Transportability

User Tutorial for the Transportability Test Bench

May 2, 2014

1.0 Purpose

The purpose of the Transportability Test Bench is to provide the designer with information about what types of transports the design will fit into.

2.0 Procedures

2.1 Installation

Initial installations will be provided with the installation of the CyPhy tool suite. Future version may be packaged as a standalone or combined package for test benches.

2.2 Tool

The Transportability Test Bench in GME allows the user to interface with the Transportability Tool which is a software application that accepts a design, analyzes it and returns a list of transports the vehicle will fit in.
Transportability analysis is an automated process to estimate in what the design can be carried. Specifically the tool collects information on the total mass, center of gravity, and the hull geometry to determine the overall dimensions of the vehicle, mass, and center of gravity.

3.0 Requirements tested

- **Container Fit:** Based on container dimensions supplied by MIL-STD-1366D, determines if the vehicle can fit into or onto transports for road, MPF water, well deck water, rail, highways, the C5 aircraft, and the C17 aircraft.

4.0 Required Components

4.1 Explicit requirements

```
parts_of_interest = {
"Eye_Welded": {"Datum": ["INT_LOAD_LOCATION"],
                                "PrimitiveProperty": ["load_rating.x",
                                                      "load_rating.y",
```

```
                                        "load_rating.z"],
                "Required": "{4}"},
"Ring_Hoist": {"Datum": ["INT_LOAD_LOCATION"],
                "PrimitiveProperty": ["load_rating.x",
                                      "load_rating.y",
                                      "load_rating.z"],
                "Required": "{4}"},
"Eye_Bolted": {"Datum": ["INT_LOAD_LOCATION"],
                "PrimitiveProperty": ["load_rating.x",
                                      "load_rating.y",
                                      "load_rating.z"],
                "Required": "{*}"},
"D_Ring_Lashing": {"Datum": ["INT_LOAD_LOCATION"],
                   "PrimitiveProperty": ["load_rating.x",
                                         "load_rating.y",
                                         "load_rating.z"],
                   "Required": "{*}"},
"Pintle_Tow": {"Datum": ["INT_LOAD_LOCATION"],
                "PrimitiveProperty": ["load_rating.x",
                                      "load_rating.y",
                                      "load_rating.z"],
                "Required": "{*}"},
"Cleat_Mooring": {"Datum": ["INT_LOAD_LOCATION"],
                  "PrimitiveProperty": ["load_rating.x",
                                        "load_rating.y",
                                        "load_rating.z"],
                  "Required": "{*}"},
"Drawbar_Bolted": {"Datum": ["INT_LOAD_LOCATION"],
                   "PrimitiveProperty": ["load_rating.x",
                                         "load_rating.y",
                                         "load_rating.z"],
                   "Required": "{*}"},
"Drawbar_Eyebolt": {"Datum": ["INT_LOAD_LOCATION"],
                    "PrimitiveProperty": ["load_rating.x",
                                          "load_rating.y",
                                          "load_rating.z"],
                    "Required": "{*}"},
"Drawbar_Welded": {"Datum": ["INT_LOAD_LOCATION"],
                   "PrimitiveProperty": ["load_rating.x",
                                         "load_rating.y",
                                         "load_rating.z"],
                   "Required": "{*}"}}
```

4.2 Implicit requirements

In addition to the properties (such as lift eye location) that are explicitly requested, the transportability test bench requires a reasonably complete vehicle model. (the calculation of vehicle dimensions is not very useful if there are no wheels!)
Certain calculations- such as approach angles or lifting- require the geometry of specific parts. Lift and tie down tests require that the assembly contain exactly 4 of exactly the classes specified:

- wheel_set = {"Roadwheel", "Sprocket_And_Carrier_Drive", "Wheel_Idler"}
- track_set = {"Track"}
- lift_set = {"Eye_Welded"}
- tie_down_set = {"Ring_Hoist"}

4.3 Manually specified information

The settings.js file contains information on transport vehicle dimensions, which should not normally need to be changed.

5.0 Requirements to run the Test Bench

The Test Bench requires that there be at least four (4) components of the class "Eye_Welded" and four (4) components of class "D_Ring_Lashing" or the Test Bench will fail.
For accurate results regarding container fitting and calculated approach angles, the geometry must include a hull, suspension, road wheels, and tracks. Without these components the vehicle dimensions will not be accurate and results will be unreliable.

6.0 Theory of Operation

The system (design) is assembled into a 3D CAD representation with the customization / generation of parameterized components. The data is analyzed to determine the designs overall dimensions and using those dimension the transportability of the design is determined.

7.0 Test Bench Structure

The test bench contains a system under test that is assembled and analyzed for the specific metrics that correspond to the vehicle requirements as outlined in Table 1 below.

Step 1

In the GME Browser, insert a new Test Bench subfolder ("Transportability") within the "Testing" Test Bench folder.

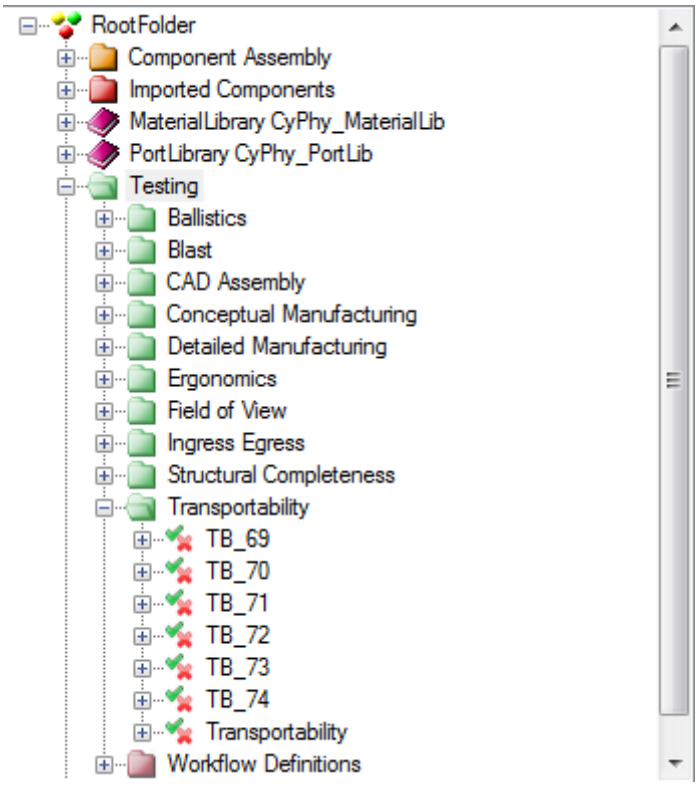

Figure 1: Transportability Test Bench and Mode

Step 2

An assembly now needs to be added to the test bench. In the “Transportability” test bench Cop/Paste…As Reference the assembly to be tested.

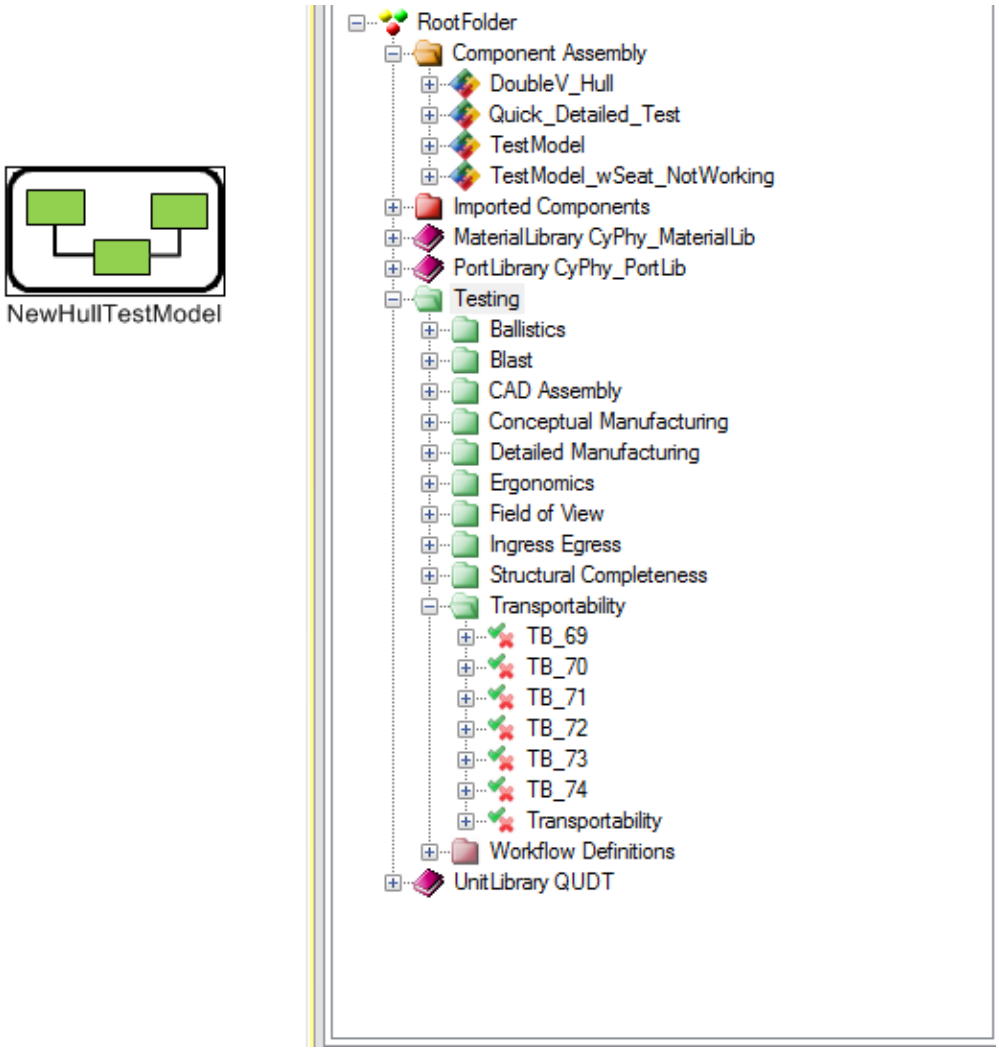

Figure 2: Copy/Paste... As Reference

Step 3

In GME, within the Workflow Definition subfolder create a new workflow model named “Transportability”.

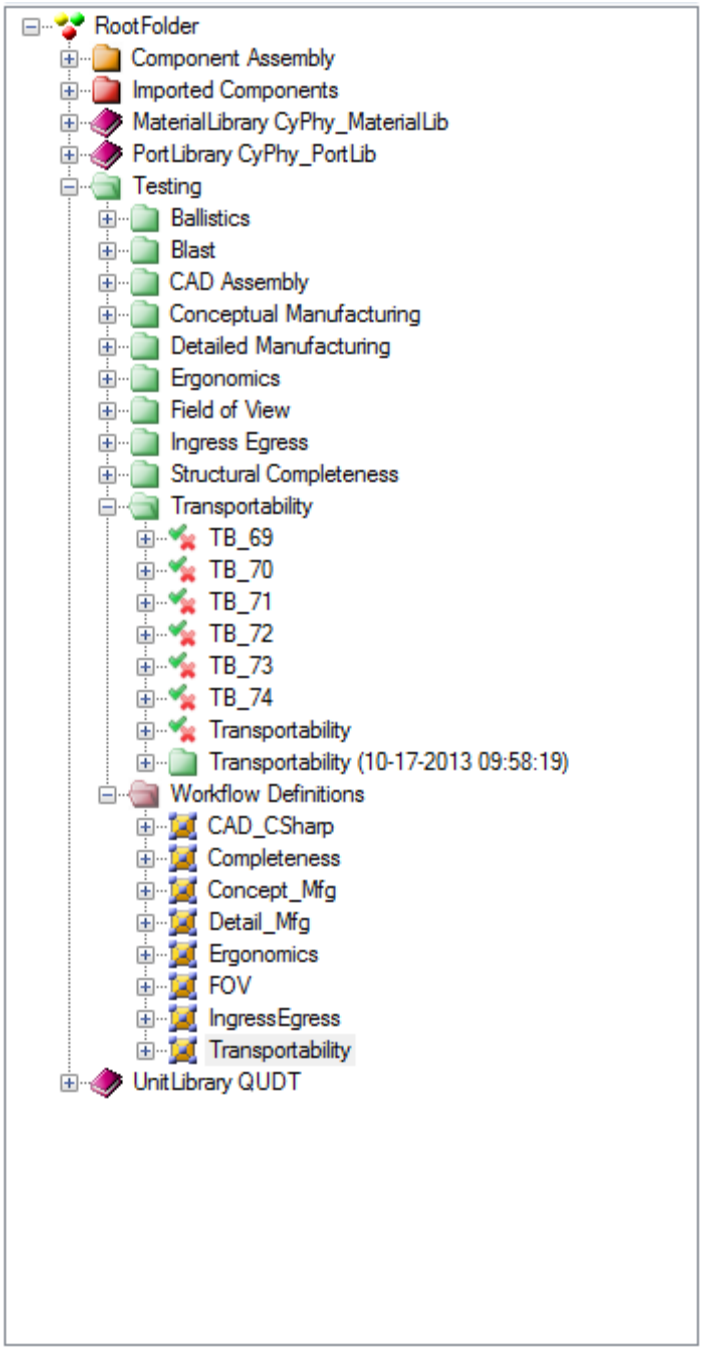

Figure 3: Workflow Definition

Step 4

Open the "Transportability" Workflow Model and drag a "Task" element into the workspace. Select "CyPhyCADAnalysis" as the interpreter from the window that pops up.

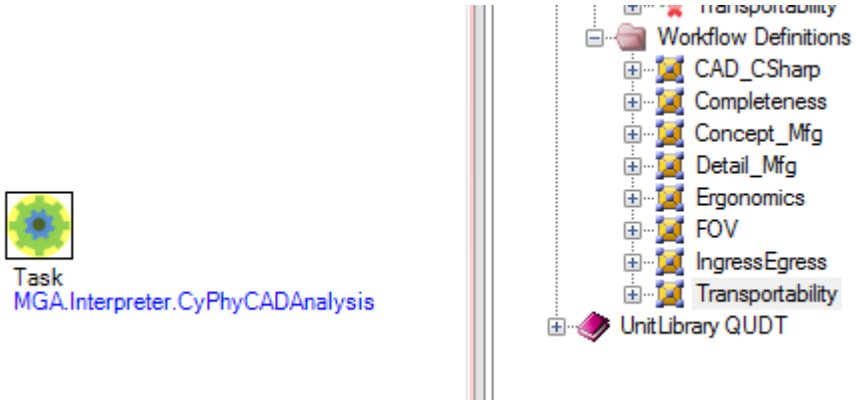

Figure 4: Transportability Workflow Model with Task

Step 5

Double click the newly created task and select "transportability" as the analysis tool.

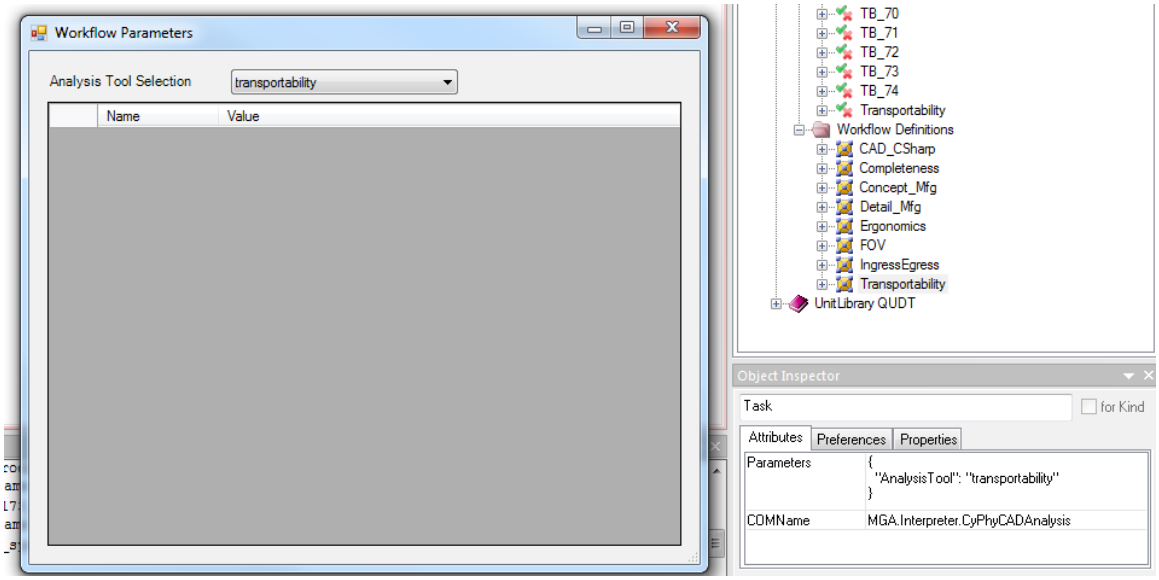

Figure 5: Setting up Task Parameters

Step 6

Open the “Transportability” test bench drag and drop the “transportability” workflow definition and 10 metrics. Metrics can be dragged and dropped from the Part Browser.

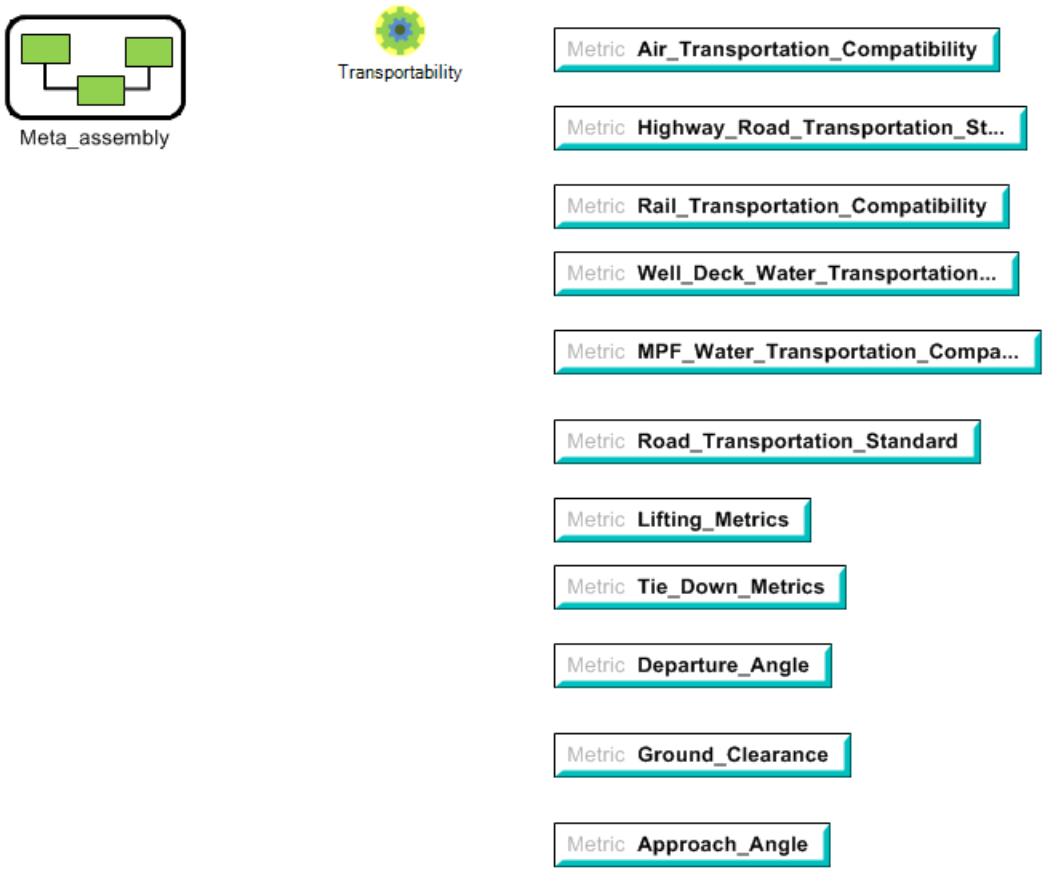

Figure 6: Transportability with Metrics added

Step 7

To exercise the test bench, run the Master Interpreter. For the transportability test bench, there is no need to check the box for any of the STEP file formats. However, the "Use Project Manifest" box must be checked.

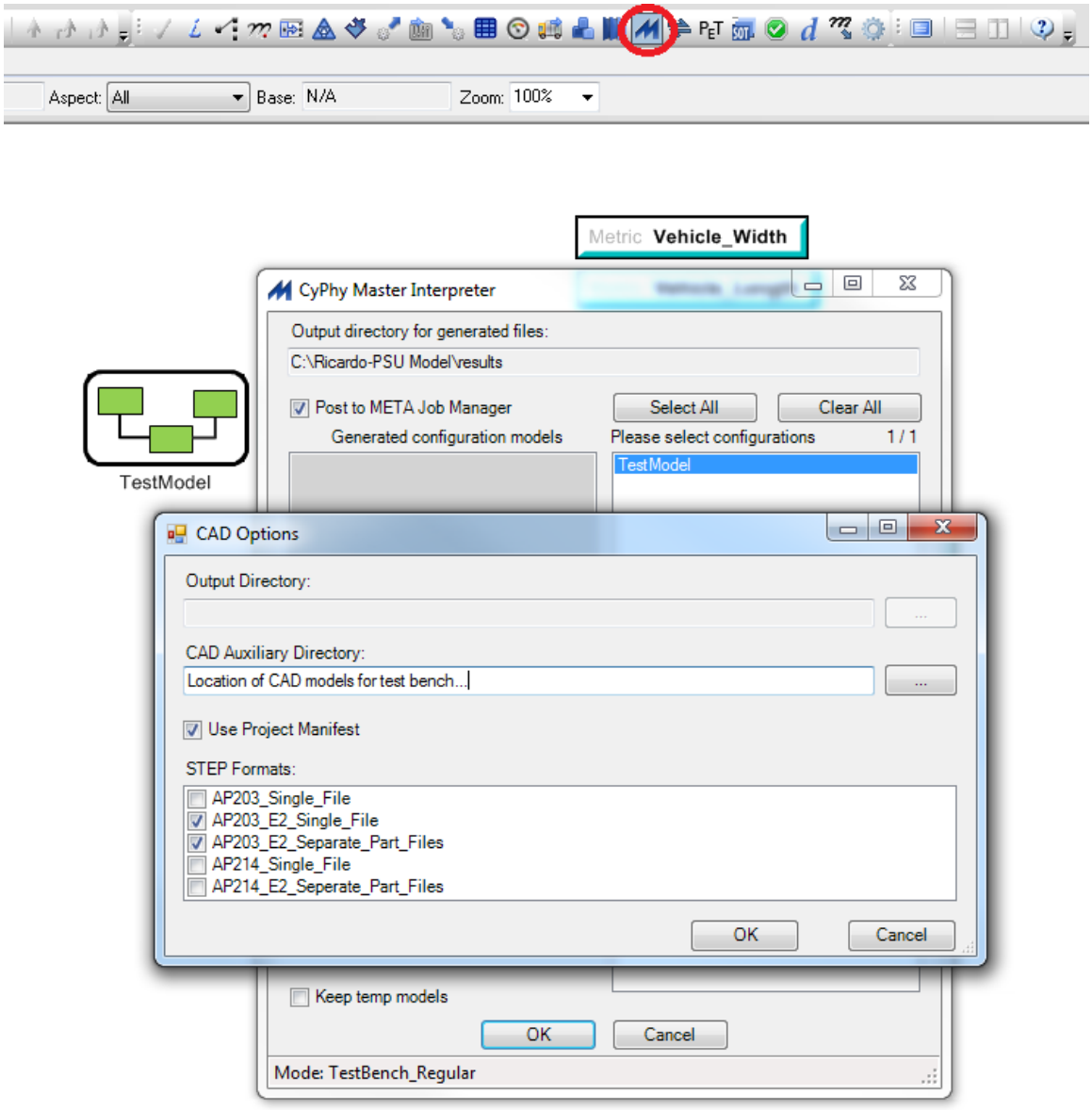

Figure 7: Running the test bench

The test bench will create a results folder and then run. To access the results folder right click the job in Job Manager and choose "Show in explorer".

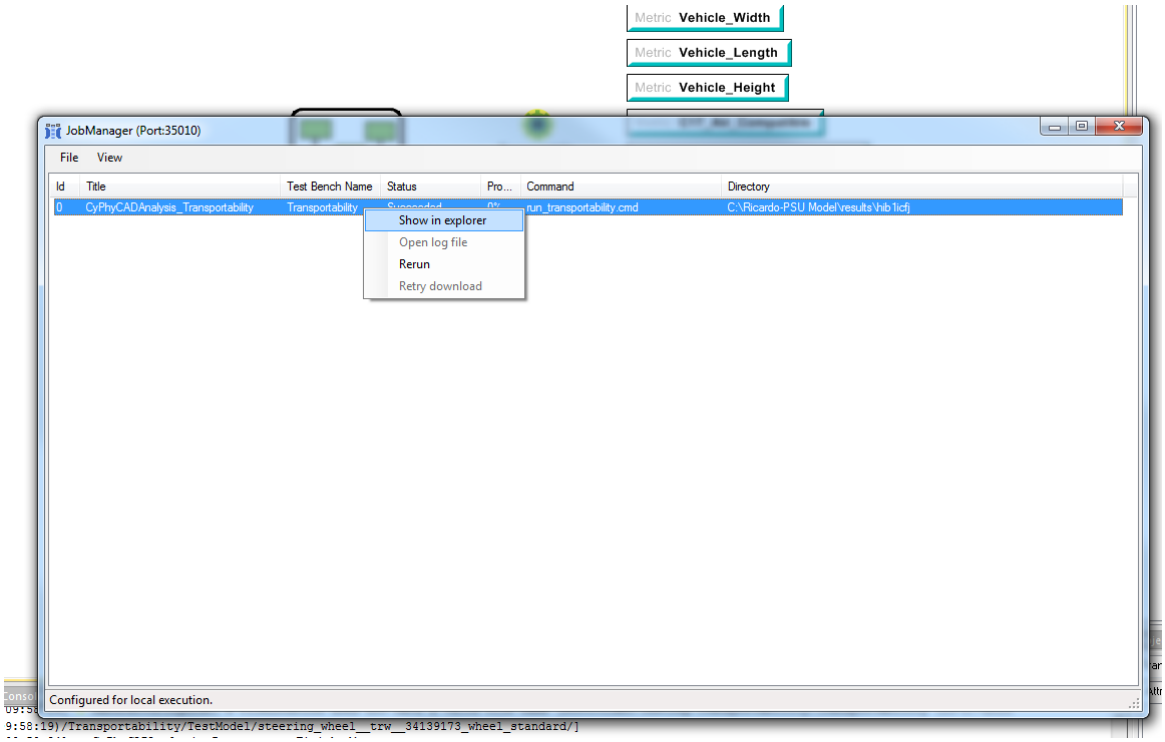

Figure 8: Viewing result of the test bench.

8.0 Description

Transportability analysis calculates the vehicle dimensions. The dimensions of the design are compared to established dimensions of various transports to determine if the design will fit.

The System Under Test is assembled in CREO and then each component making up the system is saved as an individual step file. Data about procurement for each component is also gathered. This information is packaged and analyzed by the Transportability Tool as a post-processing step.

Results are returned in a file named “summary.testresults.json”. Three image files are also generated for visual verification of the data.

8.1 Metrics

Test Bench #	Metrics	Description
69	Well_deck_Water_Compatible	True or False the design can be transported via well deck type of vessel.
70	MPF_Water_Compatible	True or False will the design fit on a MPF vessel
71	Air_Transport_Compatibility	True or false will the design fit in a C-5 Galaxy and in a C-17 Globemaster
72	Rail_Transport_Compatibility	True or False can the design be transported via rail
73	Road_Transport_Standard	True of False the design can be transported via normal roads
74	Highway_Road_Transport_Standards	True or False can the design be transported on a highway system
102	Tow_Pintle	Number of towing pintles present
104	Mooring_Bits	Number of mooring bits present
105	Tow_Eyes	Number of towing eyes present
106	Lift_Eyes	Number of lift eyes present
118	Approach_Angle	The maximum angle of approach for the design
119	Departure_Angle	The maximum angle of departure for the design
120	Ground_Clearance	The distance between the ground and lowest part of the design
	Lifting_Metrics (needed for transport)	For each lifting eye, pass if calculated load does not exceed load rating. Fail if load exceeds rating
	Tie_Down_Metrics (needed for transport)	For each tie down component, pass if calculated load does not exceed load rating. Fail if load exceeds rating.

Table 1: Transportability Metrics

8.2 Required Connection to System Under Test

NONE

8.3 Outputs

The output of the test bench is a result file test_bench_manifest.json with calculated metrics. The the vehicle height, width, and length are measured in meters. The compatibility with the various transports is reported as True of the vehicle fits and False if it does not.

```
"AnalysisStatus": "OK",
"TestBench": "Transportability",
"DesignName": "Transportability",
"Metrics": [
    {
        "Name": "C5_Air_Compatible",
        "DisplayedName": null,
        "GMEID": "id-0067-0003631f",
        "Value": "True",
        "ID": "cc63364f-1935-4e98-9059-55eca85ecae7",
        "Unit": ""
    },
    {
        "Name": "Vehicle_Width",
        "DisplayedName": null,
        "GMEID": "id-0067-00036321",
        "Value": "3.771900177",
        "ID": "c6642030-0dc6-4b3e-aee0-306680ac7857",
        "Unit": ""
    },
    {
        "Name": "MPF_Water_Compatible",
        "DisplayedName": null,
        "GMEID": "id-0067-00036320",
        "Value": "False",
        "ID": "bc221b87-1aa0-4c76-8faf-5e84316bbd51",
        "Unit": ""
    },
    {
        "Name": "Road_Compatible",
        "DisplayedName": null,
        "GMEID": "id-0067-00036322",
        "Value": "False",
        "ID": "f5982a9e-951f-486f-87d9-c3a223ba8b10",
        "Unit": ""
    },
```


Figure 9: Summary Results sample

The test bench also writes out three images to the output folder. These images can be used as visual guides for debugging purposes.

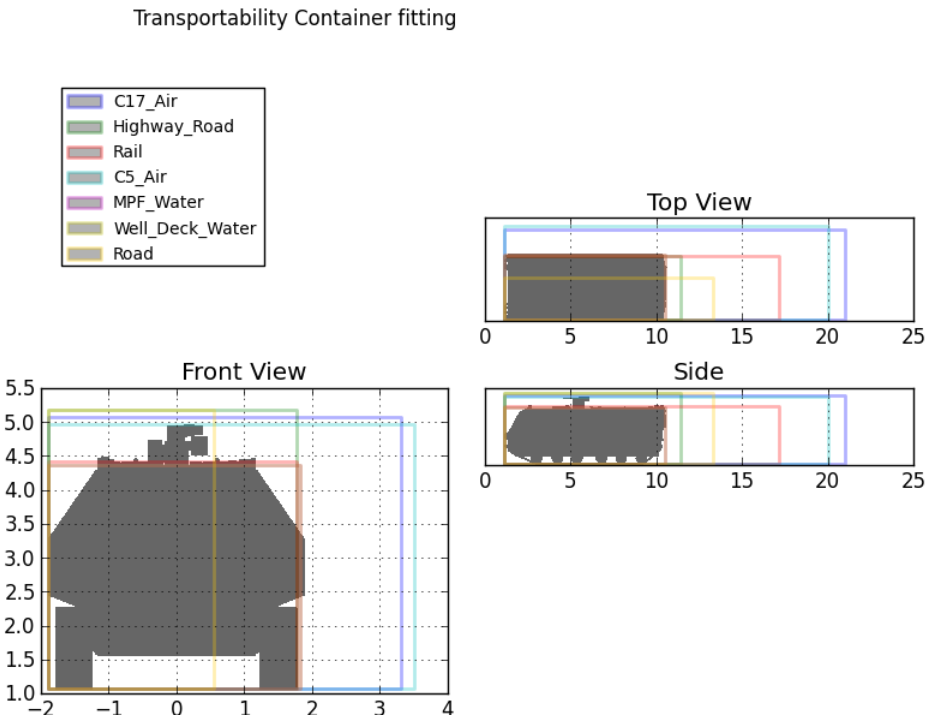

Figure 10: Transportability Container Fitting sample image.

Figure 11: Location of components recognized as lift eyes (green) and tie downs (blue) for load tests

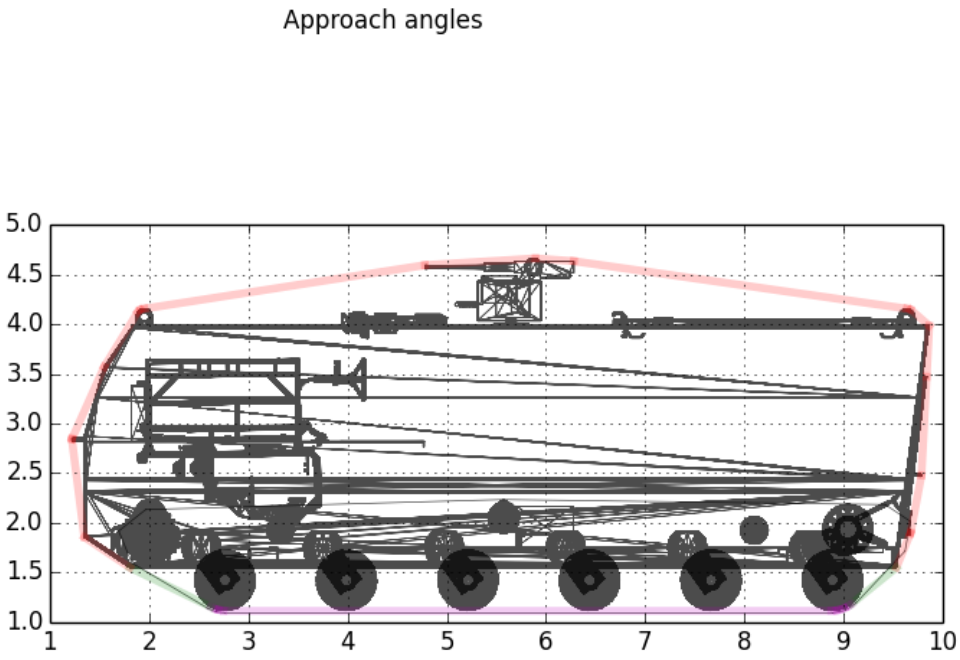

Figure 12: Approach angles

9.0 Troubleshooting

The test bench requires four (and exactly four) of each lift eye/tie down class. If a different number of these components is present, the test bench will crash immediately without evaluating any of the metrics outlined in Table 1.

The lifting and tie-down load tests also assume that one particular component class is being used for each test: Eye_Welded for lifting, and Ring_Hoist for tie-down.

Ensure that all components in the assembly are located in an appropriate position for lifting or tie-down: for example, lift eyes should not be on the bottom of the vehicle. The debugging images may be useful in validating appropriate placement.