

# Results and graphs

ANSYS, Inc.

This tutorial demonstrates how the STK object model provides direct access to the data provider tools exposed by each object in STK that form the foundation of the report styles in the GUI.

The following example uses the J2000 Position Velocity report to demonstrate the retrieval of data through the object model. This report consists of specific J2000 data provider elements from two groups: Cartesian Velocity and Cartesian Position.

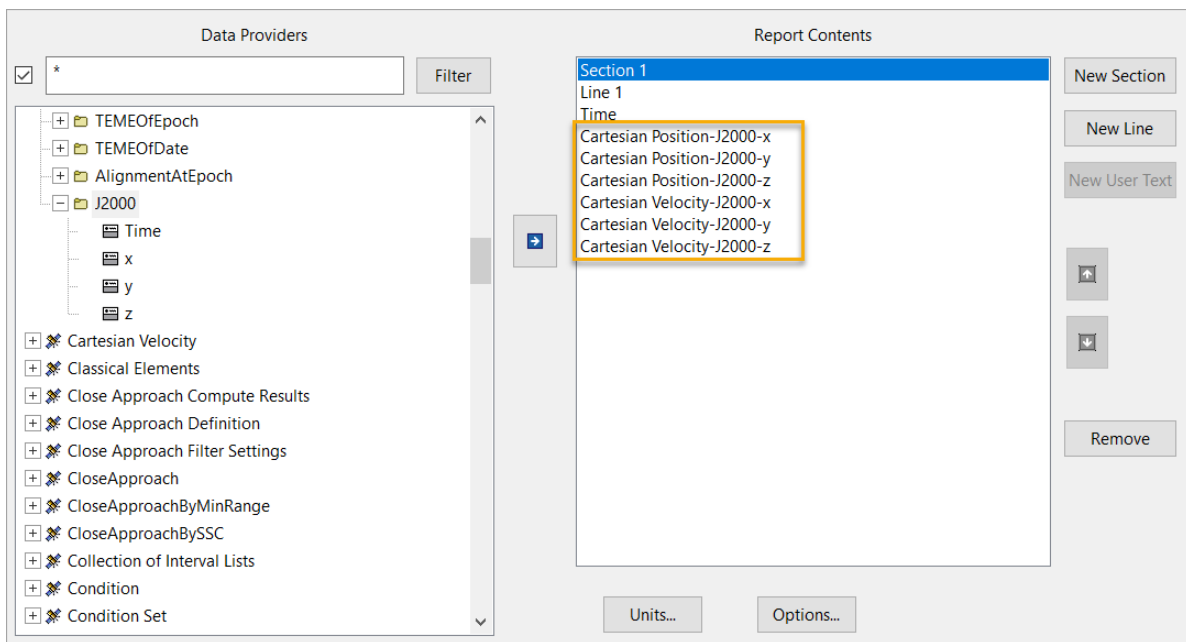


Figure 1: The J2000 Position Velocity report contents

## Launch a new STK instance

Start by launching a new STK instance. In this example, STKEngine is used.

```
from ansys.stk.core.stkengine import STKEngine
```

```
stk = STKEngine.start_application(no_graphics=False)  
print(f"Using {stk.version}")
```

Using STK Engine v12.10.0

Create an STK scenario using the STK Root object:

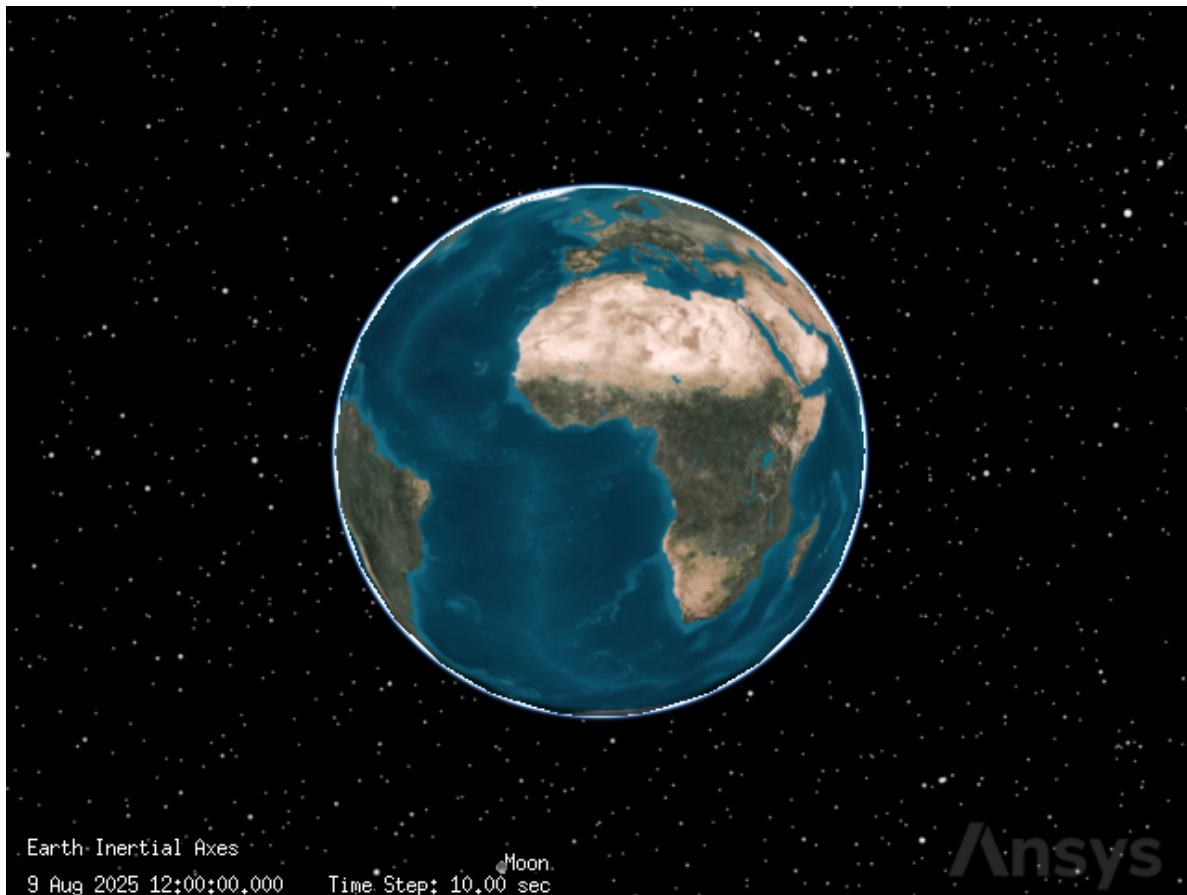
```
root = stk.new_object_root()  
root.new_scenario("GraphsAndResults")
```

Once the scenario is created, it is possible to show a 3D graphics window by running:

```
from ansys.stk.core.stkengine.experimental.jupyterwidgets import GlobeWidget
```

```
globe_widget = GlobeWidget(root, 640, 480)  
globe_widget.show()
```

```
RFBOutputContext()
```

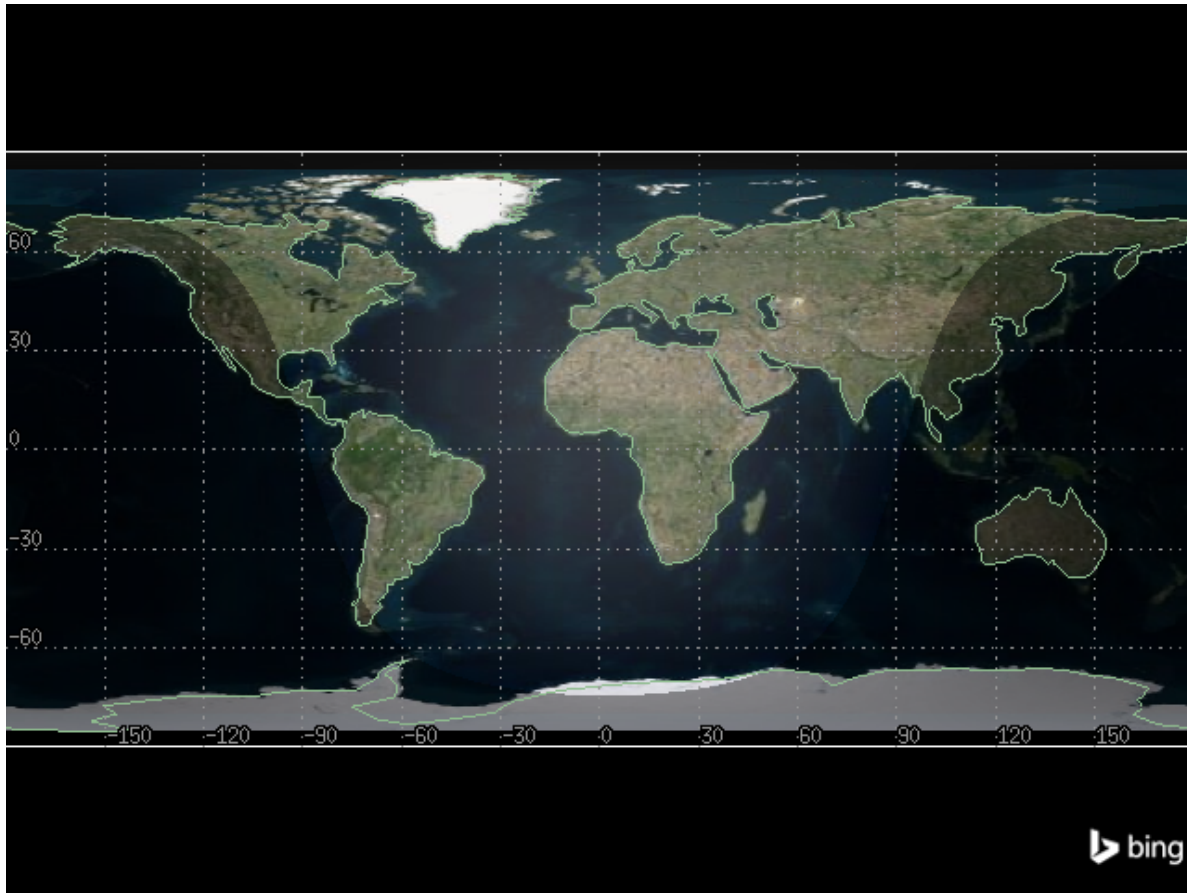


Show a 2D graphics window by running:

```
from ansys.stk.core.stkengine.experimental.jupyterwidgets import MapWidget
```

```
map_widget = MapWidget(root, 640, 480)  
map_widget.show()
```

```
RFBOutputContext()
```



### Set the scenario time period

Using the newly created scenario, set the start and stop times. Rewind the scenario so that the graphics match the start and stop times of the scenario:

```
scenario = root.current_scenario
scenario.set_time_period("1 Jul 2020 17:14:00.00", "1 Jul 2020 17:29:00.00")
root.rewind()
```

### Adding a satellite to the scenario

Now that a new scenario is available, add a new satellite:

```
from ansys.stk.core.stkobjects import STKObjectType
```

```
satellite = root.current_scenario.children.new(
    STKObjectType.SATELLITE, "SatelliteTwoBody"
)
```

Ensure that the satellite's associated times use the scenario's times as well.

```
from ansys.stk.core.stkobjects import PropagatorTwoBody, PropagatorType
```

```
satellite.set_propagator_type(PropagatorType.TWO_BODY)
```

```
propagator = PropagatorTwoBody(satellite.propagator)
propagator.ephemeris_interval.set_start_and_stop_times(
    "1 Jul 2020 17:14:00.00", "1 Jul 2020 17:29:00.00"
)
```

```
propagator.propagate()
```

## Setup data providers for use in the object model

To retrieve the data for the J2000 Position Velocity report, setup its specific data providers for use in the Object Model. Use the various `DataProvider` interfaces to do this:

```
from ansys.stk.core.stkobjects import DataProviderGroup
```

```
cart_vel = DataProviderGroup(satellite.data_providers["Cartesian Velocity"])
cart_pos = DataProviderGroup(satellite.data_providers["Cartesian Position"])
```

```
cart_vel_j2000 = cart_vel.group.item("J2000")
cart_pos_j2000 = cart_pos.group.item("J2000")
```

The `DataProviderCollection` and `DataProviderGroup` variables can be used to access information about the J2000 Position Velocity report.

```
print('Some data providers available for the the "SatelliteTwoBody" satellite:')

data_providers = list(satellite.data_providers)
for index in range(len(data_providers)):
    if index > 9:
        print(f"\t...and {len(data_providers) - 10} more ")
        break
    print("\t" + str(data_providers[index].name))
```

```

print("Some data providers within the Cartesian Velocity group:")

for item in cart_vel.group:
    print("\t" + str(item.name))

print("Some data providers within the Cartesian Position group:")

for item in cart_pos.group:
    print("\t" + str(item.name))

```

Some data providers available for the the "SatelliteTwoBody" satellite:

```

Active Constraints
All Constraints
Angles
Articulation
Astrogator Accel Hist
Astrogator Log
Astrogator MCS Ephemeris Segments
Astrogator Maneuver Ephemeris Block Final
Astrogator Maneuver Ephemeris Block History
Astrogator Maneuver Ephemeris Block Initial
...and 150 more

```

Some data providers within the Cartesian Velocity group:

```

TrueOfDateRotating
Fixed
ICRF
MeanOfDate
MeanOfEpoch
TrueOfDate
TrueOfEpoch
B1950
TEMEOfEpoch
TEMEOfDate
AlignmentAtEpoch
J2000

```

Some data providers within the Cartesian Position group:

```

TrueOfDateRotating
Fixed
ICRF
MeanOfDate
MeanOfEpoch

```

```
TrueOfDate
TrueOfEpoch
B1950
TEMEOfEpoch
TEMEOfDate
AlignmentAtEpoch
J2000
```

The basic interfaces are now setup to compute information from the data providers that the report is using. Next, cast these objects to provide the `IDataProvider` interface with inputs so it can compute the proper data.

### Data provider “PreData” inputs

Some data providers require input data before the calculation can provide data results. This data is known as PreData. There are two ways to ascertain if PreData is required for a particular data provider: - Refer to the data provider documentation which provides the format of the PreData if any is required. - Retrieve the data provider schema and parse it for PreData tags.

Use the `DataProviderCollection.get_schema()` method to get the schema for all STK data providers.

```
schema = str(satellite.data_providers.get_schema())
```

Once the format of the PreData is known, set the `IDataProvider.pre_data` property. This property must be set before issuing the data provider’s calculation method.

### Set the pre\_data property on the IDataProvider interface

The following example demonstrates setting the satellite’s object path as the PreData for the RIC Coordinates data provider and then calls the data provider’s computation execution method.

```
from ansys.stk.core.stkobjects import DataProviderResult, DataProviderTimeVarying

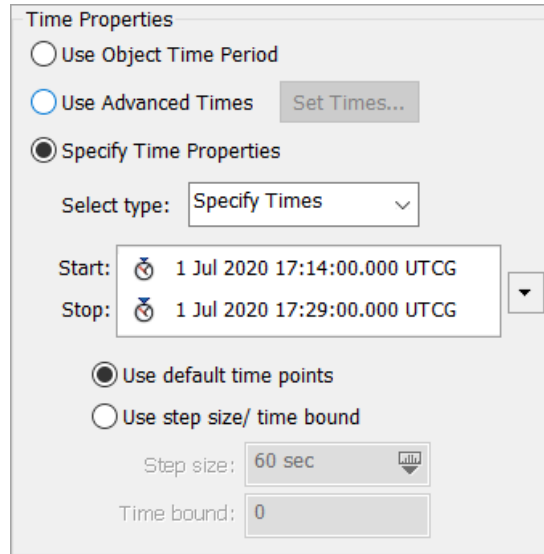
provider = DataProviderTimeVarying(satellite.data_providers["RIC Coordinates"])

provider.pre_data = "Satellite/SatelliteTwoBody"

result = provider.execute("1 Jul 2020 17:14:00.00", "1 Jul 2020 17:29:00.00", 1)
```

## Data provider time inputs

In the Time Period section of the Report window in STK, highlight J2000 Position Velocity and click the Specify Time Properties radio button. The J2000 Position Velocity report uses a time period to provide the underlying data provider's information about what data to compute. Provide the same information to the object model data providers.



The screenshot shows the 'Time Properties' dialog box. It has three radio buttons: 'Use Object Time Period' (unselected), 'Use Advanced Times' (unselected), and 'Specify Time Properties' (selected). To the right of the 'Use Advanced Times' button is a 'Set Times...' button. Below the radio buttons is a 'Select type:' dropdown menu with 'Specify Times' selected. Underneath are 'Start:' and 'Stop:' labels, each followed by a clock icon and a time string: '1 Jul 2020 17:14:00.000 UTCG' for Start and '1 Jul 2020 17:29:00.000 UTCG' for Stop. Below these are two more radio buttons: 'Use default time points' (selected) and 'Use step size/ time bound' (unselected). At the bottom, there are two input fields: 'Step size:' with '60 sec' and a small icon, and 'Time bound:' with '0'.

Figure 2: Report time properties

## Retrieve the data

There are three ways to compute the data, depending on the data provider type. The first method requires a time interval and step size, the second requires only a time interval, and the third is independent of time.

Provide input information to the data providers by casting the data provider interfaces to the proper execution interface. In the case of the `Cartesian Velocity` and `Cartesian Position` data providers, cast to `DataProviderTimeVarying`:

```
vel_time_var = DataProviderTimeVarying(cart_vel_j2000)
pos_time_var = DataProviderTimeVarying(cart_pos_j2000)
```

Retrieve the information from the data providers. The data is always returned as a `DataProviderResult` object. Provide the `DataProviderTimeVarying.execute()` method of the `DataProviderTimeVarying` interfaces with the data provider inputs (start time, stop time, and step size):



```
vel_result = vel_time_var.execute("1 Jul 2020 17:14:00.00", "1 Jul 2020 17:29:00.00", 1)
pos_result = pos_time_var.execute("1 Jul 2020 17:14:00.00", "1 Jul 2020 17:29:00.00", 1)
```

`vel_result` and `pos_result` now contain the data from the J2000 Cartesian Velocity and Cartesian Position data providers, more data than the original report contained.

## Retrieve specific elements

Recall that the original Cartesian Position Velocity report contained only four elements of the Cartesian Velocity J2000 group: `x`, `y`, `z`, and `speed`. Similarly, the Cartesian Position J2000 data provider contained within your report style only contains three elements: `x`, `y`, and `z`.

When the J2000 data provider of Cartesian Velocity was executed, seven elements were retrieved instead of the four specifically contained in the report, adding the `time`, `radial`, and `intrack` elements to the `DataProviderResult`. To be precise as possible, `DataProviderResult` should contain only the elements which were contained in the original report. To do this, use the `DataProviderTimeVarying.execute_elements()` method.

First, specify in an array the elements to retrieve from the data provider. Next, pass the array into `DataProviderTimeVarying.execute_elements()`:

```
vel_elems = ["x", "y", "z", "speed"]
pos_elems = ["x", "y", "z"]

vel_result = vel_time_var.execute_elements(
    "1 Jul 2020 17:14:00.00", "1 Jul 2020 17:29:00.00", 60, vel_elems
)
pos_result = pos_time_var.execute_elements(
    "1 Jul 2020 17:14:00.00", "1 Jul 2020 17:29:00.00", 60, pos_elems
)
```

The original data from the J2000 Position Velocity report is now stored in `DataProviderResult` objects and ready to traverse.

## Traverse the result data

Review the original report. The data in the report consisted of time intervals with various elements.

Satellite-LEO: J2000 Position & Velocity						
Time (UTCG)	x (km)	y (km)	z (km)	vx (km/sec)	vy (km/sec)	vz (km/sec)
1 Jul 2020 17:14:00.000	3754.865409	4852.230856	2637.118756	-6.388884	3.819334	2.069346
1 Jul 2020 17:15:00.000	3362.013168	5069.855625	2755.174269	-6.675307	3.420148	1.852083
1 Jul 2020 17:16:00.000	2952.905510	5262.983988	2859.878049	-6.929454	3.004438	1.625844
1 Jul 2020 17:17:00.000	2529.520484	5430.682790	2950.722693	-7.150097	2.574210	1.391726
1 Jul 2020 17:18:00.000	2093.905173	5572.141748	3027.267964	-7.336169	2.131544	1.150864
1 Jul 2020 17:19:00.000	1648.165795	5686.677360	3089.142920	-7.486770	1.678580	0.904425
1 Jul 2020 17:20:00.000	1194.457514	5773.736214	3136.047710	-7.601173	1.217504	0.653603
1 Jul 2020 17:21:00.000	734.974027	5832.897659	3167.755031	-7.678824	0.750546	0.399613
1 Jul 2020 17:22:00.000	271.936953	5863.875838	3184.111227	-7.719347	0.279961	0.143687
1 Jul 2020 17:23:00.000	-192.414906	5866.521068	3185.037037	-7.722547	-0.191976	-0.112935
1 Jul 2020 17:24:00.000	-655.836394	5840.820564	3170.527972	-7.688409	-0.662986	-0.369010
1 Jul 2020 17:25:00.000	-1116.086851	5786.898503	3140.654345	-7.617096	-1.130792	-0.623297
1 Jul 2020 17:26:00.000	-1570.940951	5705.015421	3095.560925	-7.508955	-1.593135	-0.874563
1 Jul 2020 17:27:00.000	-2018.199457	5595.566954	3035.466237	-7.364508	-2.047780	-1.121591
1 Jul 2020 17:28:00.000	-2455.699861	5459.081929	2960.661505	-7.184453	-2.492531	-1.363184
1 Jul 2020 17:29:00.000	-2881.326833	5296.219808	2871.509235	-6.969661	-2.925239	-1.598171

Figure 3: Original report

Similarly, the result needs to be cast to the appropriate interface to make use of the data. In the case of the J2000 Cartesian Velocity and Position data providers, that interface is the `DataProviderResultIntervalCollection`. Since each data provider result shares the same result type, consolidate the data traversal into one method, which takes a `DataProviderResult`:

```
def write_interval_data(result: DataProviderResult):
    """Traverse and write the data stored in a DataProviderResult."""
    intervals = result.intervals

    # iterate through the intervals
    for interval in intervals:
        print(f"Interval from {interval.start_time} to {interval.stop_time}:")

        # iterate through the datasets stored in the interval
        for data_set in interval.data_sets:
            print(
                f"\tFound {data_set.count} values for {data_set.element_name} (element type -
            )

            # get the values stored in the datasets
            values = data_set.get_values()

            # iterate through the array of values
            for value in values:
                print(f"\t\t{str(value)}")
```

**Note:** the type of data returned by the `DataProvider` can be determined using the `DataProviderResult.category` property, which returns an enumeration describing the interface. The `DataProviderResult.value` property is then cast to one of three interfaces, depending on the category enumeration: `DataProviderResultIntervalCollection`, `DataProviderResultSubSectionCollection`, or `DataProviderResultTextMessage`.

## Complete the output

Finally, call the method with `DataProviderResult` arguments. The data from the J2000 Position Velocity report is traversed and output:

```
print("Position Results:")
write_interval_data(pos_result)
print("Velocity Results:")
write_interval_data(vel_result)
```

Position Results:

Interval from 1 Jul 2020 17:14:00.000 to 1 Jul 2020 17:29:00.000:

Found 16 values for x (element type 0, Distance dimension):

```
6678.136999999842
6662.055595999814
6613.888738883715
6533.868407417515
6422.379991449177
6279.960435813884
6107.295654327432
5905.217226323169
5674.698391641722
5416.849363363476
5132.911980855586
4824.253728889795
4492.361151630885
4138.832693218803
3765.3709994230403
3373.77471744714
```

Found 16 values for y (element type 0, Distance dimension):

```
1.2844455118041068e-07
407.04478219807294
812.1291759033289
1213.3022344024714
1608.6318484279448
1996.2140516114755
```

2374.1821902710767  
2740.715913492852  
3094.049940212913  
3432.4825610729454  
3754.3838341085398  
4058.203434790289  
4342.478122619497  
4605.838788311895  
4847.017047632431  
5064.851350122475

Found 16 values for z (element type 0, Distance dimension):

-0.0014439285727015064  
221.00581861546254  
440.9486841830188  
658.7678751383198  
873.4143417791785  
1083.8543147167877  
1289.0742836632373  
1488.0858786481817  
1679.9306301559957  
1863.6845852578706  
2038.4627575068937  
2203.423389164732  
2357.7720052324125  
2500.7652397603797  
2631.7144160097528  
2749.988863222182

Velocity Results:

Interval from 1 Jul 2020 17:14:00.000 to 1 Jul 2020 17:29:00.000:

Found 16 values for x (element type 0, Rate dimension):

7.969357629372144e-07  
-0.5358323531434941  
-1.0690848547132925  
-1.597188484213541  
-2.1175998158204066  
-2.627812470963073  
-3.1253691894177638  
-3.6078736638386957  
-4.073002080732068  
-4.5185143122870635  
-4.942264705167773  
-5.342212414297114  
-5.716431231872658

```

-6.063118864269918
-6.380605612157488
-6.6673624120176225
Found 16 values for y (element type 0, Rate dimension):
6.789530475108605
6.7731807795289605
6.724210435379403
6.642855291139251
6.529507165313793
6.384711959378201
6.20916702863432
6.003717823643776
5.7693538184117195
5.507203744933367
5.218530157050754
4.9047233498069955
4.567294663576756
4.207869205226281
3.8281780213560204
3.4300497613226204
Found 16 values for z (element type 0, Rate dimension):
3.686413846300054
3.6775368027751996
3.650948193658638
3.6067760736564716
3.545233182285063
3.466615919285813
3.3713029171197983
3.2597532174173915
3.1325040601653185
2.9901682962787737
2.8334314360200348
2.6630483474788242
2.4798396210150284
2.284687617173175
2.0785322171024756
1.8623662959490732
Found 16 values for speed (element type 0, Rate dimension):
7.725760229169805
7.725760229169805
7.725760229169805
7.725760229169806
7.725760229169804

```

```
7.725760229169806
7.725760229169804
7.725760229169804
7.725760229169803
7.725760229169802
7.7257602291698015
7.725760229169803
7.7257602291698015
7.725760229169802
7.725760229169805
7.725760229169806
```

As previously noted, it is up to you to decide in what unit the data is returned. Issuing the following command before calling `write_interval_data()` changes the data that is output to be displayed in meters per second, rather than kilometers per second.

```
root.units_preferences.set_current_unit("DistanceUnit", "m")
```

```
write_interval_data(pos_result)
write_interval_data(vel_result)
```

Interval from 1 Jul 2020 17:14:00.000 to 1 Jul 2020 17:29:00.000:

Found 16 values for x (element type 0, Distance dimension):

```
6678136.999999843
6662055.595999814
6613888.738883715
6533868.407417515
6422379.991449177
6279960.435813884
6107295.654327433
5905217.226323169
5674698.391641722
5416849.3633634765
5132911.980855586
4824253.728889795
4492361.151630885
4138832.693218803
3765370.99942304
3373774.7174471403
```

Found 16 values for y (element type 0, Distance dimension):

```
0.00012844455118041069
407044.78219807293
```

812129.1759033289  
1213302.2344024715  
1608631.8484279448  
1996214.0516114754  
2374182.1902710767  
2740715.913492852  
3094049.940212913  
3432482.5610729456  
3754383.83410854  
4058203.434790289  
4342478.122619498  
4605838.788311895  
4847017.047632431  
5064851.350122475

Found 16 values for z (element type 0, Distance dimension):

-1.4439285727015063  
221005.81861546254  
440948.6841830188  
658767.8751383198  
873414.3417791785  
1083854.3147167878  
1289074.2836632372  
1488085.8786481817  
1679930.6301559957  
1863684.5852578706  
2038462.7575068937  
2203423.389164732  
2357772.0052324124  
2500765.23976038  
2631714.4160097525  
2749988.863222182

Interval from 1 Jul 2020 17:14:00.000 to 1 Jul 2020 17:29:00.000:

Found 16 values for x (element type 0, Rate dimension):

0.0007969357629372144  
-535.8323531434941  
-1069.0848547132925  
-1597.1884842135412  
-2117.5998158204065  
-2627.812470963073  
-3125.3691894177637  
-3607.873663838696  
-4073.002080732068  
-4518.514312287063

-4942.264705167773  
-5342.212414297114  
-5716.431231872658  
-6063.118864269918  
-6380.605612157488  
-6667.362412017623

Found 16 values for y (element type 0, Rate dimension):

6789.530475108605  
6773.180779528961  
6724.210435379403  
6642.855291139252  
6529.507165313793  
6384.711959378201  
6209.16702863432  
6003.717823643777  
5769.35381841172  
5507.2037449333675  
5218.5301570507545  
4904.723349806995  
4567.294663576756  
4207.869205226281  
3828.1780213560205  
3430.0497613226203

Found 16 values for z (element type 0, Rate dimension):

3686.413846300054  
3677.5368027751997  
3650.948193658638  
3606.7760736564715  
3545.2331822850633  
3466.6159192858127  
3371.302917119798  
3259.7532174173916  
3132.5040601653186  
2990.1682962787736  
2833.4314360200347  
2663.0483474788243  
2479.8396210150286  
2284.687617173175  
2078.5322171024754  
1862.3662959490732

Found 16 values for speed (element type 0, Rate dimension):

7725.760229169805  
7725.760229169805



7725.760229169805  
7725.760229169806  
7725.760229169804  
7725.760229169806  
7725.760229169804  
7725.760229169804  
7725.760229169803  
7725.760229169802  
7725.760229169801  
7725.760229169803  
7725.760229169801  
7725.760229169802  
7725.760229169805  
7725.760229169806