (`ReferenceFrame`) –

Return type tuple of (float, float, float)

time_to_soi_change
The time until the object changes sphere of influence, in seconds. Returns `NaN` if the object is not going to change sphere of influence.

Attribute Read-only, cannot be set

Return type float

next_orbit
If the object is going to change sphere of influence in the future, returns the new orbit after the change. Otherwise returns `None`.

Attribute Read-only, cannot be set

Return type *`Orbit`*

7.2.6 Control

class `SpaceCenter.`**`Control`**
Used to manipulate the controls of a vessel. This includes adjusting the throttle, enabling/disabling systems such as SAS and RCS, or altering the direction in which the vessel is pointing.

Note: Control inputs (such as pitch, yaw and roll) are zeroed when all clients that have set one or more of these inputs are no longer connected.

sas

The state of SAS.

Attribute Can be read or written

Return type bool

Note: Equivalent to *AutoPilot.sas*

sas_mode

The current *SASMode*. These modes are equivalent to the mode buttons to the left of the navball that appear when SAS is enabled.

Attribute Can be read or written

Return type *SASMode*

Note: Equivalent to *AutoPilot.sas_mode*

speed_mode

The current *SpeedMode* of the navball. This is the mode displayed next to the speed at the top of the navball.

Attribute Can be read or written

Return type *SpeedMode*

rcs

The state of RCS.

Attribute Can be read or written

Return type bool

gear

The state of the landing gear/legs.

Attribute Can be read or written

Return type bool

lights

The state of the lights.

Attribute Can be read or written

Return type bool

brakes

The state of the wheel brakes.

Attribute Can be read or written

Return type bool

abort

The state of the abort action group.

Attribute Can be read or written

Return type bool

`throttle`
The state of the throttle. A value between 0 and 1.

Attribute Can be read or written

Return type float

`pitch`
The state of the pitch control. A value between -1 and 1. Equivalent to the w and s keys.

Attribute Can be read or written

Return type float

`yaw`
The state of the yaw control. A value between -1 and 1. Equivalent to the a and d keys.

Attribute Can be read or written

Return type float

`roll`
The state of the roll control. A value between -1 and 1. Equivalent to the q and e keys.

Attribute Can be read or written

Return type float

`forward`
The state of the forward translational control. A value between -1 and 1. Equivalent to the h and n keys.

Attribute Can be read or written

Return type float

`up`
The state of the up translational control. A value between -1 and 1. Equivalent to the i and k keys.

Attribute Can be read or written

Return type float

`right`
The state of the right translational control. A value between -1 and 1. Equivalent to the j and l keys.

Attribute Can be read or written

Return type float

`wheel_throttle`
The state of the wheel throttle. A value between -1 and 1. A value of 1 rotates the wheels forwards, a value of -1 rotates the wheels backwards.

Attribute Can be read or written

Return type float

`wheel_steering`
The state of the wheel steering. A value between -1 and 1. A value of 1 steers to the left, and a value of -1 steers to the right.

Attribute Can be read or written

Return type float

current_stage

The current stage of the vessel. Corresponds to the stage number in the in-game UI.

Attribute Read-only, cannot be set

Return type int

activate_next_stage()

Activates the next stage. Equivalent to pressing the space bar in-game.

Returns A list of vessel objects that are jettisoned from the active vessel.

Return type list of *Vessel*

get_action_group(*group*)

Returns True if the given action group is enabled.

Parameters **group** (*int*) – A number between 0 and 9 inclusive.

Return type bool

set_action_group(*group*, *state*)

Sets the state of the given action group (a value between 0 and 9 inclusive).

Parameters

- **group** (*int*) – A number between 0 and 9 inclusive.
- **state** (*bool*) –

toggle_action_group(*group*)

Toggles the state of the given action group.

Parameters **group** (*int*) – A number between 0 and 9 inclusive.

add_node(*ut*[, *prograde = 0.0*][, *normal = 0.0*][, *radial = 0.0*])

Creates a maneuver node at the given universal time, and returns a *Node* object that can be used to modify it. Optionally sets the magnitude of the delta-v for the maneuver node in the prograde, normal and radial directions.

Parameters

- **ut** (*float*) – Universal time of the maneuver node.
- **prograde** (*float*) – Delta-v in the prograde direction.
- **normal** (*float*) – Delta-v in the normal direction.
- **radial** (*float*) – Delta-v in the radial direction.

Return type *Node*

nodes

Returns a list of all existing maneuver nodes, ordered by time from first to last.

Attribute Read-only, cannot be set

Return type list of *Node*

remove_nodes()

Remove all maneuver nodes.

class SpaceCenter.**SASMode**

The behavior of the SAS auto-pilot. See *AutoPilot.sas_mode*.

stability_assist

Stability assist mode. Dampen out any rotation.

maneuver
Point in the burn direction of the next maneuver node.

prograde
Point in the prograde direction.

retrograde
Point in the retrograde direction.

normal
Point in the orbit normal direction.

anti_normal
Point in the orbit anti-normal direction.

radial
Point in the orbit radial direction.

anti_radial
Point in the orbit anti-radial direction.

target
Point in the direction of the current target.

anti_target
Point away from the current target.

class SpaceCenter.**SpeedMode**
See *Control.speed_mode*.

orbit
Speed is relative to the vessel's orbit.

surface
Speed is relative to the surface of the body being orbited.

target
Speed is relative to the current target.

7.2.7 Parts

The following classes allow interaction with a vessels individual parts.

Parts

class `SpaceCenter.`**`Parts`**

Instances of this class are used to interact with the parts of a vessel. An instance can be obtained by calling `Vessel.parts`.

`all`

A list of all of the vessels parts.

Attribute Read-only, cannot be set

Return type list of `Part`

`root`

The vessels root part.

Attribute Read-only, cannot be set

Return type `Part`

Note: See the discussion on *Trees of Parts*.

`controlling`

The part from which the vessel is controlled.

Attribute Can be read or written

Return type `Part`

`with_name`(*name*)

A list of parts whose `Part.name` is *name*.

Parameters **name** (*str*) –

Return type list of `Part`

with_title (*title*)
A list of all parts whose `Part.title` is *title*.

Parameters **title** (*str*) –

Return type list of `Part`

with_module (*module_name*)
A list of all parts that contain a `Module` whose `Module.name` is *module_name*.

Parameters **module_name** (*str*) –

Return type list of `Part`

in_stage (*stage*)
A list of all parts that are activated in the given *stage*.

Parameters **stage** (*int*) –

Return type list of `Part`

Note: See the discussion on *Staging*.

in_decouple_stage (*stage*)
A list of all parts that are decoupled in the given *stage*.

Parameters **stage** (*int*) –

Return type list of `Part`

Note: See the discussion on *Staging*.

modules_with_name (*module_name*)
A list of modules (combined across all parts in the vessel) whose `Module.name` is *module_name*.

Parameters **module_name** (*str*) –

Return type list of `Module`

decouplers
A list of all decouplers in the vessel.

Attribute Read-only, cannot be set

Return type list of `Decoupler`

docking_ports
A list of all docking ports in the vessel.

Attribute Read-only, cannot be set

Return type list of `DockingPort`

docking_port_with_name (*name*)
The first docking port in the vessel with the given port name, as returned by `DockingPort.name`. Returns `None` if there are no such docking ports.

Parameters **name** (*str*) –

Return type *DockingPort*

engines
A list of all engines in the vessel.

Attribute Read-only, cannot be set

Return type list of *Engine*

landing_gear
A list of all landing gear attached to the vessel.

Attribute Read-only, cannot be set

Return type list of *LandingGear*

landing_legs
A list of all landing legs attached to the vessel.

Attribute Read-only, cannot be set

Return type list of *LandingLeg*

launch_clamps
A list of all launch clamps attached to the vessel.

Attribute Read-only, cannot be set

Return type list of *LaunchClamp*

lights
A list of all lights in the vessel.

Attribute Read-only, cannot be set

Return type list of *Light*

parachutes
A list of all parachutes in the vessel.

Attribute Read-only, cannot be set

Return type list of *Parachute*

radiators
A list of all radiators in the vessel.

Attribute Read-only, cannot be set

Return type list of *Radiator*

resource_converters
A list of all resource converters in the vessel.

Attribute Read-only, cannot be set

Return type list of *ResourceConverter*

resource_harvesters
A list of all resource harvesters in the vessel.

Attribute Read-only, cannot be set

Return type list of *ResourceHarvester*

reaction_wheels
A list of all reaction wheels in the vessel.

Attribute Read-only, cannot be set

Return type list of *ReactionWheel*

sensors

A list of all sensors in the vessel.

Attribute Read-only, cannot be set

Return type list of *Sensor*

solar_panels

A list of all solar panels in the vessel.

Attribute Read-only, cannot be set

Return type list of *SolarPanel*

Part

class SpaceCenter.**Part**

Instances of this class represents a part. A vessel is made of multiple parts. Instances can be obtained by various methods in *Parts*.

name

Internal name of the part, as used in part cfg files. For example “Mark1-2Pod”.

Attribute Read-only, cannot be set

Return type str

title

Title of the part, as shown when the part is right clicked in-game. For example “Mk1-2 Command Pod”.

Attribute Read-only, cannot be set

Return type str

cost

The cost of the part, in units of funds.

Attribute Read-only, cannot be set

Return type float

vessel

The vessel that contains this part.

Attribute Read-only, cannot be set

Return type *Vessel*

parent

The parts parent. Returns `None` if the part does not have a parent. This, in combination with *Part.children*, can be used to traverse the vessels parts tree.

Attribute Read-only, cannot be set

Return type *Part*

Note: See the discussion on *Trees of Parts*.

children

The parts children. Returns an empty list if the part has no children. This, in combination with `Part.parent`, can be used to traverse the vessels parts tree.

Attribute Read-only, cannot be set

Return type list of `Part`

Note: See the discussion on *Trees of Parts*.

axially_attached

Whether the part is axially attached to its parent, i.e. on the top or bottom of its parent. If the part has no parent, returns `False`.

Attribute Read-only, cannot be set

Return type bool

Note: See the discussion on *Attachment Modes*.

radially_attached

Whether the part is radially attached to its parent, i.e. on the side of its parent. If the part has no parent, returns `False`.

Attribute Read-only, cannot be set

Return type bool

Note: See the discussion on *Attachment Modes*.

stage

The stage in which this part will be activated. Returns -1 if the part is not activated by staging.

Attribute Read-only, cannot be set

Return type int

Note: See the discussion on *Staging*.

decouple_stage

The stage in which this part will be decoupled. Returns -1 if the part is never decoupled from the vessel.

Attribute Read-only, cannot be set

Return type int

Note: See the discussion on *Staging*.

massless

Whether the part is massless.

Attribute Read-only, cannot be set

Return type bool

mass

The current mass of the part, including resources it contains, in kilograms. Returns zero if the part is massless.

Attribute Read-only, cannot be set

Return type float

dry_mass

The mass of the part, not including any resources it contains, in kilograms. Returns zero if the part is massless.

Attribute Read-only, cannot be set

Return type float

impact_tolerance

The impact tolerance of the part, in meters per second.

Attribute Read-only, cannot be set

Return type float

temperature

Temperature of the part, in Kelvin.

Attribute Read-only, cannot be set

Return type float

skin_temperature

Temperature of the skin of the part, in Kelvin.

Attribute Read-only, cannot be set

Return type float

max_temperature

Maximum temperature that the part can survive, in Kelvin.

Attribute Read-only, cannot be set

Return type float

max_skin_temperature

Maximum temperature that the skin of the part can survive, in Kelvin.

Attribute Read-only, cannot be set

Return type float

external_temperature

Temperature of the atmosphere/vacuum surrounding the part, in Kelvin. This does not include heating from direct sunlight.

Attribute Read-only, cannot be set

Return type float

thermal_mass

How much it takes to heat up the part.

Attribute Read-only, cannot be set

Return type float

thermal_skin_mass
How much it takes to heat up the part's skin.

Attribute Read-only, cannot be set

Return type float

thermal_resource_mass
How much it takes to heat up resources in the part.

Attribute Read-only, cannot be set

Return type float

thermal_conduction_flux
The speed that heat is conducting into or out of the part through contact with other parts. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

Attribute Read-only, cannot be set

Return type float

thermal_convection_flux
The speed that heat is convecting into or out of the part from the surrounding atmosphere. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

Attribute Read-only, cannot be set

Return type float

thermal_radiation_flux
The speed that heat is radiating into or out of the part from the surrounding vacuum. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

Attribute Read-only, cannot be set

Return type float

thermal_internal_flux
The speed that heat is generated by the part. For example, engines generate heat by burning fuel. A positive number means the part is gaining heat energy, negative means it is losing heat energy.

Attribute Read-only, cannot be set

Return type float

thermal_skin_to_internal_flux
The speed that heat is conducting between the part's skin and its internals.

Attribute Read-only, cannot be set

Return type float

resources
A *Resources* object for the part.

Attribute Read-only, cannot be set

Return type *Resources*

crossfeed
Whether this part is crossfeed capable.

Attribute Read-only, cannot be set

Return type bool

is_fuel_line
Whether this part is a fuel line.

Attribute Read-only, cannot be set

Return type bool

fuel_lines_from
The parts that are connected to this part via fuel lines, where the direction of the fuel line is into this part.

Attribute Read-only, cannot be set

Return type list of `Part`

Note: See the discussion on *Fuel Lines*.

fuel_lines_to
The parts that are connected to this part via fuel lines, where the direction of the fuel line is out of this part.

Attribute Read-only, cannot be set

Return type list of `Part`

Note: See the discussion on *Fuel Lines*.

modules
The modules for this part.

Attribute Read-only, cannot be set

Return type list of `Module`

decoupler
A `Decoupler` if the part is a decoupler, otherwise `None`.

Attribute Read-only, cannot be set

Return type `Decoupler`

docking_port
A `DockingPort` if the part is a docking port, otherwise `None`.

Attribute Read-only, cannot be set

Return type `DockingPort`

engine
An `Engine` if the part is an engine, otherwise `None`.

Attribute Read-only, cannot be set

Return type `Engine`

landing_gear
A `LandingGear` if the part is a landing gear , otherwise `None`.

Attribute Read-only, cannot be set

Return type `LandingGear`

landing_leg
A `LandingLeg` if the part is a landing leg, otherwise `None`.

Attribute Read-only, cannot be set

Return type *LandingLeg*

launch_clamp
A *LaunchClamp* if the part is a launch clamp, otherwise None.

Attribute Read-only, cannot be set

Return type *LaunchClamp*

light
A *Light* if the part is a light, otherwise None.

Attribute Read-only, cannot be set

Return type *Light*

parachute
A *Parachute* if the part is a parachute, otherwise None.

Attribute Read-only, cannot be set

Return type *Parachute*

radiator
A *Radiator* if the part is a radiator, otherwise None.

Attribute Read-only, cannot be set

Return type *Radiator*

reaction_wheel
A *ReactionWheel* if the part is a reaction wheel, otherwise None.

Attribute Read-only, cannot be set

Return type *ReactionWheel*

resource_converter
A *ResourceConverter* if the part is a resource converter, otherwise None.

Attribute Read-only, cannot be set

Return type *ResourceConverter*

resource_harvester
A *ResourceHarvester* if the part is a resource harvester, otherwise None.

Attribute Read-only, cannot be set

Return type *ResourceHarvester*

sensor
A *Sensor* if the part is a sensor, otherwise None.

Attribute Read-only, cannot be set

Return type *Sensor*

solar_panel
A *SolarPanel* if the part is a solar panel, otherwise None.

Attribute Read-only, cannot be set

Return type *SolarPanel*

position (*reference_frame*)
The position of the part in the given reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

direction (*reference_frame*)
The direction of the part in the given reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

velocity (*reference_frame*)
The velocity of the part in the given reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

rotation (*reference_frame*)
The rotation of the part in the given reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float, float)

reference_frame
The reference frame that is fixed relative to this part.

- The origin is at the position of the part.
- The axes rotate with the part.
- The x, y and z axis directions depend on the design of the part.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

Note: For docking port parts, this reference frame is not necessarily equivalent to the reference frame for the docking port, returned by *DockingPort.reference_frame*.

Module

class SpaceCenter.**Module**
In KSP, each part has zero or more PartModules associated with it. Each one contains some of the functionality of the part. For example, an engine has a "ModuleEngines" PartModule that contains all the functionality of an engine. This class allows you to interact with KSPs PartModules, and any PartModules that have been added by other mods.

name
Name of the PartModule. For example, "ModuleEngines".

Attribute Read-only, cannot be set

Return type str

part
The part that contains this module.

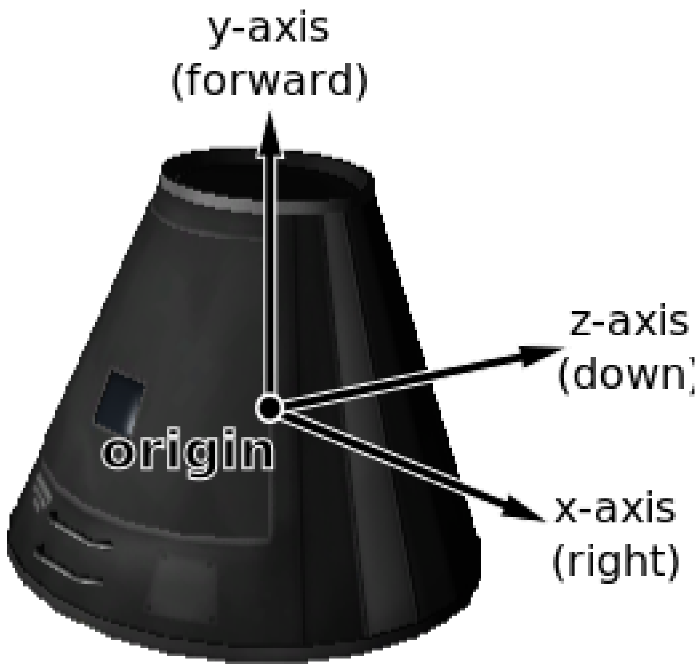


Fig. 7.7: Mk1 Command Pod reference frame origin and axes

Attribute Read-only, cannot be set

Return type `Part`

fields

The modules field names and their associated values, as a dictionary. These are the values visible in the right-click menu of the part.

Attribute Read-only, cannot be set

Return type dict from str to str

has_field(*name*)

Returns `True` if the module has a field with the given name.

Parameters **name** (*str*) – Name of the field.

Return type bool

get_field(*name*)

Returns the value of a field.

Parameters **name** (*str*) – Name of the field.

Return type str

events

A list of the names of all of the modules events. Events are the clickable buttons visible in the right-click menu of the part.

Attribute Read-only, cannot be set

Return type list of str

has_event(*name*)

`True` if the module has an event with the given name.

Parameters **name** (*str*) –

Return type bool

trigger_event (*name*)

Trigger the named event. Equivalent to clicking the button in the right-click menu of the part.

Parameters **name** (*str*) –

actions

A list of all the names of the modules actions. These are the parts actions that can be assigned to action groups in the in-game editor.

Attribute Read-only, cannot be set

Return type list of str

has_action (*name*)

`True` if the part has an action with the given name.

Parameters **name** (*str*) –

Return type bool

set_action (*name*[, *value = True*])

Set the value of an action with the given name.

Parameters

- **name** (*str*) –
- **value** (*bool*) –

Specific Types of Part

The following classes provide functionality for specific types of part.

Decoupler

class SpaceCenter.**Decoupler**

Obtained by calling *Part.decoupler*

part
The part object for this decoupler.

Attribute Read-only, cannot be set

Return type *Part*

decouple()
Fires the decoupler. Has no effect if the decoupler has already fired.

decoupled
Whether the decoupler has fired.

Attribute Read-only, cannot be set

Return type bool

impulse
The impulse that the decoupler imparts when it is fired, in Newton seconds.

Attribute Read-only, cannot be set

Return type float

Docking Port

class SpaceCenter.**DockingPort**
Obtained by calling *Part.docking_port*

part
The part object for this docking port.

Attribute Read-only, cannot be set

Return type *Part*

name
The port name of the docking port. This is the name of the port that can be set in the right click menu, when the Docking Port Alignment Indicator mod is installed. If this mod is not installed, returns the title of the part (*Part.title*).

Attribute Can be read or written

Return type str

state
The current state of the docking port.

Attribute Read-only, cannot be set

Return type *DockingPortState*

docked_part
The part that this docking port is docked to. Returns `None` if this docking port is not docked to anything.

Attribute Read-only, cannot be set

Return type *Part*

undock()
Undocks the docking port and returns the vessel that was undocked from. After undocking, the active vessel may change (`active_vessel`). This method can be called for either docking port in a docked pair - both calls will have the same effect. Returns `None` if the docking port is not docked to anything.

Return type *Vessel*

reengage_distance
The distance a docking port must move away when it undocks before it becomes ready to dock with another port, in meters.

Attribute Read-only, cannot be set

Return type float

has_shield
Whether the docking port has a shield.

Attribute Read-only, cannot be set

Return type bool

shielded
The state of the docking ports shield, if it has one. Returns `True` if the docking port has a shield, and the shield is closed. Otherwise returns `False`. When set to `True`, the shield is closed, and when set to `False` the shield is opened. If the docking port does not have a shield, setting this attribute has no effect.

Attribute Can be read or written

Return type bool

position (*reference_frame*)
The position of the docking port in the given reference frame.

Parameters **reference_frame** (`ReferenceFrame`) –

Return type tuple of (float, float, float)

direction (*reference_frame*)
The direction that docking port points in, in the given reference frame.

Parameters **reference_frame** (`ReferenceFrame`) –

Return type tuple of (float, float, float)

rotation (*reference_frame*)
The rotation of the docking port, in the given reference frame.

Parameters **reference_frame** (`ReferenceFrame`) –

Return type tuple of (float, float, float, float)

reference_frame
The reference frame that is fixed relative to this docking port, and oriented with the port.

- The origin is at the position of the docking port.
- The axes rotate with the docking port.
- The x-axis points out to the right side of the docking port.
- The y-axis points in the direction the docking port is facing.
- The z-axis points out of the bottom off the docking port.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

Note: This reference frame is not necessarily equivalent to the reference frame for the part, returned by `Part.reference_frame`.

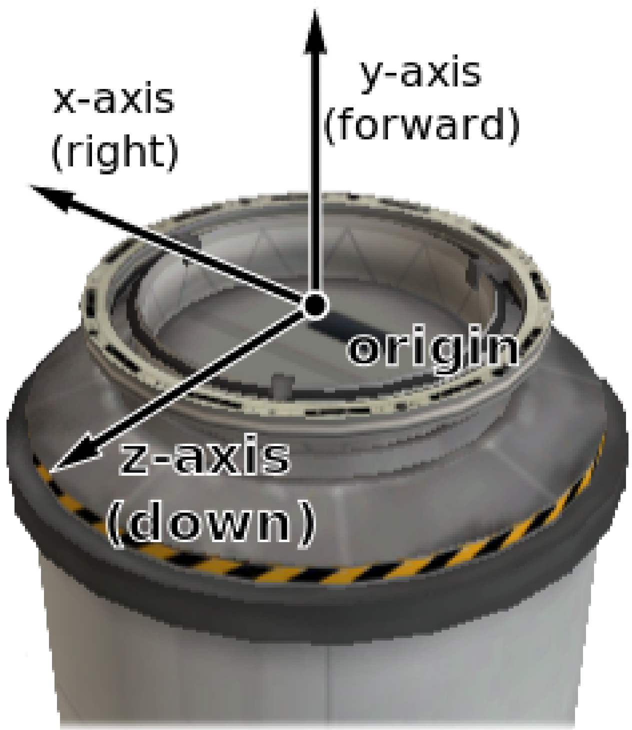


Fig. 7.8: Docking port reference frame origin and axes

class `SpaceCenter.`**`DockingPortState`**

See `DockingPort.state`.

`ready`

The docking port is ready to dock to another docking port.

`docked`

The docking port is docked to another docking port, or docked to another part (from the VAB/SPH).

`docking`

The docking port is very close to another docking port, but has not docked. It is using magnetic force to acquire a solid dock.

`undocking`

The docking port has just been undocked from another docking port, and is disabled until it moves away by a sufficient distance (`DockingPort.reengage_distance`).

`shielded`

The docking port has a shield, and the shield is closed.

`moving`

The docking ports shield is currently opening/closing.

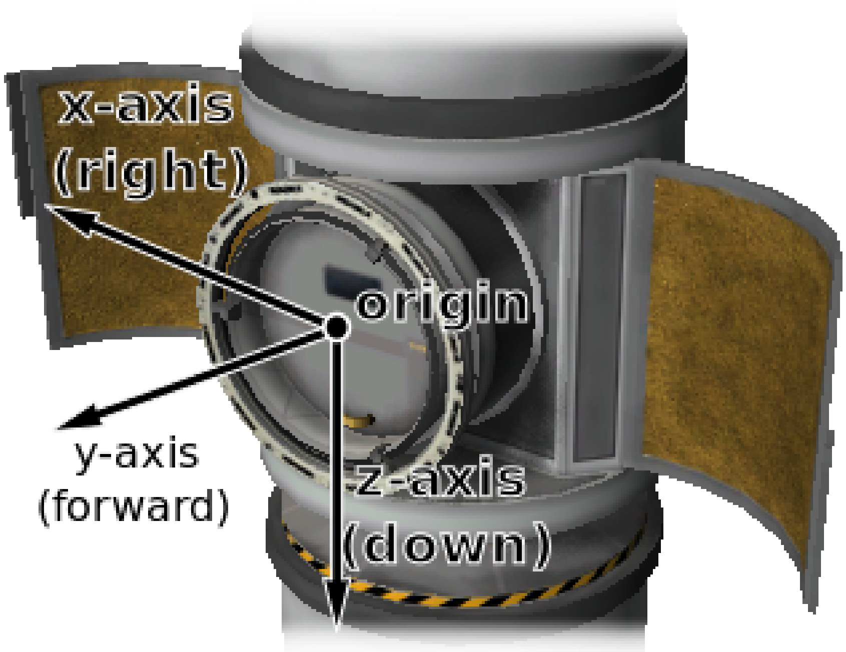


Fig. 7.9: Inline docking port reference frame origin and axes

Engine

class `SpaceCenter.`**`Engine`**

Obtained by calling *`Part.engine`*.

`part`

The part object for this engine.

Attribute Read-only, cannot be set

Return type *`Part`*

`active`

Whether the engine is active. Setting this attribute may have no effect, depending on *`Engine.can_shutdown`* and *`Engine.can_restart`*.

Attribute Can be read or written

Return type bool

`thrust`

The current amount of thrust being produced by the engine, in Newtons. Returns zero if the engine is not active or if it has no fuel.

Attribute Read-only, cannot be set

Return type float

`available_thrust`

The maximum available amount of thrust that can be produced by the engine, in Newtons. This takes *`Engine.thrust_limit`* into account, and is the amount of thrust produced by the engine when activated and the main throttle is set to 100%. Returns zero if the engine does not have any fuel.

Attribute Read-only, cannot be set

Return type float

max_thrust

Gets the maximum amount of thrust that can be produced by the engine, in Newtons. This is the amount of thrust produced by the engine when activated, *Engine.thrust_limit* is set to 100% and the main vessel's throttle is set to 100%.

Attribute Read-only, cannot be set

Return type float

max_vacuum_thrust

The maximum amount of thrust that can be produced by the engine in a vacuum, in Newtons. This is the amount of thrust produced by the engine when activated, *Engine.thrust_limit* is set to 100%, the main vessel's throttle is set to 100% and the engine is in a vacuum.

Attribute Read-only, cannot be set

Return type float

thrust_limit

The thrust limiter of the engine. A value between 0 and 1. Setting this attribute may have no effect, for example the thrust limit for a solid rocket booster cannot be changed in flight.

Attribute Can be read or written

Return type float

specific_impulse

The current specific impulse of the engine, in seconds. Returns zero if the engine is not active.

Attribute Read-only, cannot be set

Return type float

vacuum_specific_impulse

The vacuum specific impulse of the engine, in seconds.

Attribute Read-only, cannot be set

Return type float

kerbin_sea_level_specific_impulse

The specific impulse of the engine at sea level on Kerbin, in seconds.

Attribute Read-only, cannot be set

Return type float

propellants

The names of resources that the engine consumes.

Attribute Read-only, cannot be set

Return type list of str

propellant_ratios

The ratios of resources that the engine consumes. A dictionary mapping resource names to the ratios at which they are consumed by the engine.

Attribute Read-only, cannot be set

Return type dict from str to float

has_fuel

Whether the engine has run out of fuel (or flamed out).

Attribute Read-only, cannot be set

Return type bool

throttle

The current throttle setting for the engine. A value between 0 and 1. This is not necessarily the same as the vessel's main throttle setting, as some engines take time to adjust their throttle (such as jet engines).

Attribute Read-only, cannot be set

Return type float

throttle_locked

Whether the *Control.throttle* affects the engine. For example, this is `True` for liquid fueled rockets, and `False` for solid rocket boosters.

Attribute Read-only, cannot be set

Return type bool

can_restart

Whether the engine can be restarted once shutdown. If the engine cannot be shutdown, returns `False`. For example, this is `True` for liquid fueled rockets and `False` for solid rocket boosters.

Attribute Read-only, cannot be set

Return type bool

can_shutdown

Gets whether the engine can be shutdown once activated. For example, this is `True` for liquid fueled rockets and `False` for solid rocket boosters.

Attribute Read-only, cannot be set

Return type bool

gimballed

Whether the engine nozzle is gimballed, i.e. can provide a turning force.

Attribute Read-only, cannot be set

Return type bool

gimbal_range

The range over which the gimbal can move, in degrees.

Attribute Read-only, cannot be set

Return type float

gimbal_locked

Whether the engines gimbal is locked in place. Setting this attribute has no effect if the engine is not gimballed.

Attribute Can be read or written

Return type bool

gimbal_limit

The gimbal limiter of the engine. A value between 0 and 1. Returns 0 if the gimbal is locked or the engine is not gimballed. Setting this attribute has no effect if the engine is not gimballed.

Attribute Can be read or written

Return type float

Landing Gear

class SpaceCenter.**LandingGear**

Obtained by calling *Part.landing_gear*.

part

The part object for this landing gear.

Attribute Read-only, cannot be set

Return type *Part*

state

Gets the current state of the landing gear.

Attribute Read-only, cannot be set

Return type *LandingGearState*

deployed

Whether the landing gear is deployed.

Attribute Can be read or written

Return type bool

class SpaceCenter.**LandingGearState**

See *LandingGear.state*.

deployed

Landing gear is fully deployed.

retracted

Landing gear is fully retracted.

deploying

Landing gear is being deployed.

retracting

Landing gear is being retracted.

Landing Leg

class SpaceCenter.**LandingLeg**

Obtained by calling *Part.landing_leg*.

part

The part object for this landing leg.

Attribute Read-only, cannot be set

Return type *Part*

state

The current state of the landing leg.

Attribute Read-only, cannot be set

Return type *LandingLegState*

deployed

Whether the landing leg is deployed.

Attribute Can be read or written

Return type bool

class SpaceCenter.**LandingLegState**

See *LandingLeg.state*.

deployed

Landing leg is fully deployed.

retracted

Landing leg is fully retracted.

deploying

Landing leg is being deployed.

retracting

Landing leg is being retracted.

broken

Landing leg is broken.

repairing

Landing leg is being repaired.

Launch Clamp

class SpaceCenter.**LaunchClamp**

Obtained by calling *Part.launch_clamp*.

part

The part object for this launch clamp.

Attribute Read-only, cannot be set

Return type *Part*

release()

Releases the docking clamp. Has no effect if the clamp has already been released.

Light

class SpaceCenter.**Light**

Obtained by calling *Part.light*.

part

The part object for this light.

Attribute Read-only, cannot be set

Return type *Part*

active

Whether the light is switched on.

Attribute Can be read or written

Return type bool

power_usage

The current power usage, in units of charge per second.

Attribute Read-only, cannot be set

Return type float

Parameter

class SpaceCenter.**Parachute**
Obtained by calling `Part.parachute`.

part
The part object for this parachute.

Attribute Read-only, cannot be set

Return type `Part`

deploy()
Deploys the parachute. This has no effect if the parachute has already been deployed.

deployed
Whether the parachute has been deployed.

Attribute Read-only, cannot be set

Return type bool

state
The current state of the parachute.

Attribute Read-only, cannot be set

Return type `ParachuteState`

deploy_altitude
The altitude at which the parachute will full deploy, in meters.

Attribute Can be read or written

Return type float

deploy_min_pressure
The minimum pressure at which the parachute will semi-deploy, in atmospheres.

Attribute Can be read or written

Return type float

class SpaceCenter.**ParachuteState**
See `Parachute.state`.

stowed
The parachute is safely tucked away inside its housing.

active
The parachute is still stowed, but ready to semi-deploy.

semi_deployed
The parachute has been deployed and is providing some drag, but is not fully deployed yet.

deployed
The parachute is fully deployed.

cut
The parachute has been cut.

Radiator

class SpaceCenter.**Radiator**
Obtained by calling *Part.radiator*.

part
The part object for this radiator.

Attribute Read-only, cannot be set

Return type *Part*

deployed
Whether the radiator is extended.

Attribute Can be read or written

Return type bool

state
The current state of the radiator.

Attribute Read-only, cannot be set

Return type *RadiatorState*

class SpaceCenter.**RadiatorState**
RadiatorState

extended
Radiator is fully extended.

retracted
Radiator is fully retracted.

extending
Radiator is being extended.

retracting
Radiator is being retracted.

broken
Radiator is being broken.

Resource Converter

class SpaceCenter.**ResourceConverter**
Obtained by calling *Part.resource_converter*.

part
The part object for this converter.

Attribute Read-only, cannot be set

Return type *Part*

count
The number of converters in the part.

Attribute Read-only, cannot be set

Return type int

name (*index*)
The name of the specified converter.

Parameters **index** (*int*) – Index of the converter.

Return type str

active (*index*)
True if the specified converter is active.

Parameters **index** (*int*) – Index of the converter.

Return type bool

start (*index*)
Start the specified converter.

Parameters **index** (*int*) – Index of the converter.

stop (*index*)
Stop the specified converter.

Parameters **index** (*int*) – Index of the converter.

state (*index*)
The state of the specified converter.

Parameters **index** (*int*) – Index of the converter.

Return type *ResourceConverterState*

status_info (*index*)
Status information for the specified converter. This is the full status message shown in the in-game UI.

Parameters **index** (*int*) – Index of the converter.

Return type str

inputs (*index*)
List of the names of resources consumed by the specified converter.

Parameters **index** (*int*) – Index of the converter.

Return type list of str

outputs (*index*)
List of the names of resources produced by the specified converter.

Parameters **index** (*int*) – Index of the converter.

Return type list of str

class SpaceCenter.**ResourceConverterState**
See *ResourceConverter.state()*.

running
Converter is running.

idle
Converter is idle.

missing_resource
Converter is missing a required resource.

storage_full
No available storage for output resource.

capacity
At preset resource capacity.

unknown
Unknown state. Possible with modified resource converters. In this case, check *ResourceConverter.status_info()* for more information.

Resource Harvester

class SpaceCenter.**ResourceHarvester**
Obtained by calling *Part.resource_harvester*.

part
The part object for this harvester.

Attribute Read-only, cannot be set

Return type *Part*

state
The state of the harvester.

Attribute Read-only, cannot be set

Return type ResourceHarvesterState

deployed
Whether the harvester is deployed.

Attribute Can be read or written

Return type bool

active
Whether the harvester is actively drilling.

Attribute Can be read or written

Return type bool

extraction_rate
The rate at which the drill is extracting ore, in units per second.

Attribute Read-only, cannot be set

Return type float

thermal_efficiency
The thermal efficiency of the drill, as a percentage of its maximum.

Attribute Read-only, cannot be set

Return type float

core_temperature
The core temperature of the drill, in Kelvin.

Attribute Read-only, cannot be set

Return type float

optimum_core_temperature
The core temperature at which the drill will operate with peak efficiency, in Kelvin.

Attribute Read-only, cannot be set

Return type float

Reaction Wheel

class SpaceCenter.**ReactionWheel**

Obtained by calling *Part.reaction_wheel*.

part

The part object for this reaction wheel.

Attribute Read-only, cannot be set

Return type *Part*

active

Whether the reaction wheel is active.

Attribute Can be read or written

Return type bool

broken

Whether the reaction wheel is broken.

Attribute Read-only, cannot be set

Return type bool

pitch_torque

The torque in the pitch axis, in Newton meters.

Attribute Read-only, cannot be set

Return type float

yaw_torque

The torque in the yaw axis, in Newton meters.

Attribute Read-only, cannot be set

Return type float

roll_torque

The torque in the roll axis, in Newton meters.

Attribute Read-only, cannot be set

Return type float

Sensor

class SpaceCenter.**Sensor**

Obtained by calling *Part.sensor*.

part

The part object for this sensor.

Attribute Read-only, cannot be set

Return type *Part*

active

Whether the sensor is active.

Attribute Can be read or written

Return type bool

value
The current value of the sensor.

Attribute Read-only, cannot be set

Return type str

power_usage
The current power usage of the sensor, in units of charge per second.

Attribute Read-only, cannot be set

Return type float

Solar Panel

class SpaceCenter.**SolarPanel**
Obtained by calling *Part.solar_panel*.

part
The part object for this solar panel.

Attribute Read-only, cannot be set

Return type *Part*

deployed
Whether the solar panel is extended.

Attribute Can be read or written

Return type bool

state
The current state of the solar panel.

Attribute Read-only, cannot be set

Return type *SolarPanelState*

energy_flow
The current amount of energy being generated by the solar panel, in units of charge per second.

Attribute Read-only, cannot be set

Return type float

sun_exposure
The current amount of sunlight that is incident on the solar panel, as a percentage. A value between 0 and 1.

Attribute Read-only, cannot be set

Return type float

class SpaceCenter.**SolarPanelState**
See *SolarPanel.state*.

extended
Solar panel is fully extended.

retracted
Solar panel is fully retracted.

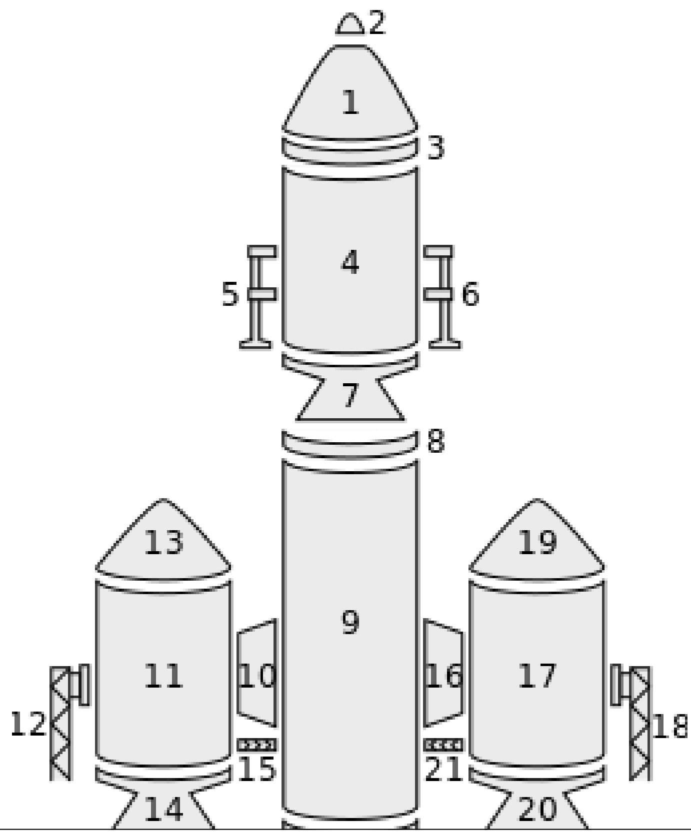
extending
Solar panel is being extended.

retracting
Solar panel is being retracted.

broken
Solar panel is broken.

Trees of Parts

Vessels in KSP are comprised of a number of parts, connected to one another in a *tree* structure. An example vessel is shown in Figure 1, and the corresponding tree of parts in Figure 2. The craft file for this example can also be `downloaded here`.



Traversing the Tree

The tree of parts can be traversed using the attributes *SpaceCenter.Parts.root*, *SpaceCenter.Part.parent* and *SpaceCenter.Part.children*.

The root of the tree is the same as the vessels *root part* (part number 1 in the example above) and can be obtained by calling *SpaceCenter.Parts.root*. A parts children can be obtained by calling *SpaceCenter.Part.children*. If the part does not have any children, *SpaceCenter.Part.children* returns an empty list. A parts parent can be obtained by calling *SpaceCenter.Part.parent*. If the part does not have a parent (as is the case for the root part), *SpaceCenter.Part.parent* returns `None`.

The following Python example uses these attributes to perform a depth-first traversal over all of the parts in a vessel:

```
root = vessel.parts.root
stack = [(root, 0)]
while len(stack) > 0:
    part,depth = stack.pop()
    print(' '*depth, part.title)
    for child in part.children:
        stack.append((child, depth+1))
```

When this code is execute using the craft file for the example vessel pictured above, the following is printed out:

```
Command Pod Mk1
 TR-18A Stack Decoupler
  FL-T400 Fuel Tank
   LV-909 Liquid Fuel Engine
    TR-18A Stack Decoupler
     FL-T800 Fuel Tank
      LV-909 Liquid Fuel Engine
      TT-70 Radial Decoupler
       FL-T400 Fuel Tank
        TT18-A Launch Stability Enhancer
        FTX-2 External Fuel Duct
        LV-909 Liquid Fuel Engine
        Aerodynamic Nose Cone
      TT-70 Radial Decoupler
       FL-T400 Fuel Tank
        TT18-A Launch Stability Enhancer
        FTX-2 External Fuel Duct
        LV-909 Liquid Fuel Engine
        Aerodynamic Nose Cone
   LT-1 Landing Struts
   LT-1 Landing Struts
 Mk16 Parachute
```

Attachment Modes

Parts can be attached to other parts either *radially* (on the side of the parent part) or *axially* (on the end of the parent part, to form a stack).

For example, in the vessel pictured above, the parachute (part 2) is *axially* connected to its parent (the command pod – part 1), and the landing leg (part 5) is *radially* connected to its parent (the fuel tank – part 4).

The root part of a vessel (for example the command pod – part 1) does not have a parent part, so does not have an attachment mode. However, the part is consider to be *axially* attached to nothing.

The following Python example does a depth-first traversal as before, but also prints out the attachment mode used by the part:

```python
root = vessel.parts.root
stack = [(root, 0)]
while len(stack) > 0:
    part,depth = stack.pop()
    if part.axially_attached:
        attach_mode = 'axial'
    else: # radially_attached
        attach_mode = 'radial'
    print(' '*depth, part.title, '-', attach_mode)
    for child in part.children:
        stack.append((child, depth+1))
```

When this code is execute using the craft file for the example vessel pictured above, the following is printed out:

```
Command Pod Mk1 - axial
 TR-18A Stack Decoupler - axial
  FL-T400 Fuel Tank - axial
   LV-909 Liquid Fuel Engine - axial
    TR-18A Stack Decoupler - axial
     FL-T800 Fuel Tank - axial
      LV-909 Liquid Fuel Engine - axial
      TT-70 Radial Decoupler - radial
       FL-T400 Fuel Tank - radial
        TT18-A Launch Stability Enhancer - radial
        FTX-2 External Fuel Duct - radial
        LV-909 Liquid Fuel Engine - axial
        Aerodynamic Nose Cone - axial
      TT-70 Radial Decoupler - radial
       FL-T400 Fuel Tank - radial
        TT18-A Launch Stability Enhancer - radial
        FTX-2 External Fuel Duct - radial
        LV-909 Liquid Fuel Engine - axial
        Aerodynamic Nose Cone - axial
   LT-1 Landing Struts - radial
   LT-1 Landing Struts - radial
 Mk16 Parachute - axial
```

Fuel Lines

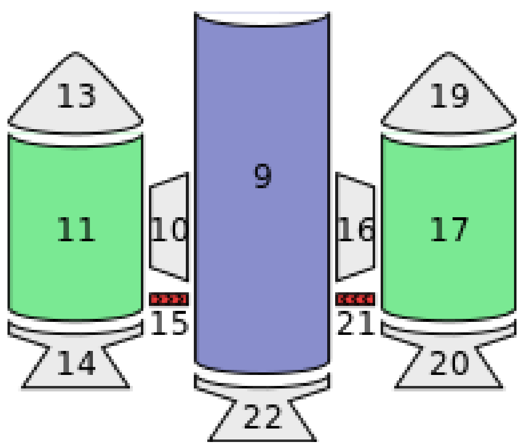


Fig. 7.12: **Figure 5** – Fuel lines from the example in Figure 1. Fuel flows from the parts highlighted in green, into the part highlighted in blue.

Fuel lines are considered parts, and are included in the parts tree (for example, as pictured in Figure 4). However, the parts tree does not contain information about which parts fuel lines connect to. The parent part of a fuel line is the part from which it will take fuel (as shown in Figure 4) however the part that it will send fuel to is not represented in the parts tree.

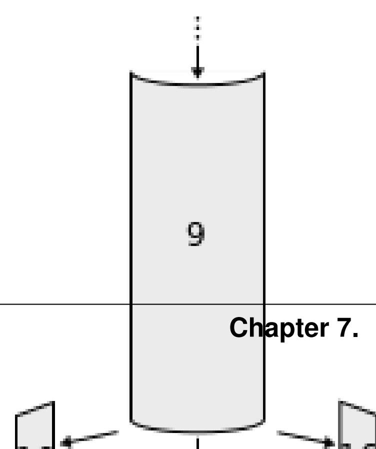


Figure 5 shows the fuel lines from the example vessel pictured earlier. Fuel line part 15 (in red) takes fuel from a fuel tank (part

11 – in green) and feeds it into another fuel tank (part 9 – in blue). The fuel line is therefore a child of part 11, but its connection to part 9 is not represented in the tree.

The attributes `SpaceCenter.Part.fuel_lines_from` and `SpaceCenter.Part.fuel_lines_to` can be used to discover these connections. In the example in Figure 5, when `SpaceCenter.Part.fuel_lines_to` is called on fuel tank part 11, it will return a list of parts containing just fuel tank part 9 (the blue part). When `SpaceCenter.Part.fuel_lines_from` is called on fuel tank part 9, it will return a list containing fuel tank parts 11 and 17 (the parts colored green).

Staging

Each part has two staging numbers associated with it: the stage in which the part is *activated* and the stage in which the part is *decoupled*. These values can be obtained using `SpaceCenter.Part.stage` and `SpaceCenter.Part.decouple_stage` respectively. For parts that are not activated by staging, `SpaceCenter.Part.stage` returns -1. For parts that are never decoupled, `SpaceCenter.Part.decouple_stage` returns a value of -1.

Figure 6 shows an example staging sequence for a vessel. Figure 7 shows the stages in which each part of the vessel will be *activated*. Figure 8 shows the stages in which each part of the vessel will be *decoupled*.

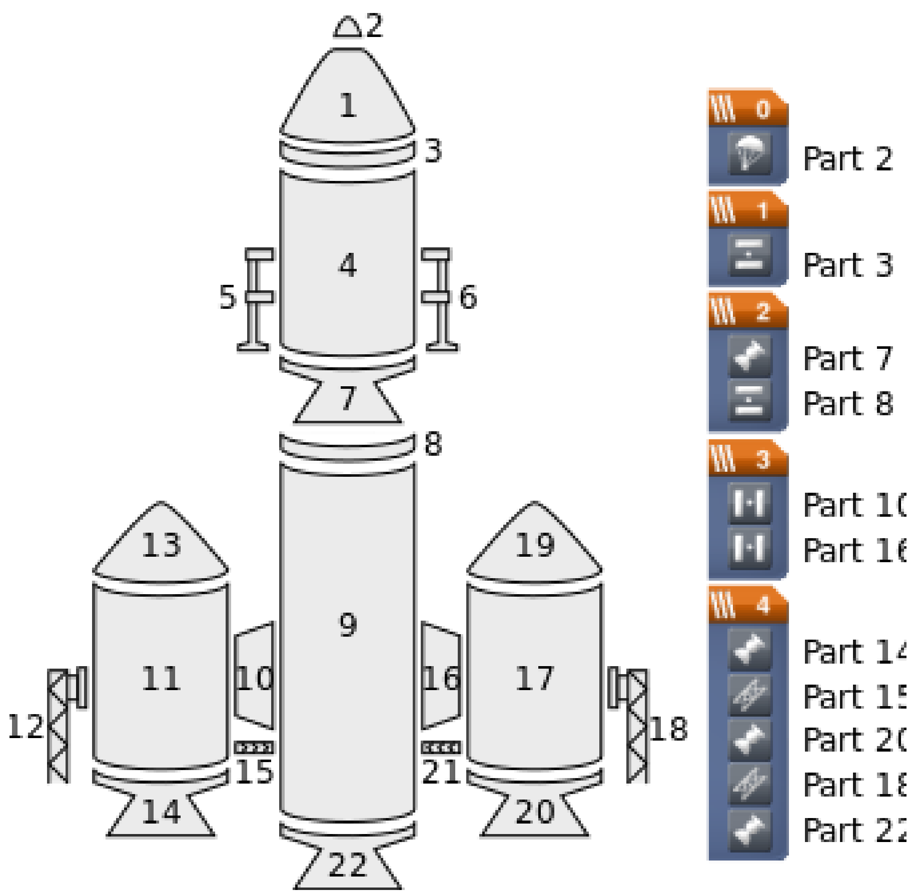


Fig. 7.14: **Figure 6** – Example vessel from Figure 1 with a staging sequence

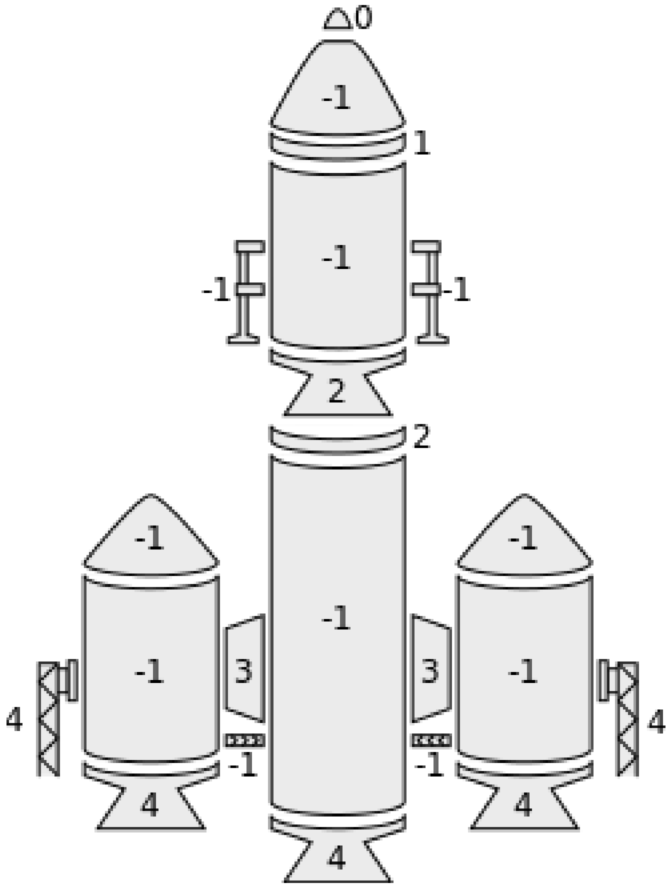
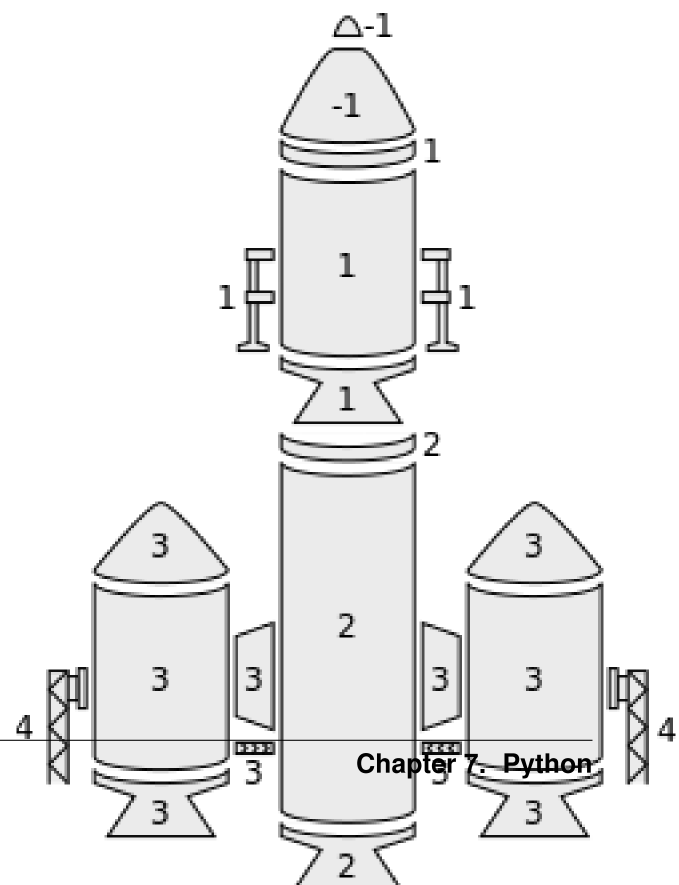


Fig. 7.15: **Figure 7** – The stage in which each part is *activated*.

7.2.8 Resources



class SpaceCenter.**Resources**

Created by calling *Vessel.resources*, *Vessel.resources_in_decouple_stage()* or *Part.resources*.

names

A list of resource names that can be stored.

Attribute Read-only, cannot be set

Return type list of str

has_resource(*name*)

Check whether the named resource can be stored.

Parameters **name** (*str*) – The name of the resource.

Return type bool

max(*name*)

Returns the amount of a resource that can be stored.

Parameters **name** (*str*) – The name of the resource.

Return type float

amount (*name*)
Returns the amount of a resource that is currently stored.

Parameters **name** (*str*) – The name of the resource.

Return type float

static **density** (*name*)
Returns the density of a resource, in kg/l.

Parameters **name** (*str*) – The name of the resource.

Return type float

static **flow_mode** (*name*)
Returns the flow mode of a resource.

Parameters **name** (*str*) – The name of the resource.

Return type *ResourceFlowMode*

class SpaceCenter.**ResourceFlowMode**
See *Resources.flow_mode()*.

vessel
The resource flows to any part in the vessel. For example, electric charge.

stage
The resource flows from parts in the first stage, followed by the second, and so on. For example, mono-propellant.

adjacent
The resource flows between adjacent parts within the vessel. For example, liquid fuel or oxidizer.

none
The resource does not flow. For example, solid fuel.

7.2.9 Node

class SpaceCenter.**Node**
Represents a maneuver node. Can be created using *Control.add_node()*.

prograde
The magnitude of the maneuver nodes delta-v in the prograde direction, in meters per second.

Attribute Can be read or written

Return type float

normal
The magnitude of the maneuver nodes delta-v in the normal direction, in meters per second.

Attribute Can be read or written

Return type float

radial

The magnitude of the maneuver nodes delta-v in the radial direction, in meters per second.

Attribute Can be read or written

Return type float

delta_v

The delta-v of the maneuver node, in meters per second.

Attribute Can be read or written

Return type float

Note: Does not change when executing the maneuver node. See *Node.remaining_delta_v*.

remaining_delta_v

Gets the remaining delta-v of the maneuver node, in meters per second. Changes as the node is executed. This is equivalent to the delta-v reported in-game.

Attribute Read-only, cannot be set

Return type float

burn_vector ([*reference_frame = None*])

Returns a vector whose direction the direction of the maneuver node burn, and whose magnitude is the delta-v of the burn in m/s.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

Note: Does not change when executing the maneuver node. See *Node.remaining_burn_vector()*.

remaining_burn_vector ([*reference_frame = None*])

Returns a vector whose direction the direction of the maneuver node burn, and whose magnitude is the delta-v of the burn in m/s. The direction and magnitude change as the burn is executed.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

ut

The universal time at which the maneuver will occur, in seconds.

Attribute Can be read or written

Return type float

time_to

The time until the maneuver node will be encountered, in seconds.

Attribute Read-only, cannot be set

Return type float

orbit

The orbit that results from executing the maneuver node.

Attribute Read-only, cannot be set

Return type *Orbit*

remove()

Removes the maneuver node.

reference_frame

Gets the reference frame that is fixed relative to the maneuver node's burn.

- The origin is at the position of the maneuver node.
- The y-axis points in the direction of the burn.
- The x-axis and z-axis point in arbitrary but fixed directions.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

orbital_reference_frame

Gets the reference frame that is fixed relative to the maneuver node, and orientated with the orbital prograde/normal/radial directions of the original orbit at the maneuver node's position.

- The origin is at the position of the maneuver node.
- The x-axis points in the orbital anti-radial direction of the original orbit, at the position of the maneuver node.
- The y-axis points in the orbital prograde direction of the original orbit, at the position of the maneuver node.
- The z-axis points in the orbital normal direction of the original orbit, at the position of the maneuver node.

Attribute Read-only, cannot be set

Return type *ReferenceFrame*

position (*reference_frame*)
Returns the position vector of the maneuver node in the given reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

direction (*reference_frame*)
Returns the unit direction vector of the maneuver nodes burn in the given reference frame.

Parameters **reference_frame** (ReferenceFrame) –

Return type tuple of (float, float, float)

7.2.10 Comms

class SpaceCenter.**Comms**
Used to interact with RemoteTech. Created using a call to *Vessel.comms*.

Note: This class requires RemoteTech to be installed.

has_local_control
Whether the vessel can be controlled locally.

Attribute Read-only, cannot be set

Return type bool

has_flight_computer
Whether the vessel has a RemoteTech flight computer on board.

Attribute Read-only, cannot be set

Return type bool

has_connection
Whether the vessel can receive commands from the KSC or a command station.

Attribute Read-only, cannot be set

Return type bool

has_connection_to_ground_station
Whether the vessel can transmit science data to a ground station.

Attribute Read-only, cannot be set

Return type bool

signal_delay
The signal delay when sending commands to the vessel, in seconds.

Attribute Read-only, cannot be set

Return type float

signal_delay_to_ground_station

The signal delay between the vessel and the closest ground station, in seconds.

Attribute Read-only, cannot be set

Return type float

signal_delay_to_vessel (*other*)

Returns the signal delay between the current vessel and another vessel, in seconds.

Parameters **other** (Vessel) –

Return type float

7.2.11 ReferenceFrame

class SpaceCenter.**ReferenceFrame**

Represents a reference frame for positions, rotations and velocities. Contains:

- The position of the origin.
- The directions of the x, y and z axes.
- The linear velocity of the frame.
- The angular velocity of the frame.

Note: This class does not contain any properties or methods. It is only used as a parameter to other functions.

7.2.12 AutoPilot

class SpaceCenter.**AutoPilot**

Provides basic auto-piloting utilities for a vessel. Created by calling *Vessel.auto_pilot*.

engage ()

Engage the auto-pilot.

disengage ()

Disengage the auto-pilot.

wait ()

Blocks until the vessel is pointing in the target direction (if set) and has the target roll (if set).

error

The error, in degrees, between the direction the ship has been asked to point in and the direction it is pointing in. Returns zero if the auto-pilot has not been engaged, SAS is not enabled, SAS is in stability assist mode, or no target direction is set.

Attribute Read-only, cannot be set

Return type float

roll_error

The error, in degrees, between the roll the ship has been asked to be in and the actual roll. Returns zero if the auto-pilot has not been engaged or no target roll is set.

Attribute Read-only, cannot be set

Return type float

reference_frame

The reference frame for the target direction (*AutoPilot.target_direction*).

Attribute Can be read or written

Return type *ReferenceFrame*

target_direction

The target direction. `None` if no target direction is set.

Attribute Can be read or written

Return type tuple of (float, float, float)

target_pitch_and_heading (*pitch*, *heading*)

Set (*AutoPilot.target_direction*) from a pitch and heading angle.

Parameters

- **pitch** (*float*) – Target pitch angle, in degrees between -90° and +90°.
- **heading** (*float*) – Target heading angle, in degrees between 0° and 360°.

target_roll

The target roll, in degrees. `NaN` if no target roll is set.

Attribute Can be read or written

Return type float

sas

The state of SAS.

Attribute Can be read or written

Return type bool

Note: Equivalent to *Control.sas*

sas_mode

The current *SASMode*. These modes are equivalent to the mode buttons to the left of the navball that appear when SAS is enabled.

Attribute Can be read or written

Return type *SASMode*

Note: Equivalent to *Control.sas_mode*

rotation_speed_multiplier

Target rotation speed multiplier. Defaults to 1.

Attribute Can be read or written

Return type float

max_rotation_speed

Maximum target rotation speed. Defaults to 1.

Attribute Can be read or written

Return type float

roll_speed_multiplier

Target roll speed multiplier. Defaults to 1.

Attribute Can be read or written

Return type float

max_roll_speed

Maximum target roll speed. Defaults to 1.

Attribute Can be read or written

Return type float

set_pid_parameters([*kp = 1.0*][, *ki = 0.0*][, *kd = 0.0*])

Sets the gains for the rotation rate PID controller.

Parameters

- **kp** (*float*) – Proportional gain.
- **ki** (*float*) – Integral gain.
- **kd** (*float*) – Derivative gain.

7.2.13 Geometry Types

class SpaceCenter.**Vector3**

3-dimensional vectors are represented as a 3-tuple.
For example:

```
import krpc
conn = krpc.connect()
v = conn.space_center.active_vessel.flight().prograde
print(v[0], v[1], v[2])
```

class SpaceCenter.**Quaternion**

Quaternions (rotations in 3-dimensional space) are encoded as a 4-tuple containing the x, y, z and w components. For example:

```
import krpc
conn = krpc.connect()
q = conn.space_center.active_vessel.flight().rotation
print(q[0], q[1], q[2], q[3])
```

7.3 InfernalRobotics API

Provides RPCs to interact with the InfernalRobotics mod. Provides the following classes:

7.3.1 InfernalRobotics

class InfernalRobotics.**InfernalRobotics**

This service provides functionality to interact with the InfernalRobotics mod.

servo_groups

A list of all the servo groups in the active vessel.

Attribute Read-only, cannot be set

Return type list of *ControlGroup*

static **servo_group_with_name**(*name*)

Returns the servo group with the given *name* or None if none exists. If multiple servo groups have the same name, only one of them is returned.

Parameters **name** (*str*) – Name of servo group to find.

Return type *ControlGroup*

static **servo_with_name**(*name*)

Returns the servo with the given *name*, from all servo groups, or None if none exists. If multiple servos have the same name, only one of them is returned.

Parameters **name** (*str*) – Name of the servo to find.

Return type *Servo*

7.3.2 ControlGroup

class InfernalRobotics.**ControlGroup**

A group of servos, obtained by calling servo_groups or servo_group_with_name(). Represents the "Servo Groups" in the InfernalRobotics UI.

name
The name of the group.

Attribute Can be read or written

Return type str

forward_key
The key assigned to be the "forward" key for the group.

Attribute Can be read or written

Return type str

reverse_key
The key assigned to be the "reverse" key for the group.

Attribute Can be read or written

Return type str

speed
The speed multiplier for the group.

Attribute Can be read or written

Return type float

expanded
Whether the group is expanded in the InfernalRobotics UI.

Attribute Can be read or written

Return type bool

servos
The servos that are in the group.

Attribute Read-only, cannot be set

Return type list of *Servo*

servo_with_name(*name*)
Returns the servo with the given *name* from this group, or `None` if none exists.

Parameters **name** (*str*) – Name of servo to find.

Return type *Servo*

move_right()
Moves all of the servos in the group to the right.

move_left()
Moves all of the servos in the group to the left.

move_center()
Moves all of the servos in the group to the center.

move_next_preset()
Moves all of the servos in the group to the next preset.

move_prev_preset()
Moves all of the servos in the group to the previous preset.

stop()
Stops the servos in the group.

7.3.3 Servo

class InfernalRobotics.**Servo**
Represents a servo. Obtained using *ControlGroup.servos*, *ControlGroup.servo_with_name()* or servo_with_name().

name
The name of the servo.

Attribute Can be read or written

Return type str

highlight
Whether the servo should be highlighted in-game.

Attribute Write-only, cannot be read

Return type bool

position
The position of the servo.

Attribute Read-only, cannot be set

Return type float

min_config_position
The minimum position of the servo, specified by the part configuration.

Attribute Read-only, cannot be set

Return type float

max_config_position
The maximum position of the servo, specified by the part configuration.

Attribute Read-only, cannot be set

Return type float

min_position
The minimum position of the servo, specified by the in-game tweak menu.

Attribute Can be read or written

Return type float

max_position
The maximum position of the servo, specified by the in-game tweak menu.

Attribute Can be read or written

Return type float

config_speed
The speed multiplier of the servo, specified by the part configuration.

Attribute Read-only, cannot be set

Return type float

speed
The speed multiplier of the servo, specified by the in-game tweak menu.

Attribute Can be read or written

Return type float

current_speed
The current speed at which the servo is moving.

Attribute Can be read or written

Return type float

acceleration
The current speed multiplier set in the UI.

Attribute Can be read or written

Return type float

is_moving
Whether the servo is moving.

Attribute Read-only, cannot be set

Return type bool

is_free_moving
Whether the servo is freely moving.

Attribute Read-only, cannot be set

Return type bool

is_locked
Whether the servo is locked.

Attribute Can be read or written

Return type bool

is_axis_inverted
Whether the servos axis is inverted.

Attribute Can be read or written

Return type bool

move_right()
Moves the servo to the right.

move_left()
Moves the servo to the left.

move_center()

Moves the servo to the center.

move_next_preset()

Moves the servo to the next preset.

move_prev_preset()

Moves the servo to the previous preset.

move_to(*position*, *speed*)

Moves the servo to *position* and sets the speed multiplier to *speed*.

Parameters

- **position** (*float*) – The position to move the servo to.
- **speed** (*float*) – Speed multiplier for the movement.

stop()

Stops the servo.

7.3.4 Example

The following example gets the control group named "MyGroup", prints out the names and positions of all of the servos in the group, then moves all of the servos to the right for 1 second.

```
import krpc, time
conn = krpc.connect(name='InfernalRobotics Example')

group = conn.infernal_robotics.servo_group_with_name('MyGroup')
if group is None:
    print('Group not found')
    exit(1)

for servo in group.servos:
    print servo.name, servo.position

group.move_right()
time.sleep(1)
group.stop()
```

7.4 Kerbal Alarm Clock API

Provides RPCs to interact with the Kerbal Alarm Clock mod. Provides the following classes:

7.4.1 KerbalAlarmClock

class KerbalAlarmClock.**KerbalAlarmClock**

This service provides functionality to interact with the Kerbal Alarm Clock mod.

alarms
A list of all the alarms.

Attribute Read-only, cannot be set

Return type list of *Alarm*

static **alarm_with_name** (*name*)
Get the alarm with the given *name*, or None if no alarms have that name. If more than one alarm has the name, only returns one of them.

Parameters **name** (*str*) – Name of the alarm to search for.

Return type *Alarm*

static **alarms_with_type** (*type*)
Get a list of alarms of the specified *type*.

Parameters **type** (AlarmType) – Type of alarm to return.

Return type list of *Alarm*

static **create_alarm** (*type*, *name*, *ut*)
Create a new alarm and return it.

Parameters

- **type** (AlarmType) – Type of the new alarm.
- **name** (*str*) – Name of the new alarm.
- **ut** (*float*) – Time at which the new alarm should trigger.

Return type *Alarm*

7.4.2 Alarm

class KerbalAlarmClock.**Alarm**
Represents an alarm. Obtained by calling alarms, alarm_with_name() or alarms_with_type().

action
The action that the alarm triggers.

Attribute Can be read or written

Return type *AlarmAction*

margin
The number of seconds before the event that the alarm will fire.

Attribute Can be read or written

Return type float

time

The time at which the alarm will fire.

Attribute Can be read or written

Return type float

type

The type of the alarm.

Attribute Read-only, cannot be set

Return type *AlarmType*

id

The unique identifier for the alarm.

Attribute Read-only, cannot be set

Return type str

name

The short name of the alarm.

Attribute Can be read or written

Return type str

notes

The long description of the alarm.

Attribute Can be read or written

Return type str

remaining

The number of seconds until the alarm will fire.

Attribute Read-only, cannot be set

Return type float

repeat

Whether the alarm will be repeated after it has fired.

Attribute Can be read or written

Return type bool

repeat_period

The time delay to automatically create an alarm after it has fired.

Attribute Can be read or written

Return type float

vessel

The vessel that the alarm is attached to.

Attribute Can be read or written

Return type *SpaceCenter.Vessel*

xfer_origin_body

The celestial body the vessel is departing from.

Attribute Can be read or written

Return type *SpaceCenter.CelestialBody*

xfer_target_body
The celestial body the vessel is arriving at.

Attribute Can be read or written

Return type *SpaceCenter.CelestialBody*

remove()
Removes the alarm.

7.4.3 AlarmType

class KerbalAlarmClock.**AlarmType**
The type of an alarm.

raw
An alarm for a specific date/time or a specific period in the future.

maneuver
An alarm based on the next maneuver node on the current ships flight path. This node will be stored and can be restored when you come back to the ship.

maneuver_auto
See *AlarmType.maneuver*.

apoapsis
An alarm for furthest part of the orbit from the planet.

periapsis
An alarm for nearest part of the orbit from the planet.

ascending_node
Ascending node for the targeted object, or equatorial ascending node.

descending_node
Descending node for the targeted object, or equatorial descending node.

closest
An alarm based on the closest approach of this vessel to the targeted vessel, some number of orbits into the future.

contract
An alarm based on the expiry or deadline of contracts in career modes.

contract_auto
See *AlarmType.contract*.

crew
An alarm that is attached to a crew member.

distance
An alarm that is triggered when a selected target comes within a chosen distance.

earth_time
An alarm based on the time in the "Earth" alternative Universe (aka the Real World).

launch_rendevous
An alarm that fires as your landed craft passes under the orbit of your target.

soi_change
An alarm manually based on when the next SOI point is on the flight path or set to continually monitor the active flight path and add alarms as it detects SOI changes.

soi_change_auto
See *AlarmType.soi_change*.

transfer
An alarm based on Interplanetary Transfer Phase Angles, i.e. when should I launch to planet X? Based on Kosmo Not's post and used in Olex's Calculator.

transfer_modelled
See *AlarmType.transfer*.

7.4.4 AlarmAction

class KerbalAlarmClock.**AlarmAction**
The action performed by an alarm when it fires.

do_nothing
Don't do anything at all...

do_nothing_delete_when_passed
Don't do anything, and delete the alarm.

kill_warp
Drop out of time warp.

kill_warp_only
Drop out of time warp.

message_only
Display a message.

pause_game
Pause the game.

7.4.5 Example

The following example creates a new alarm for the active vessel. The alarm is set to trigger after 10 seconds have passed, and display a message.

```
import krpc
conn = krpc.connect(name='Kerbal Alarm Clock Example')

alarm = conn.kerbal_alarm_clock.create_alarm(
    conn.kerbal_alarm_clock.AlarmType.raw,
    'My New Alarm',
    conn.space_center.ut+10)

alarm.notes = '10 seconds have now passed since the alarm was created.'
alarm.action = conn.kerbal_alarm_clock.AlarmAction.message_only
```

CHAPTER

EIGHT

COMPILING KRPC

kRPC uses the Bazel build system.

Bazel automatically downloads most of the required dependencies to build kRPC. However the following will need to be installed on your system:

- Mono C# compiler and runtime
- Python, including virtualenv and pip
- pdflatex
- RSVG for converting SVGs to PNGs
- libxml, libxslt and python development (for building Java documentation)

To install these dependencies on Ubuntu, follow the instructions on the Mono website and install the required packages using: `sudo apt-get install mono-complete python-virtualenv python-pip texlive-latex-base texlive-latex-recommended texlive-fonts-recommended texlive-latex-extra librsvg2-bin libxml2-dev libxslt1-dev python-dev`

Before building kRPC you need to make `lib/ksp` point to a directory containing Kerbal Space Program. For example on Linux, if your KSP directory is at `/path/to/ksp` and your kRPC source tree at `/path/to/krpc` you can create a symlink using: `ln -s /path/to/ksp /path/to/krpc/lib/ksp`

You may also need to modify the symlink at `lib/mono-4.5` to point to the correct location of your Mono installation.

To build kRPC, run `bazel build //:krpc`. The resulting archive containing the GameData directory, client libraries etc. will be placed in the `bazel-out` directory.

8.1 Using an IDE

A C# solution file is provided in the root of the project for use with MonoDevelop or a similar C# IDE.

Some of the C# source files are generated by the Bazel build scripts. You need to run `bazel build //:csproj` to generate these files before the C# solution file and C# project files can be used.

8.2 Running the Tests

The tests can be run using `bazel test //:test`. C# NUnit tests can be also run from an IDE using the C# solution file.

Bazel automatically downloads most of the required dependencies to run the tests, however you will also need to install Lua and LuaRocks on your system. These can be install on Ubuntu using: `sudo apt-get install lua5.1 luarocks`

CHAPTER

NINE

EXTENDING KRPC

9.1 The kRPC Architecture

kRPC consists of two components: a server and a client. The server plugin (provided by `KRPC.dll`) runs inside KSP. It provides a collection of *procedures* that clients can run. These procedures are arranged in groups called *services* to keep things organized. It also provides an in-game user interface that can be used to start/stop the server, change settings and monitor active clients.

Clients run outside of KSP. This gives you the freedom to run scripts in whatever environment you want. A client communicates with the server to run procedures. kRPC comes with several client libraries that implement the *communication protocol*, making it easy to write programs for these languages that can talk to the server.

kRPC comes with a collection of standard functionality for interacting with vessels, contained in a service called `SpaceCenter`. This service provides procedures for things like getting flight/orbital data and controlling the active vessel. This service is provided by `KRPC.SpaceCenter.dll`.

9.2 Service API

Third party mods can add functionality to kRPC using the *Service API*. This is done by adding *attributes* to your own classes, methods and properties to make them visible through the server. When the kRPC server starts, it scans all the assemblies loaded by the game, looking for classes, methods and properties with these attributes.

The following example implements a service that can control the throttle and staging of the active vessel. To add this to the server, compile the code and place the DLL in your GameData directory.

```
using KRPC.Service;
using KRPC.Service.Attributes;

namespace LaunchControl {

    [KRPCService (GameScene = GameScene.Flight)]
    public static class LaunchControl {

        [KRPCProperty]
        public static float Throttle {
            get { return FlightInputHandler.state.mainThrottle; }
            set { FlightInputHandler.state.mainThrottle = value; }
        }

        [KRPCProcedure]
        public static void ActivateStage ()
        {
```

```
            Staging.ActivateNextStage ();
        }
    }
}
```

The following example shows how this service can then be used from a python client:

```
import krpc
conn = krpc.connect()
conn.launch_control.throttle = 1
conn.launch_control.activate_stage()
```

Some of the client libraries automatically pick up changes to the functionality provided by the server, including the Python and Lua clients. However, some clients require stub code to be generated from the service assembly so that they can interact with new or changed functionality. See *clientgen* for details on how to generate these stubs.

9.2.1 Attributes

The following C# attributes can be used to add functionality to the kRPC server.

class **`KRPCService`**([*Name*][, *GameScene*])

Parameters

- **`Name`** (*`string`*) – Optional name for the service. If omitted, the service name is set to the name of the class this attribute is applied to.
- **`GameScene`** (`GameScene`) – The game scenes in which the services procedures are available.

This attribute is applied to a static class, to indicate that all methods, properties and classes declared within it are part of the the same service. The name of the service is set to the name of the class, or – if present – the `Name` parameter.

Multiple services with the same name can be declared, as long the classes, procedures and methods they contain have unique names. The classes will be merged to appear as a single service on the server.

The type to which this attribute is applied must satisfy the following criteria:

- The type must be a class.
- The class must be `public static`.
- The name of the class, or the `Name` parameter if specified, must be a valid *kRPC identifier*.
- The class must not be declared within another class that has the *`KRPCService`* attribute. Nesting of services is not permitted.

Services are configured to be available in specific *game scenes* via the `GameScene` parameter. If the `GameScene` parameter is not specified, the service is available in any scene. If a procedure is called when the service is not available, it will throw an exception.

Examples

- Declare a service called `EVA`:

```
[KRPCService]
public static class EVA {
    ...
}
```

- Declare a service called `MyEVAService` (different to the name of the class):

```
[KRPCService (Name = "MyEVAService")]
public static class EVA {
    ...
}
```

•Declare a service called `FlightTools` that is only available during the `Flight` game scene:

```
[KRPCService (GameScene = GameScene.Flight)]
public static class FlightTools {
    ...
}
```

class KRPCProcedure

This attribute is applied to static methods, to add them to the server as procedures.

The method to which this attribute is applied must satisfy the following criteria:

- The method must be `public static`.
- The name of the method must be a valid *kRPC identifier*.
- The method must be declared inside a class that is a *KRPCService*.
- The parameter types and return type must be *types that kRPC knows how to serialize*.
- Parameters can have default arguments.

Example

The following defines a service called `EVA` with a `PlantFlag` procedure that takes a name and an optional description, and returns a `Flag` object.

```
[KRPCService]
public static class EVA {
    [KRPCProcedure]
    public static Flag PlantFlag (string name, string description = "")
    {
        ...
    }
}
```

This can be called from a python client as follows:

```
import krpc
conn = krpc.connect()
flag = conn.eva.plant_flag('Landing Site', 'One small step for Kerbal-kind')
```

class KRPCClass ([*Service*])

Parameters **Service** (*string*) – Optional name of the service to add this class to. If omitted, the class is added to the service that contains its definition.

This attribute is applied to non-static classes. It adds the class to the server, so that references to instances of the class can be passed between client and server.

A *KRPCClass* must be part of a service, just like a *KRPCProcedure*. However, it would be restrictive if the class had to be declared as a nested class inside a class with the *KRPCService* attribute. Therefore, a *KRPCClass* can be declared outside of any service if it has the `Service` parameter set to the name of the service that it is part of. Also, the service that the `Service` parameter refers to does not have to exist. If it does not exist, a service with the given name is created.

The class to which this attribute is applied must satisfy the following criteria:

- The class must be public and *not* static.
- The name of the class must be a valid *kRPC identifier*.
- The class must either be declared inside a class that is a *KRPCService*, or have its Service parameter set to the name of the service it is part of.

Examples

- Declare a class called Flag in the EVA service:

```
[KRPCService]
public static class EVA {
    [KRPCClass]
    public class Flag {
        ...
    }
}
```

- Declare a class called Flag, without nesting the class definition in a service class:

```
[KRPCClass (Service = "EVA")]
public class Flag {
    ...
}
```

class KRPCMethod

This attribute is applied to methods inside a *KRPCClass*. This allows a client to call methods on an instance, or static methods in the class.

The method to which this attribute is applied must satisfy the following criteria:

- The method must be public.
- The name of the method must be a valid *kRPC identifier*.
- The method must be declared in a *KRPCClass*.
- The parameter types and return type must be *types that kRPC can serialize*.
- Parameters can have default arguments.

Example

Declare a Remove method in the Flag class:

```
[KRPCClass (Service = "EVA")]
public class Flag {
    [KRPCMethod]
    void Remove()
    {
        ...
    }
}
```

class KRPCProperty

This attribute is applied to class properties, and comes in two flavors:

1. Applied to static properties in a *KRPCService*. In this case, the property must satisfy the following criteria:
    - Must be public static and have at least one publicly accessible getter or setter.
    - The name of the property must be a valid *kRPC identifier*.

- Must be declared inside a *KRPCService*.

2. Applied to non-static properties in a *KRPCClass*. In this case, the property must satisfy the following criteria:
   - Must be `public` and *not* `static`, and have at least one publicly accessible getter or setter.
   - The name of the property must be a valid *kRPC identifier*.
   - Must be declared inside a *KRPCClass*.

Examples

- Applied to a static property in a service:

```
[KRPCService]
public static class EVA {
    [KRPCProperty]
    public Flag LastFlag
    {
        get { ... }
    }
}
```

This property can be accessed from a python client as follows:

```
import krpc
conn = krpc.connect()
flag = conn.eva.last_flag
```

- Applied to a non-static property in a class:

```
[KRPCClass (Service = "EVA")]
public class Flag {
    [KRPCProperty]
    public void Name { get; set; }

    [KRPCProperty]
    public void Description { get; set; }
}
```

class **KRPCEnum** ([*Service*])

Parameters **Service** (*string*) – Optional name of the service to add this enum to. If omitted, the enum is added to the service that contains its definition.

This attribute is applied to enumeration types. It adds the enumeration and its permissible values to the server. This attribute works similarly to *KRPCClass*, but is applied to enumeration types.

A *KRPCEnum* must be part of a service, just like a *KRPCClass*. Similarly, a *KRPCEnum* can be declared outside of a service if it has its `Service` parameter set to the name of the service that it is part of.

The enumeration type to which this attribute is applied must satisfy the following criteria:

- The enumeration must be `public`.
- The name of the enumeration must be a valid *kRPC identifier*.
- The enumeration must either be declared inside a *KRPCService*, or have it's `Service` parameter set to the name of the service it is part of.
- The underlying C# type must be an `int`.

Examples

•Declare an enumeration type with two values:

```
[KRPCEnum (Service = "EVA")]
public enum FlagState {
    Raised,
    Lowered
}
```

This can be used from a python client as follows:

```
import krpc
conn = krpc.connect()
state = conn.eva.FlagState.lowered
```

9.2.2 Identifiers

An identifier must only contain alphanumeric characters and underscores. An identifier must not start with an underscore. Identifiers should follow CamelCase capitalization conventions.

Note: Although underscores are permitted, they should be avoided as they are used for internal name mangling.

9.2.3 Serializable Types

A type can only be used as a parameter or return type if kRPC knows how to serialize it. The following types are serializable:

- The C# types `double`, `float`, `int`, `long`, `uint`, `ulong`, `bool`, `string` and `byte[]`
- Any type annotated with *KRPCClass*
- Any type annotated with *KRPCEnum*
- Collections of serializable types:
  - `System.Collections.Generic.IList<T>` where `T` is a serializable type
  - `System.Collections.Generic.IDictionary<K,V>` where `K` is one of `int`, `long`, `uint`, `ulong`, `bool` or `string` and `V` is a serializable type
  - `System.Collections.HashSet<V>` where `V` is a serializable type
- Return types can be `void`
- Protocol buffer message types from namespace `KRPC.Schema.KRPC`

9.2.4 Game Scenes

Each service is configured to be available from a particular game scene, or scenes.

class **GameScene**

SpaceCenter
: The game scene showing the Kerbal Space Center buildings.

Flight
: The game scene showing a vessel in flight (or on the launchpad/runway).

TrackingStation
The tracking station.

EditorVAB
The Vehicle Assembly Building.

EditorSPH
The Space Plane Hangar.

Editor
Either the VAB or the SPH.

All
All game scenes.

Examples

- Declare a service that is available in the *GameScene.Flight* game scene:

```
[KRPCService (GameScene = GameScene.Flight)]
public static class MyService {
    ...
}
```

- Declare a service that is available in the *GameScene.Flight* and *GameScene.Editor* game scenes:

```
[KRPCService (GameScene = (GameScene.Flight | GameScene.Editor))]
public static class MyService {
    ...
}
```

9.3 Documentation

Documentation can be added using C# XML documentation. The documentation will be automatically exported to clients when they connect.

9.4 Further Examples

See the SpaceCenter service implementation for more extensive examples.

9.5 Generating Service Code for Static Clients

Some of the client libraries dynamically construct the code necessary to interact with the server when they connect. This means that these libraries will automatically pick up changes to service code. Such client libraries include those for Python and Lua.

Other client libraries required code to be generated and compiled into them statically. They do not automatically pick up changes to service code. Such client libraries include those for C++ and C#.

Code for these 'static' libraries is generated using the *krpc-clientgen* tool. This is provided as a Python script on PyPi. It can be installed using pip:

```
pip install krpc.clientgen
```

You can then run the script from the command line:

```
$ krpc-clientgen --help
usage: krpc-clientgen [-h] [-v] [-o OUTPUT] [--ksp KSP]
                      [--output-defs OUTPUT_DEFS]
                      {cpp,csharp} service input [input ...]

Generate client source code for kRPC services.

positional arguments:
  {cpp,csharp}          Language to generate
  service               Name of service to generate
  input                 Path to service definition JSON file or assembly
                        DLL(s)

optional arguments:
  -h, --help            show this help message and exit
  -v, --version         show program's version number and exit
  -o OUTPUT, --output OUTPUT
                        Path to write source code to. If not specified, writes
                        source code to standard output.
  --ksp KSP             Path to Kerbal Space Program directory. Required when
                        reading from an assembly DLL(s)
  --output-defs OUTPUT_DEFS
                        When generting client code from a DLL, output the
                        service definitions to the given JSON file
```

Client code can be generated either directly from an assembly DLL containing the service, or from a JSON file that has previously been generated from an assembly DLL (using the `--output-defs` flag).

Generating client code from an assembly DLL requires a copy of Kerbal Space Program and a C# runtime to be available on the machine. In contrast, generating client code from a JSON file does not have these requirements and so is more portable.

9.5.1 Example

The following demonstrates how to generate code for the C++ and C# clients to interact with the LaunchControl service, given in an example previously.

krpc-clientgen expects to be passed the location of your copy of Kerbal Space Program, the name of the language to generate, the name of the service (from the *KRPCService* attribute), a path to the assembly containing the service and the path to write the generated code to.

For C++, run the following:

```
krpc-clientgen --ksp=/path/to/ksp cpp LaunchControl LaunchControl.dll
launch_control.hpp
```

To then use the LaunchControl service from C++, you need to link your code against the C++ client library, and include *launch_control.hpp*.

For C#, run the following:

```
krpc-clientgen --ksp=/path/to/ksp csharp LaunchControl LaunchControl.dll
LaunchControl.cs
```

To then use the LaunchControl service from a C# client, you need to reference the *KRPC.Client.dll* and include *LaunchControl.cs* in your project.

CHAPTER

TEN

COMMUNICATION PROTOCOL

Clients invoke Remote Procedure Calls (RPCs) by communicating with the server using Protocol Buffer v3 messages sent over a TCP/IP connection.

The kRPC download comes with a protocol buffer message definitions file (KRPC.proto) that defines the structure of these messages. It also includes versions of this file compiled for Python, Java and C++ using Google's protocol buffers compiler.

10.1 Establishing a Connection

kRPC consists of two servers: an *RPC Server* (over which clients send and receive RPCs) and a *Stream Server* (over which clients receive *Streams*). A client first connects to the *RPC Server*, then (optionally) to the *Stream Server*.

10.1.1 Connecting to the RPC Server

To establish a connection to the *RPC Server*, a client must do the following:

1. Open a TCP socket to the server on its RPC port (which defaults to 50000).
2. Send this 12 byte hello message: `0x48 0x45 0x4C 0x4C 0x4F 0x2D 0x52 0x50 0x43 0x00 0x00 0x00`
3. Send a 32 byte message containing a name for the connection, that will be displayed on the in-game server window. This should be a UTF-8 encoded string, up to a maximum of 32 bytes in length. If the string is shorter than 32 bytes, it should be padded with zeros.
4. Receive a 16 byte unique client identifier. This is sent to the client when the connection is granted, for example after the user has clicked accept on the in-game UI.

For example, this python code will connect to the *RPC Server* at address `127.0.0.1:50000` using the identifier `Jeb`:

```
import socket
rpc_conn = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
rpc_conn.connect(('127.0.0.1', 50000))
# Send the 12 byte hello message
rpc_conn.sendall(b'\x48\x45\x4C\x4C\x4F\x2D\x52\x50\x43\x00\x00\x00')
# Send the 32 byte client name 'Jeb' padded with zeroes
name = 'Jeb'.encode('utf-8')
name += (b'\x00' * (32-len(name)))
rpc_conn.sendall(name)
# Receive the 16 byte client identifier
identifier = b''
while len(identifier) < 16:
```

```
    identifier += rpc_conn.recv(16 - len(identifier))
# Connection successful. Print out a message along with the client identifier.
printable_identifier = ''.join('%02s' % x for x in identifier)
print('Connected to RPC server, client idenfitier = %s' % printable_identifier)
```

10.1.2 Connecting to the Stream Server

To establish a connection to the *Stream Server*, a client must first *connect to the RPC Server* then do the following:

1. Open a TCP socket to the server on its Stream port (which defaults to 50001).
2. Send this 12 byte hello message: `0x48 0x45 0x4C 0x4C 0x4F 0x2D 0x53 0x54 0x52 0x45 0x41 0x4D`
3. Send a 16 byte message containing the client's unique identifier. This identifier is given to the client after it successfully connects to the *RPC Server*.
4. Receive a 2 byte OK message: `0x4F 0x4B` This indicates a successful connection.

Note: Connecting to the Stream Server is optional. If the client doesn't require stream functionality, there is no need to connect.

For example, this python code will connect to the *Stream Server* at address `127.0.0.1:50001`. Note that `identifier` is the unique client identifier received when *connecting to the RPC server*.

```
import socket
stream_conn = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
stream_conn.connect(('127.0.0.1', 50001))
# Send the 12 byte hello message
stream_conn.sendall(b'\x48\x45\x4C\x4C\x4F\x2D\x53\x54\x52\x45\x41\x4D')
# Send the 16 byte client identifier
stream_conn.sendall(identifier)
# Receive the 2 byte OK message
ok_message = b''
while len(ok_message) < 2:
    ok_message += stream_conn.recv(2 - len(ok_message))
# Connection successful
print('Connected to stream server')
```

10.2 Remote Procedures

Remote procedures are arranged into groups called services. These act as a single-level namespacing to keep things organized. Each service has a unique name used to identify it, and within a service each procedure has a unique name.

10.2.1 Invoking Remote Procedures

Remote procedures are invoked by sending a request message to the RPC server, and waiting for a response message. These messages are encoded as Protocol Buffer messages.

The request message contains the name of the procedure to invoke, and the values of any arguments to pass it. The response message contains the value returned by the procedure (if any) and any errors that were encountered.

Requests are processed in order of receipt. The next request will not be processed until the previous one completes and it's response has been received by the client. When there are multiple client connections, the requests are processed in round-robin order.

10.2.2 Anatomy of a Request

A request is sent to the server using a `Request` Protocol Buffer message with the following format:

```
message Request {
  string service = 1;
  string procedure = 2;
  repeated Argument arguments = 3;
}

message Argument {
  uint32 position = 1;
  bytes value = 2;
}
```

The fields are:

- `service` - The name of the service in which the remote procedure is defined.
- `procedure` - The name of the remote procedure to invoke.
- `arguments` - A sequence of `Argument` messages containing the values of the procedure's arguments. The fields are:
  - `position` - The zero-indexed position of the of the argument in the procedure's signature.
  - `value` - The value of the argument, encoded in Protocol Buffer format.

The `Argument` messages have a position field to allow values for default arguments to be omitted. See *Protocol Buffer Encoding* for details on how to serialize the argument values.

10.2.3 Anatomy of a Response

A response is sent to the client using a `Response` Protocol Buffer message with the following format:

```
message Response {
  double time = 1;
  bool has_error = 2;
  string error = 3;
  bool has_return_value = 4;
  bytes return_value = 5;
}
```

The fields are:

- `time` - The universal time (in seconds) when the request completed processing.
- `has_error` - True if there was an error executing the remote procedure.
- `error` - If `has_error` is true, contains a description of the error.
- `has_return_value` - True if the remote procedure returned a value.
- `return_value` - If `has_return_value` is true and `has_error` is false, contains the value returned by the remote procedure, encoded in protocol buffer format.

See *Protocol Buffer Encoding* for details on how to unserialize the return value.

10.2.4 Encoding and Sending Requests and Responses

To send a request:

1. Encode a `Request` message using the *Protocol Buffer Encoding*.
2. Send the size in bytes of the encoded `Request` message, encoded as a Protocol Buffer varint.
3. Send the message data.

To receive a response:

1. Read a Protocol Buffer varint, which contains the length of the `Response` message data in bytes.
2. Receive and decode the `Response` message.

10.2.5 Example RPC invocation

The following Python script invokes the `GetStatus` procedure from the *KRPC service* using an already established connection to the server (the `rpc_conn` variable).

The `krpc.schema.KRPC` package contains the Protocol Buffer message formats `Request`, `Response` and `Status` compiled to python code using the Protocol Buffer compiler. The `EncodeVarint` and `DecodeVarint` functions are used to encode/decode integers to/from the Protocol Buffer varint format.

```
def EncodeVarint(value):
  return krpc.Encoder.encode(value,krpc.types.ValueType("int32"))
def DecodeVarint(data) :
  return krpc.Decoder.decode(data,krpc.types.ValueType("int32"))

# Create Request message
request = krpc.schema.KRPC.Request()
request.service = 'KRPC'
request.procedure = 'GetStatus'

# Encode and send the request
data = request.SerializeToString()
header = EncodeVarint(len(data))
rpc_conn.sendall(header + data)

# Receive the size of the response data
data = b''
while True:
    data += rpc_conn.recv(1)
    try:
        size = DecodeVarint(data)
        break
    except IndexError:
        pass

# Receive the response data
data = b''
while len(data) < size:
    data += rpc_conn.recv(size - len(data))

# Decode the response message
response = krpc.schema.KRPC.Response()
response.ParseFromString(data)

# Check for an error response
```

```
if response.has_error:
    print('ERROR:', response.error)

# Decode the return value as a Status message
else:
    status = krpc.schema.KRPC.Status()
    assert response.has_return_value
    status.ParseFromString(response.return_value)

    # Print out the version string from the Status message
    print(status.version)
```

10.3 Protocol Buffer Encoding

Values passed as arguments or received as return values are encoded using the Protocol Buffer serialization format:

- Documentation for this encoding can be found here: https://developers.google.com/protocol-buffers/docs/encoding
- Protocol Buffer serialization libraries are available for C++/Java/Python here: http://code.google.com/p/protobuf/downloads/list
- There are implementations available for most popular languages here: http://code.google.com/p/protobuf/wiki/ThirdPartyAddOns

10.4 Streams

Streams allow the client to repeatedly execute a Remote Procedure Call on the server and receive its results, without needing to repeatedly call the Remote Procedure Call directly, avoiding the communication overhead that this would involve.

A stream is created on the server by calling *AddStream* which returns a unique identifier for the stream. Once a client is finished with a stream, it can remove it from the server by calling *RemoveStream* with the stream's identifier. Streams are automatically removed when the client that created it disconnects from the server. Streams are local to each client. There is no way to share a stream between clients.

The results of the RPCs for each stream are sent to the client over the Stream Server's TCP/IP connection, as repeated *stream messages*. The RPC for each stream is invoked every fixed update. Updates are sent to clients when the value returned by the RPC changes to minimize network traffic.

10.4.1 Anatomy of a Stream Message

A stream message is sent to the client using a `StreamMessage` Protocol Buffer message with the following format:

```
message StreamMessage {
  repeated StreamResponse responses = 1;
}
```

This message contains a list of `StreamResponse` messages, one for each stream that exists on the server for that client, with the following format:

```
message StreamResponse {
  uint32 id = 1;
  Response response = 2;
}
```

The fields are:

- `id` - The identifier of the stream. This is the value returned by *AddStream* when the stream is created.
- `response` - A `Response` message containing the result of the stream's RPC. This is identical to the `Response` message returned when calling the RPC directly. See *Anatomy of a Response* for details on the format and contents of this message.

10.5 KRPC Service

The server provides a service called `KRPC` containing procedures that are used to retrieve information about the server and add/remove streams.

10.5.1 GetStatus

The `GetStatus` procedure returns status information about the server. It returns a Protocol Buffer message with the format:

```
message Status {
  string version = 1;
  uint64 bytes_read = 2;
  uint64 bytes_written = 3;
  float bytes_read_rate = 4;
  float bytes_written_rate = 5;
  uint64 rpcs_executed = 6;
  float rpc_rate = 7;
  bool one_rpc_per_update = 8;
  uint32 max_time_per_update = 9;
  bool adaptive_rate_control = 10;
  bool blocking_recv = 11;
  uint32 recv_timeout = 12;
  float time_per_rpc_update = 13;
  float poll_time_per_rpc_update = 14;
  float exec_time_per_rpc_update = 15;
  uint32 stream_rpcs = 16;
  uint64 stream_rpcs_executed = 17;
  float stream_rpc_rate = 18;
  float time_per_stream_update = 19;
}
```

The `version` field contains the version string of the server. The remaining fields contain performance information about the server.

10.5.2 GetServices

The `GetServices` procedure returns a Protocol Buffer message containing information about all of the services and procedures provided by the server. It also provides type information about each procedure, in the form of *attributes*. The format of the message is:

```
message Services {
  repeated Service services = 1;
}
```

This contains a single field, which is a list of `Service` messages with information about each service provided by the server. The content of these `Service` messages are *documented below*.

10.5.3 AddStream

The `AddStream` procedure adds a new stream to the server. It takes a single argument containing the RPC to invoke, encoded as a `Request` object. See *Anatomy of a Request* for the format and contents of this object. See *Streams* for more information on working with streams.

10.5.4 RemoveStream

The `RemoveStream` procedure removes a stream from the server. It takes a single argument – the identifier of the stream to be removed. This is the identifier returned when the stream was added by calling *AddStream*. See *Streams* for more information on working with streams.

10.6 Service Description Message

The *GetServices procedure* returns information about all of the services provided by the server. Details about a service are given by a `Service` message, with the format:

```
message Service {
  string name = 1;
  repeated Procedure procedures = 2;
  repeated Class classes = 3;
  repeated Enumeration enumerations = 4;
  string documentation = 5;
}
```

The fields are:

- `name` - The name of the service.
- `procedures` - A list of `Procedure` messages, one for each procedure defined by the service.
- `classes` - A list of `Class` messages, one for each *`KRPCClass`* defined by the service.
- `enumerations` - A list of `Enumeration` messages, one for each *`KRPCEnum`* defined by the service.
- `documentation` - Documentation for the service, as C# XML documentation.

Note: See the *Extending kRPC* documentation for more details about *`KRPCClass`* and *`KRPCEnum`*.

10.6.1 Procedures

Details about a procedure are given by a `Procedure` message, with the format:

```
message Procedure {
  string name = 1;
  repeated Parameter parameters = 2;
  bool has_return_type = 3;
  string return_type = 4;
  repeated string attributes = 5;
  string documentation = 6;
}

message Parameter {
  string name = 1;
  string type = 2;
  bool has_default_argument = 3;
  bytes default_argument = 4;
}
```

The fields are:

- `name` - The name of the procedure.
- `parameters` - A list of `Parameter` messages containing details of the procedure's parameters, with the following fields:
  - `name` - The name of the parameter, to allow parameter passing by name.
  - `type` - The *type* of the parameter.
  - `has_default_argument` - True if the parameter has a default value.
  - `default_argument` - If `has_default_argument` is true, contains the value of the default value of the parameter, *encoded using Protocol Buffer format*.
- `has_return_type` - True if the procedure returns a value.
- `return_type` - If `has_return_type` is true, contains the *return type* of the procedure.
- `attributes` - The procedure's *attributes*.
- `documentation` - Documentation for the procedure, as C# XML documentation.

10.6.2 Classes

Details about each `KRPCClass` are specified in a `Class` message, with the format:

```
message Class {
  string name = 1;
  string documentation = 2;
}
```

The fields are:

- `name` - The name of the class.
- `documentation` - Documentation for the class, as C# XML documentation.

10.6.3 Enumerations

Details about each `KRPCEnum` are specified in an `Enumeration` message, with the format:

```
message Enumeration {
  string name = 1;
  repeated EnumerationValue values = 2;
  string documentation = 3;
}

message EnumerationValue {
  string name = 1;
  int32 value = 2;
  string documentation = 3;
}
```

The fields are:

- `name` - The name of the enumeration.
- `values` - A list of `EnumerationValue` messages, indicating the values that the enumeration can be assigned. The fields are:
  - `name` - The name associated with the value for the enumeration.
  - `value` - The possible value for the enumeration as a 32-bit integer.
  - `documentation` - Documentation for the enumeration value, as C# XML documentation.
- `documentation` - Documentation for the enumeration, as C# XML documentation.

10.6.4 Attributes

Additional type information about a procedure is encoded as a list of attributes, and included in the `Procedure` message. For example, if the procedure implements a method for a class (see *proxy objects*) this fact will be specified in the attributes.

The following attributes specify what the procedure implements:

- `Property.Get(property-name)`

  Indicates that the procedure is a property getter (for the service) with the given `property-name`.
- `Property.Set(property-name)`

  Indicates that the procedure is a property setter (for the service) with the given `property-name`.
- `Class.Method(class-name,method-name)`

  Indicates that the procedure is a method for a class with the given `class-name` and `method-name`.
- `Class.StaticMethod(class-name,method-name)`

  Indicates that the procedure is a static method for a class with the given `class-name` and `method-name`.
- `Class.Property.Get(class-name,property-name)`

  Indicates that the procedure is a property getter for a class with the given `class-name` and `property-name`.
- `Class.Property.Set(class-name,property-name)`

  Indicates that the procedure is a property setter for a class with the given `class-name` and `property-name`.

The following attributes specify more details about the return and parameter types of the procedure.

- `ReturnType.type-name`

  Specifies the actual *return type* of the procedure, if it differs to the type specified in the `Procedure` message. For example, this is used with *proxy objects*.

- `ParameterType(parameter-position).type-name`

  Specifies the actual *parameter type* of the procedure, if it differs to the type of the corresponding parameter specified in the `Parameter` message. For example, this is used with *proxy objects*.

10.6.5 Type Names

The `GetServices` procedure returns type information about parameters and return values as strings. Type names can be any of the following:

- A Protocol Buffer value type. One of `double`, `float`, `int32`, `int64`, `uint32`, `uint64`, `bool`, `string` or `bytes`
- A KRPCClass, in the format `Class(ClassName)`
- A KRPCEnum, in the format `Enum(ClassName)`
- A Protocol Buffer message type, in the format `KRPC.MessageType`. Only message types defined in `krpc.proto` are permitted.

10.6.6 Proxy Objects

kRPC allows procedures to create objects on the server, and passes unique identifiers for them to the client. This allows the client to create a *proxy* object for the actual object, whose methods and properties make remote procedure calls to the server. Object identifiers have type `uint64`.

When a procedure returns a proxy object, the procedure will have the attribute `ReturnType.Class(ClassName)` where `ClassName` is the name of the class.

When a procedure takes a proxy object as a parameter, the procedure will have the attribute `ParameterType(n).Class(ClassName)` where `n` is the position of the parameter and `ClassName` is the name of the class.

CHAPTER

ELEVEN

INTERNALS OF KRPC

11.1 Server Performance Settings

kRPC receives RPCs, execute them and returns results when the mod's `FixedUpdate` method is invoked. kRPC may execute multiple RPCs within a single call to `FixedUpdate` and this behavior is controlled by several configurable settings:

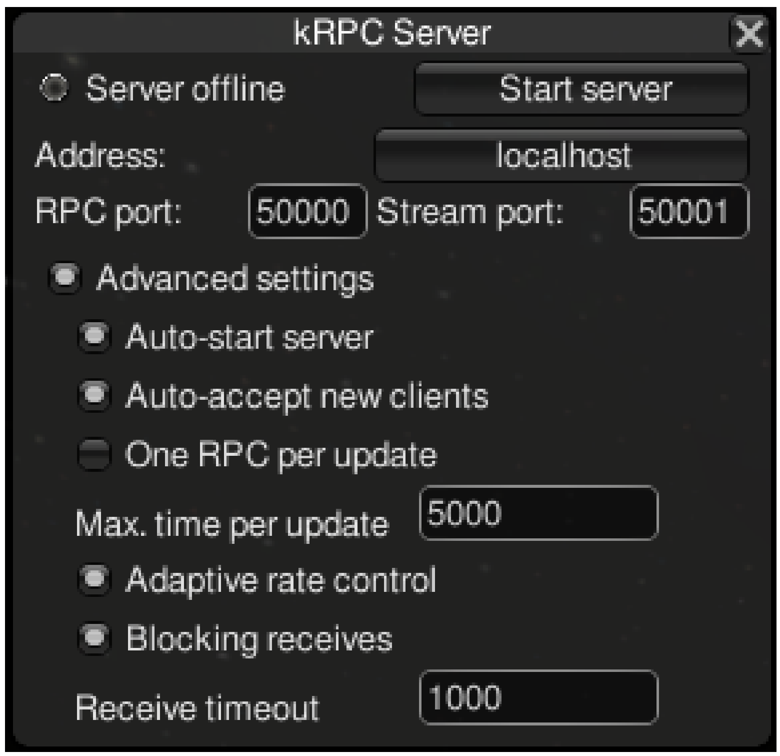


Fig. 11.1: Server window showing the advanced settings.

1. **Auto-start server**: When enabled, the server will start automatically when the game loads.
2. **Auto-accept new clients**: When enabled, new client connections are automatically allowed. When disabled, a pop-up is displayed asking whether the new client connection should be allowed.
3. **One RPC per update**: When enabled, the server will execute at most one RPC per client per update.
4. **Maximum time per update**: This is the maximum number of nanoseconds that the server will spend processing RPCs in the call to FixedUpdte. This is used to limit the time taken by the server per frame. A high value, for

example 20000 ns, will allow the server to process many RPCs at the expense of the game's framerate. A low value, for example 1000 ns, won't allow the server to execute many RPCs per update, but will allow the game to run at a much higher framerate.

5. **Adaptive rate control**: If enabled, the server will automatically adjust the maximum time per update parameter, so that the game runs at a minimum of 60 FPS.
6. **Blocking receives**: If enabled, when the server checks for new RPCs from clients, it will wait for a up to a fixed amount of time.
7. **Receive timeout**: When blocking receives are enabled, this is the maximum amount of time the server will wait for a new RPC from a client.

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