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`.

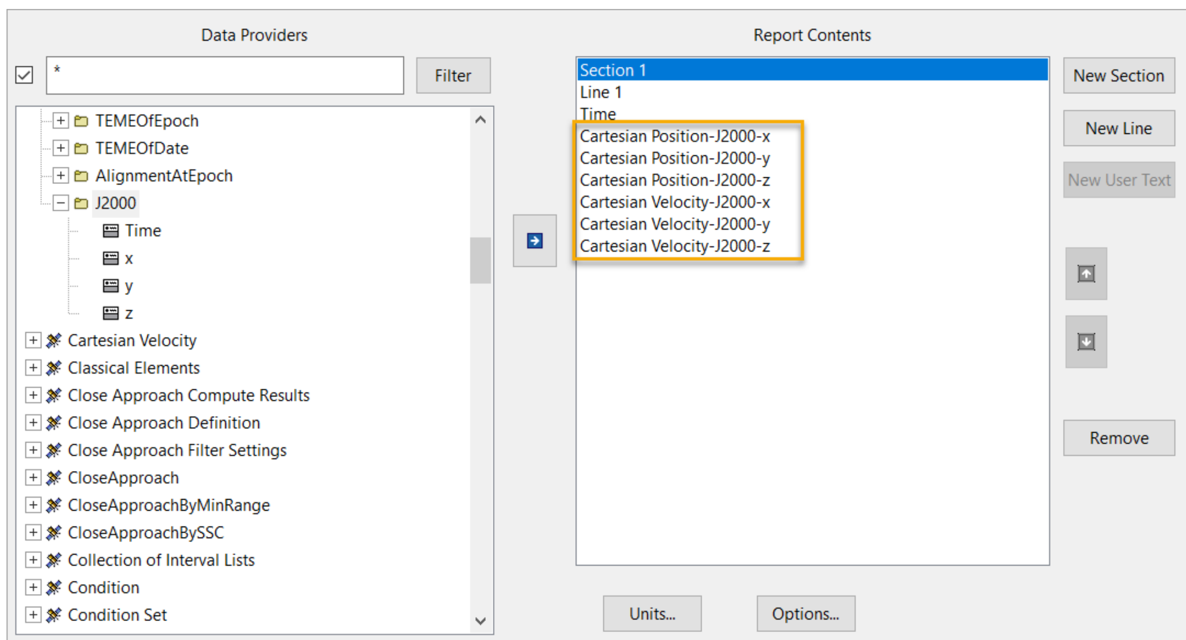


Figure 1: The J2000 Position Velocity report contents

Launch a new STK instance

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

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


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

```
Using STK Engine v13.1.0
```

Create an STK scenario using the STK Root object:

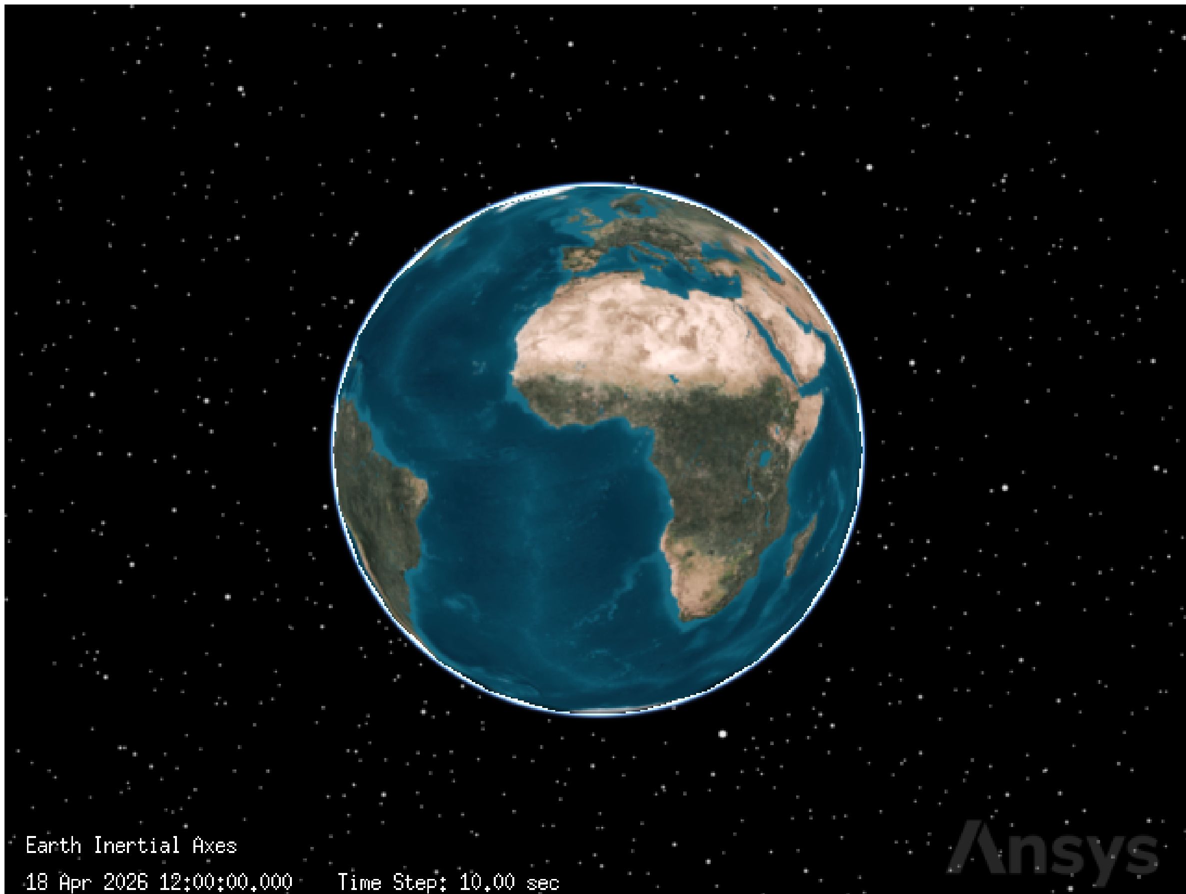
```python
root = stk.new_object_root()
root.new_scenario("GraphsAndResults")
```

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

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


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

```
RFBOutputContext()
```

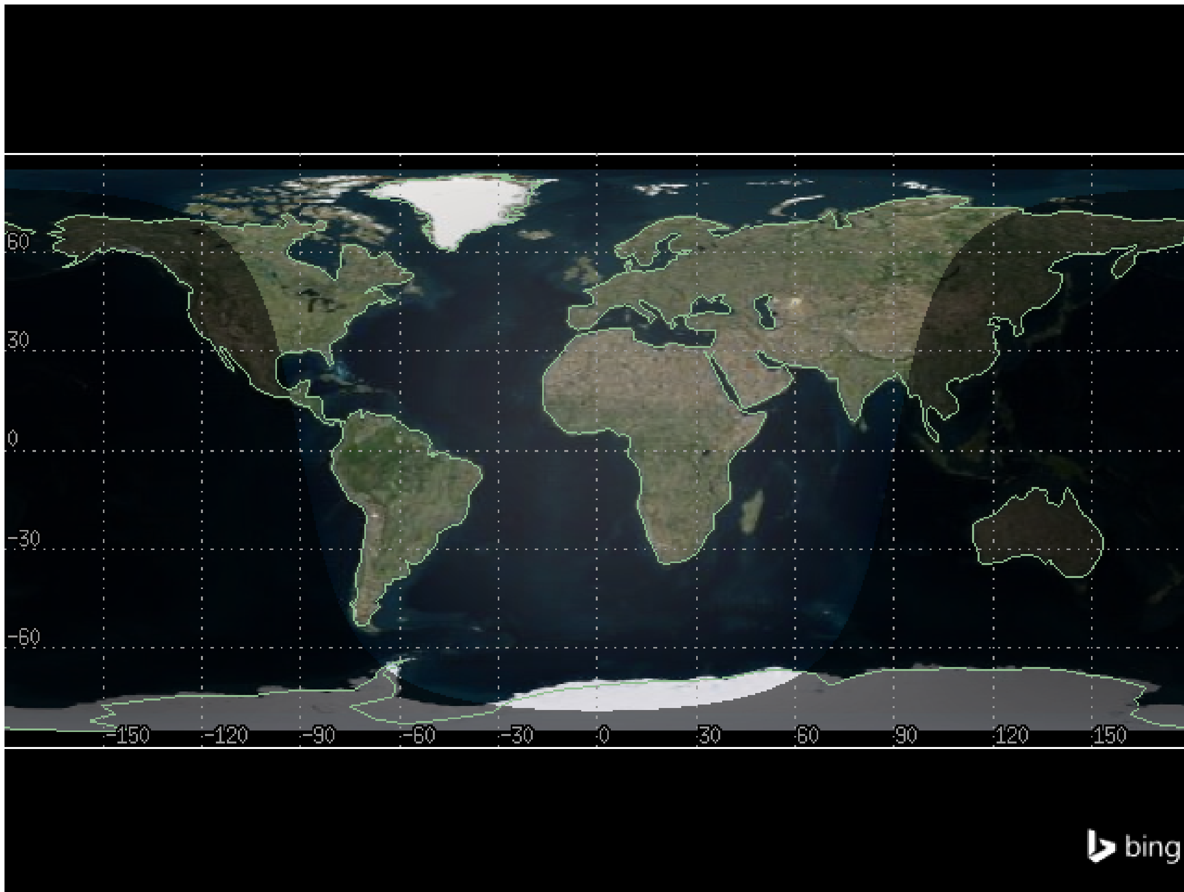


Show a 2D graphics window by running:

```
from ansys.stk.core.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
```

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

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

```python
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:

```python
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.

```python
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))
```

```python
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:
    Access Listing
    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
    ...and 151 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.

```python
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.

```python
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.

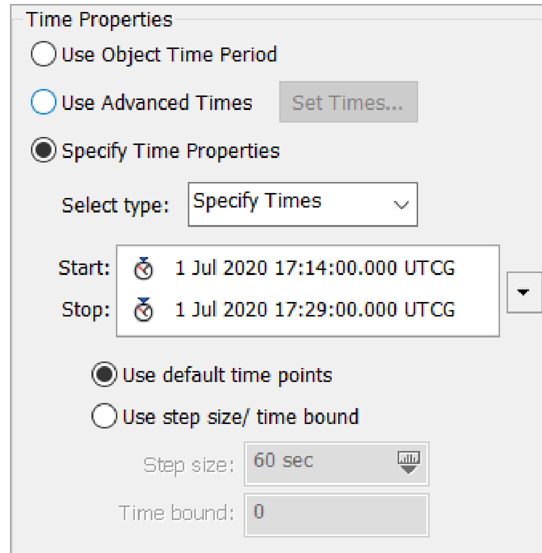


Figure 2: Report time properties

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`:

```python
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):
        6678.136999999843
        6662.0555962110375
        6613.888739305161
        6533.8684080471585
        6422.379992283994
        6279.96043684986
        6107.295655559587
        5905.2172277455775
        5674.698393247611
        5416.849365144897
        5132.911982804197
        4824.253730996136
        4492.361153884821
        4138.832695609372
        3765.3710019389473
        3373.774720076172
    Found 16 values for y (element type 0, Distance dimension):
        1.1889069058033974e-07
        407.04478176122734
        812.129175041251
        1213.3022331192808
        1608.6318467297879
        1996.2140495065125
```

```
        2374.1821877694038
        2740.7159106064864
        3094.049936955603
        3432.4825574607376
        3754.3838301584196
        4058.203430521383
        4342.478118052342
        4605.8387834685645
        4847.017042536039
        5064.851344797643
    Found 16 values for z (element type 0, Distance dimension):
        -0.0014502934943832727
        221.00581305277632
        440.94867944942007
        658.7678712566681
        873.4143387682304
        1083.854312591107
        1289.0742824331235
        1488.0858783196206
        1679.9306307306301
        1863.6845867329937
        2038.4627598754578
        2203.423392415386
        2357.7720093495554
        2500.7652447242353
        2631.7144217964624
        2749.9888698039244
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):
        8.004589941580925e-07
        -0.5358323496286873
        -1.0690848512238271
        -1.5971884807662238
        -2.11759981243184
        -2.627812467649594
        -3.125369186195321
        -3.607873660722812
        -4.073002077737629
        -4.518514309428885
        -4.942264702459237
        -5.342212411751398
        -5.716431229502031
```

```
    -6.063118862085906
    -6.380605610170424
    -6.667362410237169
Found 16 values for y (element type 0, Rate dimension):
    6.789530467981203
    6.773180772419215
    6.724210428321562
    6.64285528416731
    6.529507158461344
    6.384711952678248
    6.209167022119151
    6.003717817344789
    5.769353812359358
    5.5072037391565125
    5.2185301515775535
    4.904723344663729
    4.567294658788225
    4.207869200815429
    3.8281780173443996
    3.430049757729453
Found 16 values for z (element type 0, Rate dimension):
    3.6864138594270974
    3.6775368163818443
    3.6509482076793662
    3.6067760880237647
    3.5452331969297295
    3.46661593413732
    3.3713029321066124
    3.2597532324673226
    3.1325040752058664
    2.990168311237481
    2.8334314508248304
    2.663048362058375
    2.4798396352990832
    2.284687631092899
    2.0785322305907865
    1.862366308940962
Found 16 values for speed (element type 0, Rate dimension):
    7.725760229169806
    7.725760229169804
    7.725760229169806
    7.725760229169805
    7.725760229169806
```

```
        7.725760229169807
        7.725760229169802
        7.725760229169804
        7.725760229169804
        7.725760229169806
        7.725760229169802
        7.725760229169803
        7.725760229169802
        7.725760229169803
        7.725760229169806
        7.725760229169804
```

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 then 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):
        6678136.999999844
        6662055.596211038
        6613888.739305161
        6533868.408047158
        6422379.992283994
        6279960.4368498605
        6107295.655559587
        5905217.227745578
        5674698.393247612
        5416849.365144897
        5132911.982804197
        4824253.730996137
        4492361.153884821
        4138832.6956093726
        3765371.0019389475
        3373774.7200761717
    Found 16 values for y (element type 0, Distance dimension):
        0.00011889069058033975
        407044.78176122735
```

```
        812129.175041251
        1213302.2331192808
        1608631.8467297878
        1996214.0495065125
        2374182.1877694037
        2740715.9106064863
        3094049.936955603
        3432482.5574607374
        3754383.8301584194
        4058203.430521383
        4342478.118052342
        4605838.783468565
        4847017.042536039
        5064851.344797643
    Found 16 values for z (element type 0, Distance dimension):
        -1.4502934943832726
        221005.81305277633
        440948.6794494201
        658767.871256668
        873414.3387682304
        1083854.3125911069
        1289074.2824331236
        1488085.8783196206
        1679930.6307306301
        1863684.5867329936
        2038462.7598754577
        2203423.392415386
        2357772.0093495552
        2500765.2447242355
        2631714.4217964625
        2749988.8698039246
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):
        0.0008004589941580924
        -535.8323496286873
        -1069.0848512238272
        -1597.1884807662238
        -2117.59981243184
        -2627.812467649594
        -3125.369186195321
        -3607.873660722812
        -4073.002077737629
        -4518.514309428885
```

```
    -4942.264702459237
    -5342.212411751399
    -5716.431229502031
    -6063.118862085906
    -6380.6056101704235
    -6667.36241023717
Found 16 values for y (element type 0, Rate dimension):
    6789.530467981203
    6773.180772419215
    6724.210428321561
    6642.85528416731
    6529.507158461344
    6384.711952678248
    6209.167022119151
    6003.717817344789
    5769.353812359358
    5507.203739156513
    5218.530151577554
    4904.723344663729
    4567.294658788225
    4207.8692008154285
    3828.1780173443994
    3430.0497577294527
Found 16 values for z (element type 0, Rate dimension):
    3686.4138594270976
    3677.5368163818443
    3650.948207679366
    3606.7760880237647
    3545.2331969297293
    3466.61593413732
    3371.3029321066124
    3259.7532324673225
    3132.5040752058662
    2990.168311237481
    2833.4314508248303
    2663.048362058375
    2479.839635299083
    2284.687631092899
    2078.5322305907866
    1862.366308940962
Found 16 values for speed (element type 0, Rate dimension):
    7725.760229169806
    7725.760229169804
```

```
7725.760229169806
7725.760229169805
7725.760229169806
7725.760229169807
7725.760229169802
7725.760229169804
7725.760229169804
7725.760229169806
7725.760229169802
7725.760229169803
7725.760229169802
7725.760229169803
7725.760229169806
7725.760229169804
```