Egress

User Tutorial for the Egress test bench

May 2, 2014

1.0 Purpose

The Ingress_Egress test bench tool evaluates whether troops and vehicle crew can reach vehicle exits and embark in a timely fashion.

2.0 Procedures

2.1 Installation

The test bench will be bundled with the CyPhy tool suite and Ricardo seed design. Future editions of the Ingress_Egress tool may be packaged as a standalone or combined test bench installation package.

2.2 Tool

The Ingress_Egress Test Bench in GME allows the user to interface with the Ingress_Egress Tool.

This test bench automatically loads in the vehicle geometry, contents, and troop locations. Using a series of spatial calculations, it determines:

1. The maximum time required for troops to exit a vehicle.
2. Whether all troops, crew, and vehicle commanders have a suitable path to at least one vehicle door and one roof hatch.
    a. In order to reach the door, the path must be wide enough to carry an unconscious soldier out. 3. Whether an open litter (with occupant) can fit in the space provided.

3.0 User's Guide

3.1 Requirements tested

This test bench satisfies the requirements of TB033 ("Embarked Troop Deployment"), TB034 ("Emergency Egress"), TB035 ("Crew Evacuation"), and TB036 ("Litter Evaluation").

3.2 Model requirements

The Ingress_Egress test bench works best if the model has certain features. It operates on the three-dimensional vehicle coordinates, and it will fail to recognize any component whose CAD model is not in the right location.

3.2.1 Preparation and setup

Simulations of exit time are based on the assumption that the vehicle interior is staged as it will appear when soldiers are being deployed. Thus:

- Any seats that fold must be in the upright position
- Any interior doors (such as between the crew compartment and the main exit door) be opened for crew to pass through
- Any other major obstacles to crew exit should be moved out of the way. For example, a litter for wounded soldiers will not be spread out in front of the exit during combat deployment.

> **NOTE:**
> Determining whether the manikin can go from interior to exterior requires a clear distinction between the two areas. Make sure that all exit doors are closed. Because troop manikins are used to locate the vehicle cabin area, make sure that troops do not collide with any objects when placed inside the vehicle.

3.2.2 Recognized component types

The Ingress_Egress test bench identifies relevant parts of the vehicle by looking at the name of the component class, which is identified in every component library component. Only certain classes are recognized at this time, and the test bench will not work with custom component types without modification.

For best results, ensure that the exit doors and ramps are in the closed position, creating a clear difference between the vehicle interior and the outside.

3.2.2.1 Exit doors/ramps

For the embarkation time metric, the tool must be able to locate exit doors that soldiers can walk to. Two component classes are recognized: *'Hatch_Assembly_Rear_Ramp*', '*Hatch_Assembly_Personnel_Door'*.

3.2.2.2 Roof hatches

For the emergency egress test, soldiers must be able to reach one of the two recognized roof hatch types: *'Hatch_Assembly_Driver_Commander*', *'Hatch_Assembly_Cargo*'.

3.2.2.3 Litters

The litter position assessment checks whether an object of class '*Litter_Open*' will collide with other objects when placed at a specific point in the vehicle. The correct litter model will include a transparent bounding box representing the area of the litter plus the area occupied by a soldier occupying the litter.

3.2.2.4 Manikins

The test bench requires several components of class '*Manikin*'. There must be at least one manikin assigned to the following vehicle roles: troop, troop_commander, driver, gunner, vehicle commander.

The total exit time is based on the slowest exit time of any single soldier out of all the troops: if using just one troop manikin, do not position the model unrealistically close to the door. Better results will be achieved by stationing the manikins near where they would sit (for most vehicles, the exiting soldiers will start from their seats).

3.3 Theory of operation & key assumptions

The system (design) is assembled into a 3D CAD representation. CyPhy generates custom geometry files for parameterized components as required.

The 3D vehicle geometry is examined to determine occupied or obstructed regions inside the vehicle; crew egress strategies are then evaluated based on available freedom of motion at a given point.

3.3.1 Embarked Troop Deployment

The Ingress_Egress tool assumes that soldiers can move faster when they adopt a more natural posture. To determine walkability, the shape of a manikin (50th percentile size by default) is compared to the available cabin volume at every point

in the vehicle. If the manikin would collide with more than a certain fraction of occupied vehicle points, then the manikin is not allowed to adopt that pose.

Each pose is assigned a score, and a path is found on the 2D grid of walkable floor space. The total exit time is the sum of movement scores at each individual point.

These times are approximations, only, and may underestimate by up to a factor of two depending on vehicle geometry and encumbrance of the soldiers.

3.3.2 Emergency Egress and crew evacuation

These tests work by checking whether a path exists from the starting position to the door and/or vehicle roof hatches, such that the path could fit a ball of a specified size. The use of a round sphere (rather than a full manikin model) allows the exiting soldier to adopt extremely constricted poses not in the list of premade models.

3.3.3 Litter

The litter placement check determines whether there is sufficient space to accommodate an open litter model (with occupant) in the area where it has been placed. This check will fail if more than 15% of the litter (or surrounding bounding box) collides with occupied vehicle areas.

3.3.4 Key assumptions

A point is considered completely walkable if less than 10% of the soldier would collide with the vehicle (this setting can be adjusted internally, though it is not recommended).

The vehicle geometry is used to determine walkable areas. Any obstacles that would not be present during embarkation should be removed or stowed.

3.4 Running the Test Bench

The test bench evaluates an assembled vehicle model for the requirements outlined in Table 1 (below).

Step 1

In the GME Browser, insert a new Test Bench subfolder (“Ingress_Egress”) within the “Test Benches” Test Bench folder. (Figure 1)

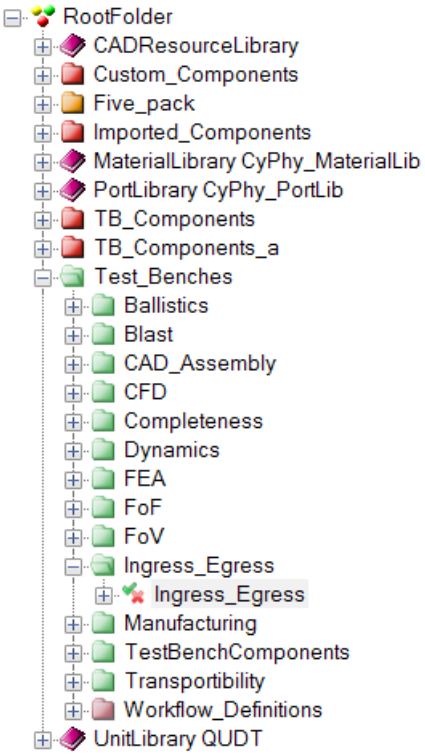


Figure 1: GME browser window showing Ingress_Egress test bench and model

Step 2

Next, create a test bench called "Ingress_Egress" by inserting a new test bench model under the Ingress_Egress test bench folder.

An assembly must now be added to the test bench. In the "Ingress_Egress" test bench workspace, Copy/Paste…As Reference the assembly to be tested.

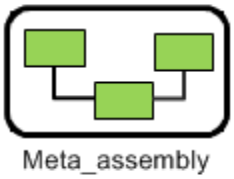


Figure 2: Assembly as seen when copied (as reference) onto the test bench canvas

Step 3

In the GME Browser, navigate to the Workflow Definition subfolder and create a new workflow model named “Ingress_Egress”.

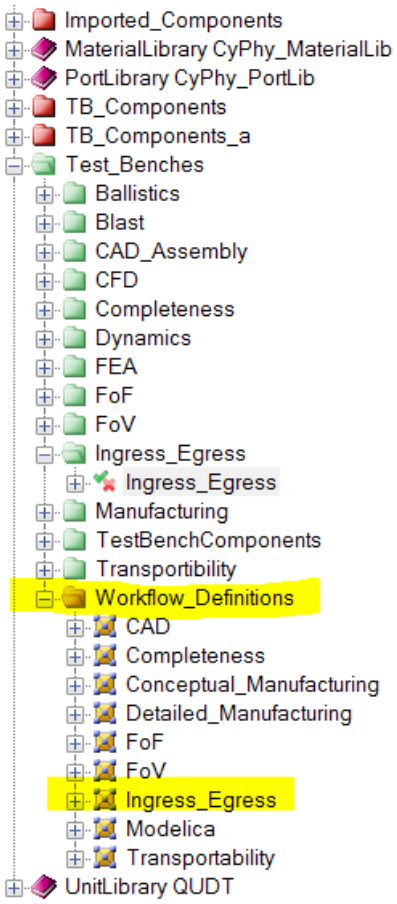


Figure 3: Workflow definition

Step 4

Double click on the “Ingress_Egress” Workflow Model and drag a “Task” element into the workspace. Select “CyPhyCADAnalysis” as the interpreter from the window that pops up.

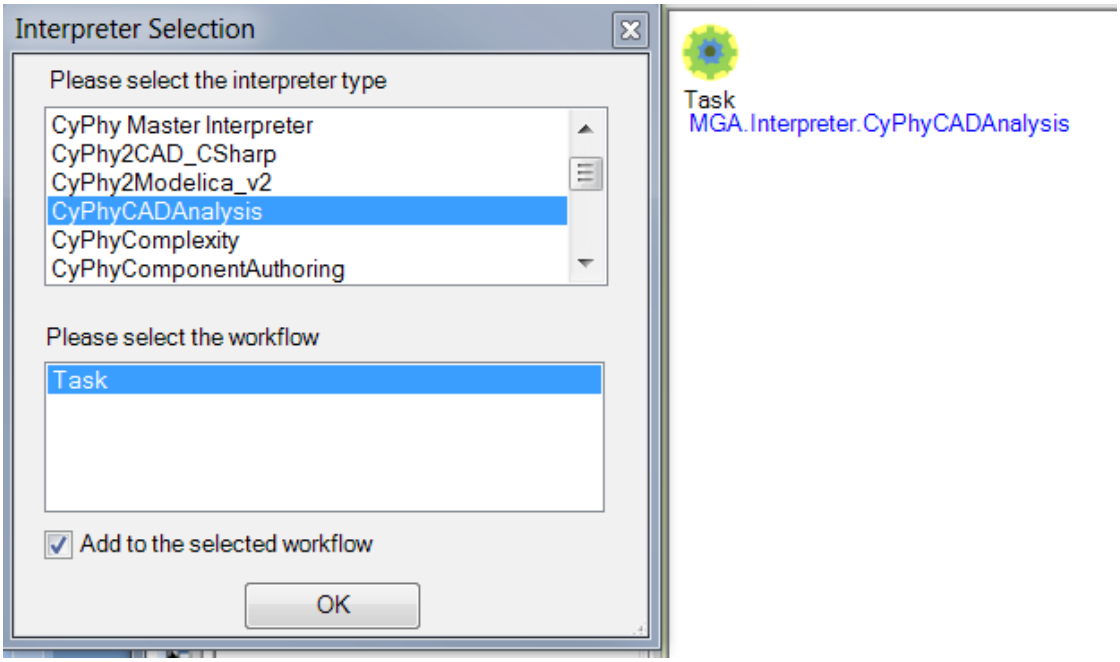


Figure 4: Interpreter selection (left) and resulting task in the workspace (right)

Step 5

Double click the newly created task and select “Ingress_Egress” as the analysis tool.

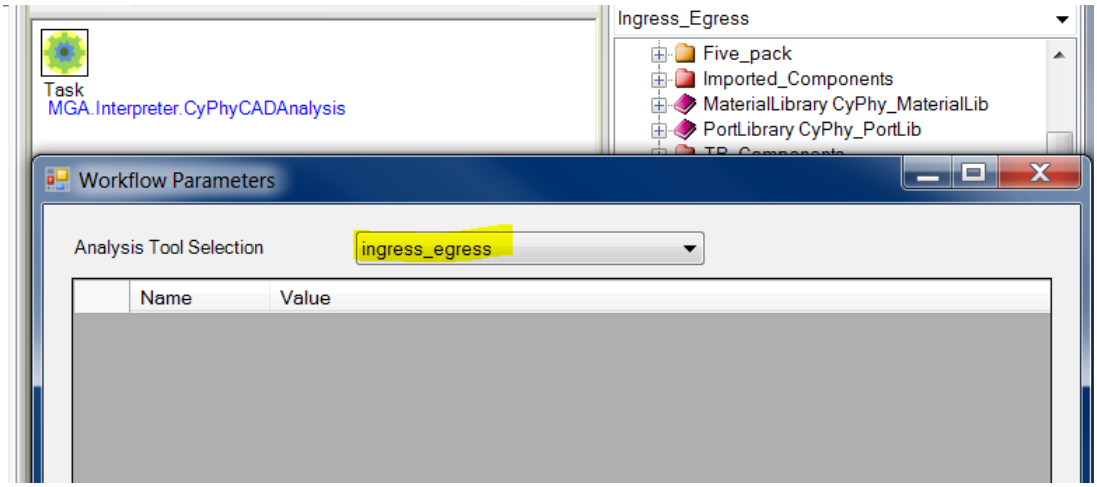


Figure 5: Choosing the analysis tool for the workflow

Step 6

Switch back from the Workflow definition to the “Ingress_Egress” test bench workspace. From the Part Browser, drag in 4 metric blocks and name them in accordance to Figure 6.

Metric names must be spelled exactly as they appear, including underscores. Otherwise the results will not be extracted correctly.

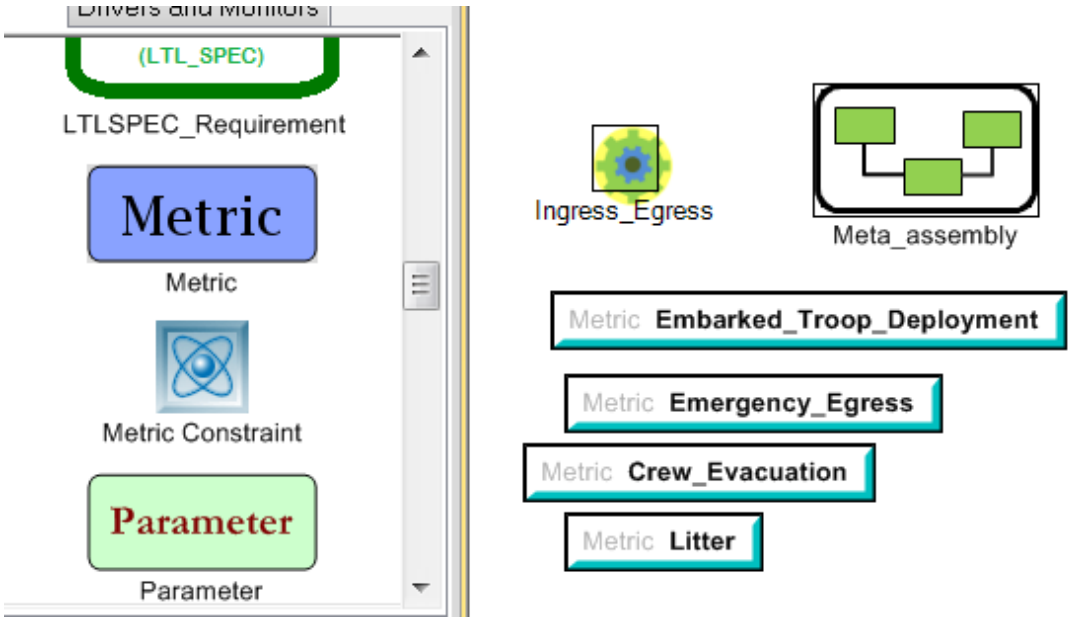
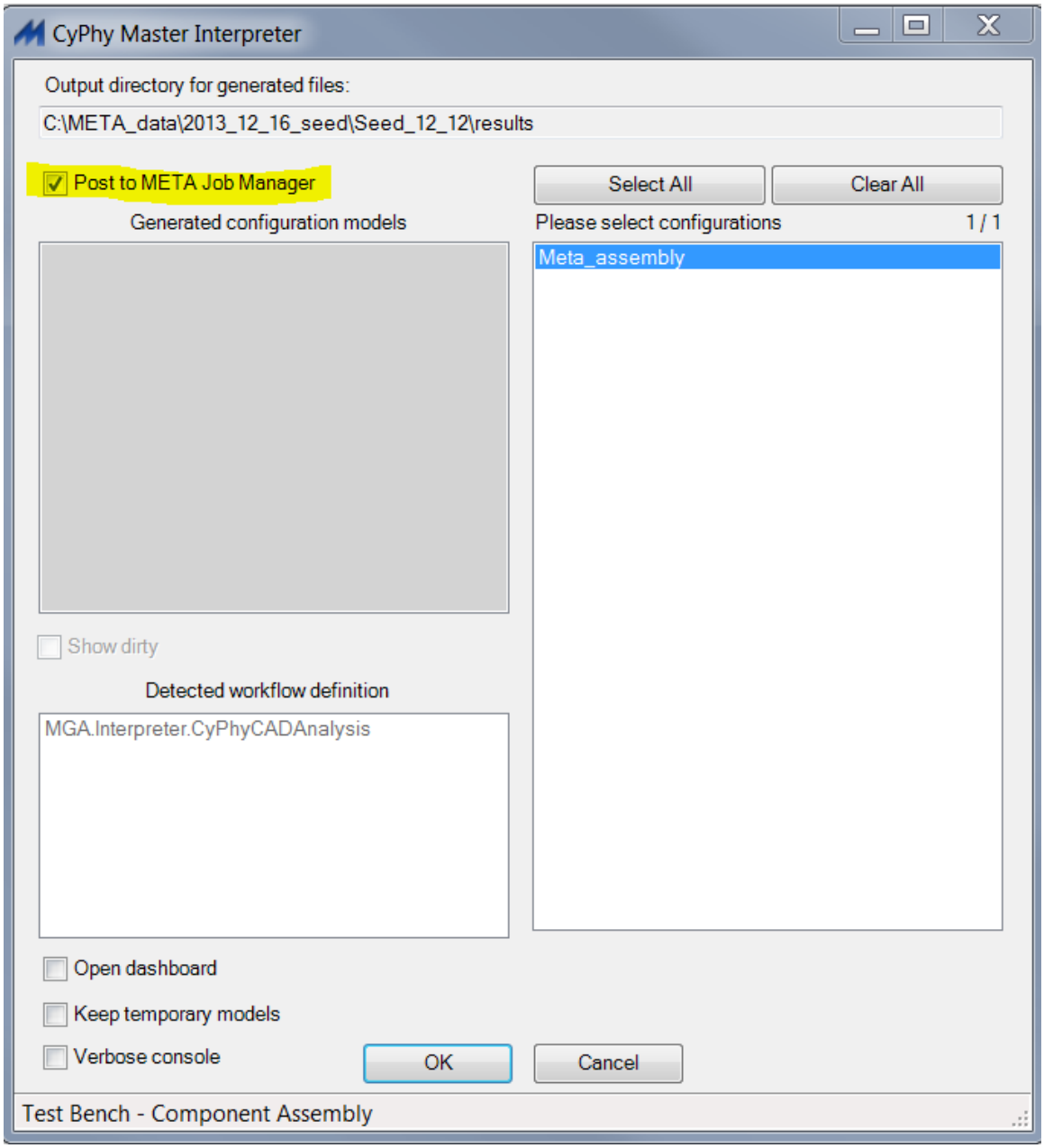


Figure 6: Ingress_Egress test bench with Metrics added

Step 7

To exercise the test bench, run the Master Interpreter ( ). For the egress 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.


CyPhy Master Interpreter
Output directory for generated files:
C:\META_data\2013_12_16_seed\Seed_12_12\results
Post to META Job Manager
Select All
Clear All
Generated configuration models
Please select configurations
1 / 1
Meta_assembly
Show dirty
Detected workflow definition
MGA.Interpreter.CyPhyCADAnalysis
Open dashboard
Keep temporary models
Verbose console
OK
Cancel
Test Bench - Component Assembly

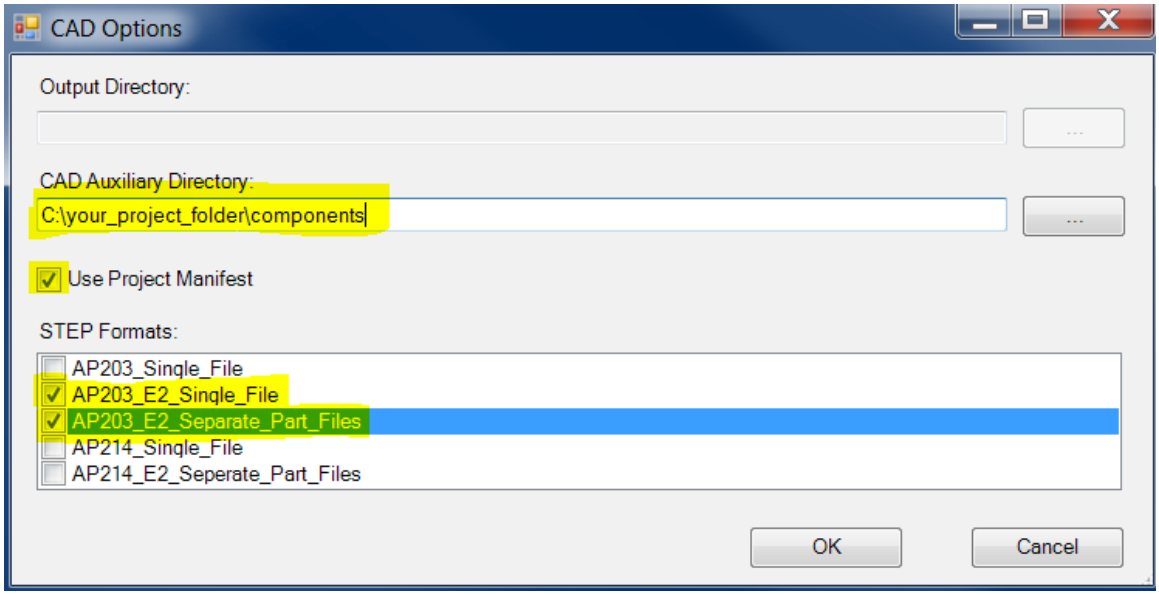


Figure 7a, 7b: Dialog boxes to run the test bench

You may get a window asking you to "configure remote execution". You can choose to do so, or click save (with no options selected). In the latter case, the test bench will run locally.

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".

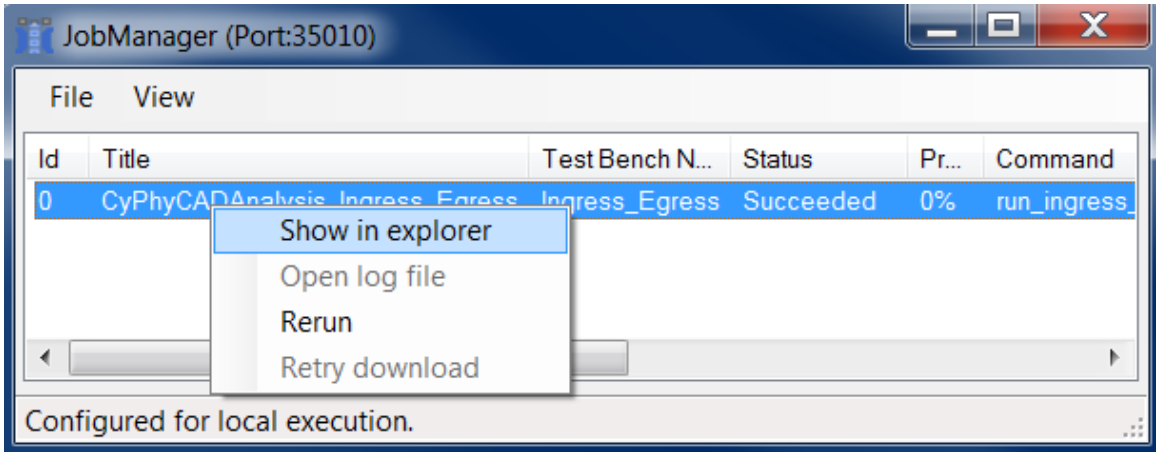


Figure 8: How to access the test bench results folder

3.5 Required Connection to System Under Test

None.

4.0 Results

4.1 Description

The egress test bench processes the vehicle geometry to locate regions where movement would be limited or obstructed.

The vehicle geometry is assembled in CREO and each component making up the system is saved as an individual step file. Relevant properties are also extracted.

Results are returned in a file named test_bench_manifest.json. Several image files are also generated for visual verification of the data.

4.2 Metrics

Test Bench #	Metrics	Description
33	Embarked_Troop_Deployment	Approximate time (in seconds) that it takes the furthest Marine (from the door) to reach the vehicle exit in an empty vehicle.
34	Emergency_Egress	Can all crew members reach a door and a roof hatch?
35	Crew_Evacuation	Can all crew members be evacuated (with assistance) through the rear exit door?
36	Litter	Is there room for an occupied litter in the designated space?

Table 1: Ingress_Egress output metrics

4.3 Output files

The test bench writes a JSON file containing results: test_bench_manifest.json (this file can be opened with a text editor like Notepad). It will be stored in the test bench output folder (see end of section Creating the Required Test Bench Structure, above).

```
{
    "Description": "",
    "DisplayedName": null,
    "GMEID": "id-0067-00002472",
    "Value": "4.91923881554",
    "ID": "acfb196e-d1bd-497f-951d-e629d618b534",
    "Unit": "sec",
    "Name": "Embarked_Troop_Deployment"
},
```


Figure 9: Summary results JSON file

If the metrics show errors, additional information can be found in several other files provided for debugging purposes.

4.3.1 Text files

- **test_bench.log:** Provides a readable summary of operations performed, and possible explanations for failure.
- **test_bench_debug.log:** More verbose version of the above. If you are filing a support request on this test bench, it may help to provide this file.

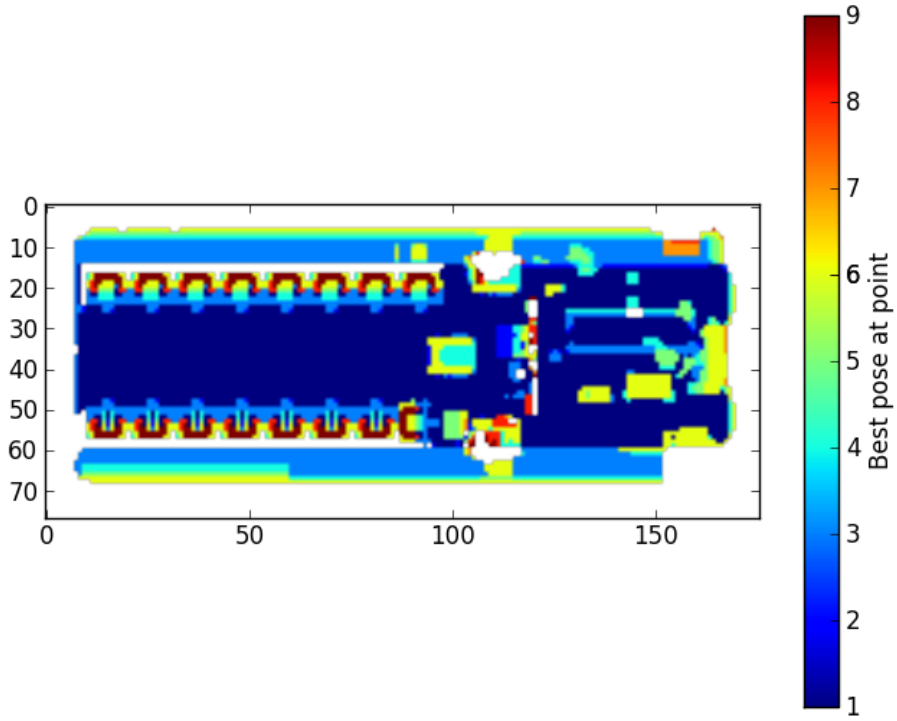
4.3.2 Images

Inside the test bench folder, you will see a series of subdirectories. Navigate to a folder name of the pattern *<tb folder>/results/<run_id>/<voxel_size>/*

Eg: <tb folder>/results/VU_Assembly/0.05

In particular, two files here will be helpful:

- **<run_id>_vox<vox_size>_best_poses.png :** Shows a color coded map indicating the most walkable pose that can be adopted at every point inside the vehicle. This represents the view of the floor from above. If the whole image appears blank, or if highly walkable (blue) regions appear to be outside the vehicle, consult the troubleshooting section.
- **troop_exit_paths.png:** Overlays the routes taken to exit the vehicle (to reach a marked door point) on top of the walkable floor geometry image. Helpful in diagnosing if soldiers are being routed to unrealistic locations along paths that make no sense.



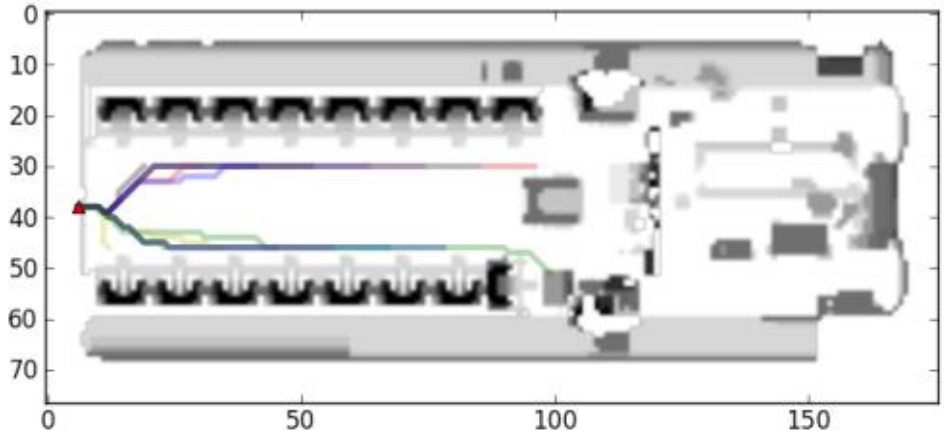


Figure 10a, 10b: Output images helpful in verifying results

5.0 Troubleshooting

5.1 Memory errors

The test bench requires access to the full set of 3D geometry for the vehicle. As a result, it may run into problems when dealing with extremely detailed component models with millions of points each (eg seats). Using a lower-resolution or more memory efficient version of the geometry may be helpful.

5.2 Unable to find walkable start points or paths to exit

In certain cases, the area around a soldier's designated start or exit positions may be too crowded to permit movement. In those cases, unrealistic exit times may be obtained, indicating the inability to find a path.

If no paths are found, the door point chosen may be difficult to reach. Consult the images (section Images) to determine where the unwalkable regions lie. These may indicate incorrect staging (seats left unfolded during exit) or design issues in the vehicle (tight hallways, ceilings too low to fit even a highly crouched soldier, etc). Check that there are no obstructions near the middle of the doorway.

5.3 Soldiers walk to places they should not

The walkable area is determined based on the interior cabin volume. If the visualization in show_2d shows a soldier walking outside the vehicle (or otherwise passing through walls), check to make sure that there is a clear distinction between inside and outside. Typically, this means that all doors to the outside of the vehicle are closed (thus separating the interior and exterior volume).

If all soldiers are exiting through a point that seems strange, examine the door_perimeter.png output image. There may be insufficient overlap between the door and vehicle edges; by default, it choose candidate exit points to be any walkable floor point within 10cm of the vehicle edge.

5.4 Estimates of exit time seem very low or very high

This test bench produces a rough estimate, typically 3-10 seconds depending on vehicle configuration (in practice this may underestimate total embarkation time by up to a factor of 2, depending on soldier encumbrance and other factors).

If your time estimates are very high or very low, consult the output images, log file, or output images above (in particular troop_exit_paths.png). Your model may require adjustments to meet the requirements of section Model requirements.