UACS Developer Manual

###### This manual discusses configuring UACS default astronaut and cargo implementations, as well as the C++ API.

## Standard Resource Names

These standard resource names should be used by vessels and cargoes. **The name must be lowercase**, and spaces can be included.

fuel, ramjet fuel, oxygen, food, water, hydrogen, helium

Note: for all ramjet engine variations, use ‘fuel’ or ‘ramjet fuel’ (i.e., if the vessel has SCRAM engines, use ‘ramjet fuel’, not ‘scram fuel’).

## Standard Astronaut Roles

These names should be by vessels and astronauts. **The role must be lowercase**, and spaces can be included.

commander, pilot, mission specialist, flight engineer

## Stations

Stations are normal Orbiter vessels that can provide breathable habitat for astronauts, unlimited resources for other vessels, or both.

Stations are created by modifying a vessel configuration file by creating a to-parent attachment point with a label that UACS uses to identify the station. UACS\_R is used for resource stations, UACS\_B for breathable stations, and UACS\_RB for both. The attachment point position, direction, and rotation have no effect, only the label is used to identify the station.

If the station supports resources, a UACS\_RESOURCES option can be added to specify resources. Use the standard resource names detailed above. If the option isn’t added, the station is assumed to support all resources. A vessel can drain resources if it’s within the station size (mean radius) plus the drain range (set by the vessel).

To create a station, open the vessel you want to be a station configuration file which can be found in the ‘Config\Vessels’ folder, and find the attachment sections.

BEGIN\_ATTACHMENT

………………………………………

END\_ATTACHMENT

If you find it, add the station attachment before END\_ATTACHMENT line. Change the attachment point label (the text at the end) to the appropriate type.

BEGIN\_ATTACHMENT

P 0 0 0 0 0 1 0 1 0 UACS\_RB

END\_ATTACHMENT

Otherwise, add the following lines to the end of the file. Change the attachment label as required.

BEGIN\_ATTACHMENT

………………………………………

P 0 0 0 0 0 1 0 1 0 UACS\_RB

END\_ATTACHMENT

If the station supports resources, add the resource names **separated by commas with no spaces between the commas**, at the top of the file. If not added, the station will support all resources.

UACS\_RESOURCES = fuel,ramjet fuel,oxygen

## Astronauts

###### Configuration File

Astronauts configuration file are saved in ‘Config\Vessels\UACS\Astronauts’ folder. If one of the required options is missing, Orbiter will crash when the cargo is loaded with a runtime error and an error message in the Orbiter.log file with the missing option.

The astronaut suit mesh and body mesh aren’t displayed at the same time. Suit mesh is displayed only when the suit is on, and body mesh when the suit is off. That means the suit mesh should contain a body inside it (i.e., the astronaut face).

The suit mass and body mass are both added plus the fuel and oxygen mass to form the astronaut total weight.

The body height and suit height rough values can be obtained by using Shipedit with the boy and suit mesh, as explained in the cargo chapter. Cross sections and inertia tensor values can be obtained from Shipedit as well. The suit mesh should be used in this case.

Since the packed cargo attachment point position is at the cargo center, the astronaut attachment point position should add the packed cargo radius (0.65m) to the desired position in the proper axis (i.e., Z axis if the cargo is held in front of the astronaut, X axis if on the right, etc.).

The camera offset is used to set the proper position for the cockpit view. It should be the coordinates of the astronaut head center. It can be obtained by opening the mesh in a 3D designer software.

Each astronaut has two to-children attachment points to hold cargoes: one with a suit, the other without it. The first attachment point must be the suit one, the second must be the body one.

The attachment points direction and rotation shouldn’t be changed to orientate grappled cargo properly.

Astronauts support an unlimited number of headlights. Each headlight is defined by a position and direction. The direction vector must be normalized. The light intensity cannot be changed.

###### Configuration File Options Reference

|  |  |
| --- | --- |
| Option | Description |
| Name | The astronaut person name. |
| Role | The astronaut person role. Use standard astronaut roles. |
| SuitMesh | The suit mesh file path from 'Meshes' folder without '.msh'. |
| BodyMesh | The body mesh file path from 'Meshes' folder without '.msh'. |
| SuitMass | The suit mass in kilograms. |
| BodyMass | The body mass in kilograms. |
| SuitHeight | The height when the suit is on in meters. |
| BodyHeight | The height when the suit is off in meters. |
| Size | The mean radius in meters. |
| PropellantResource1 | The maximum fuel mass in kilograms. |
| PropellantResource2 | The maximum oxygen mass in kilograms. |
| CrossSections | Optional: The cross sections. |
| Inertia | Optional: The inertia tensor. |
| CameraOffset | Optional: The cockpit camera offset. It should be the coordinates of the astronaut head center. |
| Headlight[n]Pos\* | Optional: The headlight position. |
| Headlight[n]Dir\* | Optional: The headlight direction. |

\*: [n] should be replaced by the headlight index (e.g., 1, 2, 3, etc.).

## Cargoes

###### Modelling

The packed cargo box dimensions must be 1.3mx1.3mx1.3m to follow the standard size. If not followed, the cargo won’t fit into cargo containers on vessels, and the touchdown points won’t be calculated correctly. The box bottom must be at -0.65m, so the cargo center is at (0 0 0), which is the attachment point position. You can use the default containers if you don’t want to design one yourself.

The packed cargo polygons should be as low as possible, as vessels can carry a lot of cargoes. Since a lot of polygons will greatly affect performance, the polygons shouldn’t exceed 200. Use a 512p x 512p texture.

For unpacked cargoes, the polygons shouldn’t exceed 1000 polygons with a 1024p x 1024p texture.

###### Configuration File

The cargo configuration file must be saved in the ‘Config\Vessels\UACS\Cargoes’ folder. The easiest way to make a configuration file is to copy a similar cargo configuration file and edit it. If the cargo contains a resource, check the standard resource names above. The mesh, texture, and configuration file should preferably have the same name, but it’s not required.

If one of the required options is missing, Orbiter will crash when the cargo is loaded with a runtime error and an error message in the Orbiter.log file with the missing option.

To align the unpacked cargoes on ground properly, UACS needs either 3 positions (front, right, and left), or a single height. The advantage of using 3 positions is that the cargo will follow terrain slopes, which isn’t possible when using a single height. The 3 positions should be used unless the unpacked cargo mesh is simple and doesn’t need to follow the terrain slope.

The 3 positions are the coordinates of the center bottom front, bottom right, and bottom left of the cargo mesh. The height is the mesh's lowest point. The best way to get these values is to open the mesh in a 3D design software, but you can get rough values from the Shipedit tool in the ‘Orbitersdk\utils’ folder.

Open the unpacked cargo mesh and check the mesh bounding box. The mesh's lowest point is the negative Y value (the center value in the negative group).

A screenshot of a computer

Description automatically generated

The height is a positive value, so the height for the picture above is 1.1m. The 3 positions are: Front (0 -1.1 3.8) Right (2.6 -1.1 -3.8) Left (-2.6 -1.1 -3.8). Keep in mind these are the bounding box values and may deviate widely from proper values, especially if there are protrusions.

The unpacked size is the cargo unpacked mesh mean radius which is simply the absolute value of the biggest number in the bounding box, so the size for the picture is 3.8m.

The unpacked attachment position should be the lowest point of the mesh front, so the cargo is carried from the bottom. It’s roughly the same as the unpacked ground front position.

To get the unpacked cross sections and inertia tensor, click on ‘Calc -> Start/continue MC integration’. Wait until the numbers at the ‘Parameters’ section stabilizes (around 500,000 samples), then stop it from ‘Calc -> Stop MC integration’.

A screenshot of a computer

Description automatically generated

The cross sections for the picture are (0.05 6.25 3.69). The inertia tensor is diagonal as marked in the picture (0.17 3.17 3.14).

###### Configuration File Options Reference

All options must be specified unless stated otherwise.

General Options

|  |  |
| --- | --- |
| Option | Description |
| PackedMesh | The packed cargo mesh file path from ‘Meshes’ folder without ‘.msh’. |
| PayloadMass | The payload mass in kilograms. |
| ContainerMass | The container mass in kilograms. |
| CargoType | 0 = Static, 1 = Unpackable. |
| UnpackOnly | Optional: if the cargo is unpackable only and cannot be packed again. Applicable only if the cargo is unpackable. If not specified, ‘FALSE’ is assumed. |
| CargoResource | Optional: the resource name (must be lowercase).  Use standard resource names. Specify if the cargo is a resource. |

Unpackable Options

|  |  |
| --- | --- |
| Option | Description |
| UnpackingType | 0 = UACS module, 1 = Orbiter vessel. |
| UnpackingMode | Optional: 0 = Manual, 1 = Released, 2 = Delayed, 3 = Landed.  If not specified, ‘Manual’ is assumed. |
| UnpackingDelay | The delay period in seconds, for 'Delayed' mode.  Applicable only if ‘UnpackingMode’ is ‘Delayed’. |
| UnpackedMesh | The unpacked cargo mesh file path from 'Meshes' folder without .msh. |
| UnpackedSize | The unpacked cargo mean radius in meters. |
| UnpackedHeight\* | The unpacked height in meters for release on ground. |
| UnpackedFrontPos\* | The unpacked cargo front touchdown point position. |
| UnpackedRightPos\* | The unpacked cargo right touchdown point position. |
| UnpackedLeftPos\* | The unpacked cargo left touchdown point position. |
| UnpackedAttachPos | Optional: the unpacked cargo attachment point position.  If not specified, '0 0 0' is assumed. |
| UnpackedCrossSections | Optional: the unpacked cargo cross sections. |
| UnpackedInertia | Optional: the unpacked cargo inertia tensor. |
| UnpackedBreathable | Optional: if the cargo can be breathed in when unpacked.  If not specified, 'FALSE' is assumed. |
| UnpackedCount | Optional: the count of cargoes that will be spawned when unpacking the cargo. 'UnpackOnly' is set to 'TRUE' regardless of the value specified. |
| UnpackedVesselName | The unpacked vessel name in the scenario. It's adjusted automatically for multiple instances. Applicable only if 'UnpackingType' is 'Orbiter vessel'. |
| UnpackedVesselModule | The unpacked vessel config file path from 'Config\Vessels' folder without '.cfg'. Applicable only if 'UnpackingType' is 'Orbiter vessel'. |

\*: Specify either UnpackedHeight or UnpackedFrontPos, UnpackedRightPos, and UnpackedLeftPos, not both.

## API

The API provides a C++ interface to support UACS in vessels, and to develop custom astronauts and cargoes. Use the API for astronauts and cargoes if the default implementation isn’t sufficient.

The API header files are in ‘Orbitersdk\include\UACS’ folder. There are 4 files: ‘Common.h’, ‘Vessel.h’, ‘Astronaut.h’, and ‘Cargo.h’.

‘Common.h’ includes definitions used in multiple APIs, and there is no need to explicitly include it. ‘Vessel.h’ contains the vessel API for vessels to support astronauts, cargoes, or both.

‘Astronaut.h’ contains the astronaut API for custom astronauts, and ‘Cargo.h’ contains the cargo API for custom cargoes.

2 files can be included simultaneously. For example, ‘Astronaut.h’ and ‘Vessel.h’ can be included for a custom astronaut that supports UACS cargoes.

Link against the API library, which is ‘UACS\_API.lib’ in ‘Orbitersdk\lib’ folder.

The API reference can be found in ‘Orbitersdk\doc’ folder.

## Vessel API

Vessels can support astronauts and cargoes by using UACS Vessel API. Cargoes are supported via slots, and astronauts via stations and airlocks.

The vessel API is used by creating an instance of it using the API constructor. It requires a pointer to the calling vessel, and a pointer to either the vessel astronaut information (as the VslAstrInfo struct), or vessel cargo information (as the VslCargoInfo struct), or both. If nullptr is passed instead of either information, don’t call its methods (i.e., don’t call astronaut methods if astronaut information is nullptr). The structs must live until the API instance is destroyed.

The instance is always usable even if UACS isn’t installed. Call GetUACSVersion to find out whether UACS is installed or not, as it returns an empty string view if UACS isn’t installed. All methods can be called and return logical values, so there is no need to check if UACS is installed before calling them. Generally, you should check if UACS is installed after creating the instance and display a message to the user if UACS is not installed.

Vessels must call 3 API methods: ParseScenarioLine, clbkPostCreation, and clbkSaveState.

The ParseScenarioLine method must be called when reading scenario in the vessel clbkLoadStateEx method. While it is used currently to load astronaut information, it should be called even if the vessel doesn’t support astronauts. If the vessel doesn’t already implement clbkLoadStateEx, use the following implementation:

void Vessel::clbkLoadStateEx(FILEHANDLE scn, void\* status)

{

char\* line;

while (oapiReadScenario\_nextline(scn, line))

{

if (!vslAPI.ParseScenarioLine(line))

{

ParseScenarioLineEx(line, status);

}

}

}

The clbkPostCreation method must be called from the vessel clbkPostCreation method, after defining all airlocks, stations, and slots. Currently, it is used to link grappled cargoes to their slots after loading the scenario, but it should be called even if the vessel doesn't support cargoes.

The clbkSaveState method must be called from the vessel clbkSaveState method. Currently, it is used to save astronaut information, but it should be called even if the vessel doesn't support astronauts.

On the ground, objects (astronauts and cargoes) are released in a table consisting of columns and rows. The GroundInfo struct provides the necessary information to build the table: initial position (i.e., first cell position), column direction, row direction, number of columns and rows, space between columns, and space between rows.

Objects are placed in the first row until all columns are filled, then placed in the next row. Since the object elevation follows ground elevation, the Y values in initial position and directions have no effect. It should be set to zero.

If the singleObject option is true and an object is in the initial release position, the onboard object can't be released. Otherwise, the onboard object is released in a table as specified by the other options. It should be set true if the vessel is an astronaut.

UACS can calculate the column and row directions based on the initial position. If the position absolute X value is greater than or equal to the absolute Z value, the directions are set as the picture below. If the absolute Z value is greater, the columns and rows are rotated (i.e., column direction is row direction and row direction is column direction).

A rocket with red arrows

Description automatically generated

###### Astronauts

Astronauts are referred to as the AstrInfo struct. They can be independent vessel in the scenario or stored as the AstrInfo struct inside vessels.

Stations, which are represented by the StationInfo struct, are defined by a name and an AstrInfo std::optional. If an astronaut is currently in the station, the station AstrInfo is defined, otherwise it’s nullopt.

Airlocks are the way in which astronauts can egress from or ingress into the vessel. They are defined by name, position, direction, rotation, open flag, release velocity (if released in space), ground release information if released on ground, and a docking handle.

The docking handle is used to transfer astronauts between docked vessels. If 2 vessels are docked through 2 docking ports, each of which is associated with an airlock, astronauts can be transferred between the vessels.

Station and airlock information to passed to UACS through the VslAstrInfo struct. All variables inside the struct can be modified at any time. The changes is applied immediately.

There are 2 ways to get scenario astronaut information: using UACS astronaut index or Orbiter vessel OBJHANDLE. The first way is done by getting the total astronaut count and looping through each index, using GetScnAstrCount and GetAstrInfoByIndex methods. It should be used if there is no need to loop all scenario vessels, only astronauts, as it is more efficient.

The second way is by using Orbiter vessel OBJHANDLE using the GetAstrInfoByHandle method. It should be used if you already have an OBJHANDLE, or you are already looping through all scenario vessels.

Vessels can add astronauts by getting the available astronaut count using GetAvailAstrCount, get his name if required using GetAvailAstrName, and add the astronaut to an empty station using AddAstronaut.

The astronaut information of any vessel can be obtained using the GetVslAstrInfo method. This information can be used to specify a target station when transferring astronauts from a vessel to another.

###### Cargoes

Cargoes are independent Orbiter vessels. They are referred to in UACS as the CargoInfo struct, which is used to identify both grappled cargoes and other scenario cargoes.

The CargoInfo struct contains the following information: the cargo OBJHANDLE, attachment flag (useful when getting information about scenario cargoes), type, unpack only flag, unpacked flag, breathable flag, and resource.

For scenario cargoes, there are 2 ways to get their information: using UACS cargo index or Orbiter vessel OBJHANDLE. The first way is done by getting the total cargo count and looping through each index, using GetScnCargoCount and GetCargoInfoByIndex methods. It should be used if there is no need to loop all scenario vessels, only cargoes, as it is more efficient.

The second way is by using Orbiter vessel OBJHANDLE using the GetCargoInfoByHandle method. It should be used if you already have an OBJHANDLE, or you are already looping through all scenario vessels.

Each slot is defined using the SlotInfo struct by an attachment point, open flag, release velocity if released in space, ground information for release on ground, and an std::optional of the slot cargo information. If no cargo is attached to the slot, the optional is a nullopt.

All of this information along with vessel-specific settings is passed to UACS through the VslCargoInfo struct. These settings are the grapple unpacked flag (if vessel can grapple unpacked cargoes, should be set true if vessel is astronaut), grapple range, packing/unpacking range, drainage range, max single cargo mass, and max total cargo max.

The best way to manage UACS cargo information is to have a member variable of the VslCargoInfo, set the options in the constructor, then set the slots in clbkSetClassCaps. All variables inside the VslCargoInfo struct can be modified at any time. The changes will apply immediately.

Vessels can add cargoes by getting the available cargo count using GetAvailCargoCount, get its name if required using GetAvailCargoName, and add the cargo to an empty slot using AddCargo.

UACS provides 3 methods to drain resources: DrainGrappledResource, DrainScenarioResource, and DrainStationResource. They should preferably be called in that order (i.e., drain from grappled resources first. If not successful, drain from scenario resource, etc.).

## Astronaut API

Astronauts that need functions outside of config file interface can use C++ API to integrate into UACS framework. Astronauts can implement both the UACS astronaut and vessel APIs.

The configuration file must be saved in ‘Config\Vessels\UACS\Astronauts’ folder alongside normal UACS astronauts. Fill the configuration file as any normal Orbiter vessel configuration file.

Inherit from UACS::API::Astronaut class, which inherits from Orbiter VESSEL4 class. Implement normal Orbiter vessel methods as necessary.

The AstrInfo struct contains the information UACS needs from the astronaut to integrate it into UACS system, which are name, role, mass, height, fuel level, oxygen level, alive flag, custom data, and class name.

The clbkSetAstrInfo and clbkGetAstrInfo methods must be implemented by astronauts. The best way is to have an AstrInfo struct member variable. In clbkGetAstrInfo, remember to set the current fuel and oxygen levels and any custom data if not set already elsewhere, then return the address of the member variable. The clbkSetAstrInfo method is used only by UACS API, and only after the astronaut creation. In it, set the member variable to the passed variable, then set the astronaut status as required.

There are 2 ways to get scenario astronaut information: using UACS astronaut index or Orbiter vessel OBJHANDLE. The first way is done by getting the total astronaut count and looping through each index, using GetScnAstrCount and GetAstrInfoByIndex methods. It should be used if there is no need to loop all scenario vessels, only astronauts, as it is more efficient. Note that your astronaut is included.

The second way is by using Orbiter vessel OBJHANDLE using the GetAstrInfoByHandle method. It should be used if you already have an OBJHANDLE, or you are already looping through all scenario vessels.

Other methods can be used as necessary. At minimum, the astronaut should provide means to ingress by calling the ingress method. The default parameters should be sufficient for basic astronauts. Otherwise, use GetVslAstrInfo to obtain a vessel astronaut information and specify a target airlock and station.

If the astronaut has a removable suit, it’s useful to call InBreathableArea method to prevent removing the suit when not in a breathable area.

## Cargo API

A custom cargo is a normal Orbiter vessel that uses the C++ API to act like normal cargoes. Follow the instructions and restrictions in the cargo section above (packed dimensions must be 1.3m x 1.3m x 1.3m, unpacked height and 3 positions, etc.).

The configuration file must be saved in ‘Config\Vessels\UACS\Cargoes’ folder alongside normal UACS cargoes. Fill the configuration file as any normal Orbiter vessel configuration file.

Cargoes must inherit from UACS::API::Cargo class, which in turn inherits from Orbiter VESSEL4 class. Implement normal Orbiter vessel methods as required.

Cargo information is handled via the CargoInfo struct that UACS gets a constant pointer to via the clbkGetCargoInfo method, which must be implemented by cargoes. These information are attachment point handle, type, unpack only flag, unpacked flag, breathable flag, ground release positions, and resource.

The struct the pointer references must live until the cargo is destroyed, so don’t return an address of a temporary variable. The best way is to have a CargoInfo member variable and return its address in that method. Methods other than clbkGetCargoInfo should be implemented based on the cargo type and functionality.

Information not related to cargo status (usually type, unpackOnly, breathable, and resource) should be set in the vessel constructor. Other information should be set in clbkSetClassCaps or clbkLoadStateEx as required. It’s important to note that the cargo is solely responsible for changing the information as required, such as setting the unpacked flag and the attachment point based on the cargo status. UACS never modifies cargo information.

The packed cargo attachment position should be at the cargo center (0 0 0), not at top or bottom. The direction should be (0 -1 0) and rotation (0 0 1). This is important so vessels can properly position cargoes in their slots depending on the slot design. The unpacked attachment position should be the center position of the mesh front, with same direction and rotation as the packed cargoes, for astronauts to carry the cargo properly.