Ergonomics

User Tutorial for the Ergonomics Test Bench

May 2, 2014

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.

VANDERBILT UNIVERSITY

1.0 Purpose

The purpose of the Ergonomics Test Bench is to provide the designer with information about whether certain components can be seen and used by individuals in the vehicle. Distances of components needs by the driver are measured against selected portions of MIL-STD-1472.

2.0 Procedures

2.1 Installation

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

2.2 Tool

The Ergonomics Test Bench in GME allows the user to interface with the Ergonomics Tool which is a software application that accepts a design, analyzes it, and returns a list of what crew interface devices each occupant can see and use. It also evaluates whether the placement of selected components meets requirements laid out in MIL-STD-1472.

3.0 Requirements tested

- **Visibility Evaluation:** Using the position of the components and crew members, determines if the occupants can see the components they need to use for their assigned roles.
- **Reach Evaluation:** Using the position of the components and the reach zones of each crew member, determines if the crew can interact with the components they need for their assigned roles.
- **MIL-STD-1472 prescribed metrics:** Determines whether occupants are within an acceptable distance range from selected components.

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.

VANDERBILT
UNIVERSITY

4.0 Required Components

4.1 Explicit requirements

The following components are the minimum set required for the test bench to operate. The Datum(s) next to each required component provide more detail on the specific area or interface of the component that the test bench reasons about.

```
parts_of_interest = {
"Manikin": {"Datum": ["EXT_GRASP_ZONE", "EXT_TOGGLE-BUTTON_ZONE",
                                   "EXT_PUSH-BUTTON_ZONE", "BOOT_LEFT_CSYS",
                                   "BOOT_RIGHT_CSYS", 'EXT_EYE_CSYS_LEFT',
                                   'EXT_EYE_CSYS_RIGHT'],
                        "Property": ["vehicle_role"],
                        "Required": "{*}"},
            "Steering_Wheel": {"Datum": ["EXT_REACH_OBJ_GRASP"], "Required":
"{+}"},

            "Gear_Select_Panel": {"Datum": ["EXT_REACH_OBJ_PUSH"], "Required":
"{+}"},

            "Pedal_Accelerator_Electric": {"Datum": ["EXT_FOOT_POINT_PEDAL",
"INT_BOLT_15"],
"Required": "{*}"},
            "Pedal_Accelerator_Mechanical": {"Datum": ["EXT_FOOT_POINT_PEDAL"],
                                       "Required": "{*}"},


            "Seat_Crew": {"Datum": ["CUSHION_FRONT_CSYS", "SRP_1472",
                                 "EXT_BOLT_4"], "Required": "{*}"},
            "Seat_Troop": {"Datum": ["CUSHION_FRONT_CSYS", "SRP_1472"],
                           "Required": "{*}"},
            "Seat_Troop_Multi_Occupant": {"Datum": ["CUSHION_FRONT_CSYS_1",
"SRP_1472_1",
                                             "CUSHION_FRONT_CSYS_2",
"SRP_1472_2",
                                             "CUSHION_FRONT_CSYS_3",
"SRP_1472_3"],
                                       "Required": "{*}"},


            "Pedal_Brake_Hydraulic": {"Datum": ["EXT_FOOT_POINT_PEDAL"],
                                 "Required": "{*}"},
            "Pedal_Brake_Electric": {"Datum": ["EXT_FOOT_POINT_PEDAL"],
                                 "Required": "{*}"}}
```

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.

VANDERBILT
UNIVERSITY

4.2 Implicit requirements

When considering the placement of the manikin inside the vehicle, certain elements of vehicle geometry and component placement must be considered. Errors may be encountered if CAD files are missing.

4.3 Manually specified information

None of the parameters in settings.js will need to be edited by the average user. Some values (image rendering, acceptable ranges, etc) may be useful for select debugging purposes.

5.0 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 if the crew and troops can interface with the driver controls and seating.

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.

VANDERBILT
UNIVERSITY

6.0 Running the Test Bench

The test bench contains a design under test that is assembled and analyzed to determine which crew members can see and manipulate components. The test bench will also measure selected distances around the occupants.

Step 1

In the GME Browser, within the "Testing" insert a new **Test Bench subfolder** call "Ergonomics".
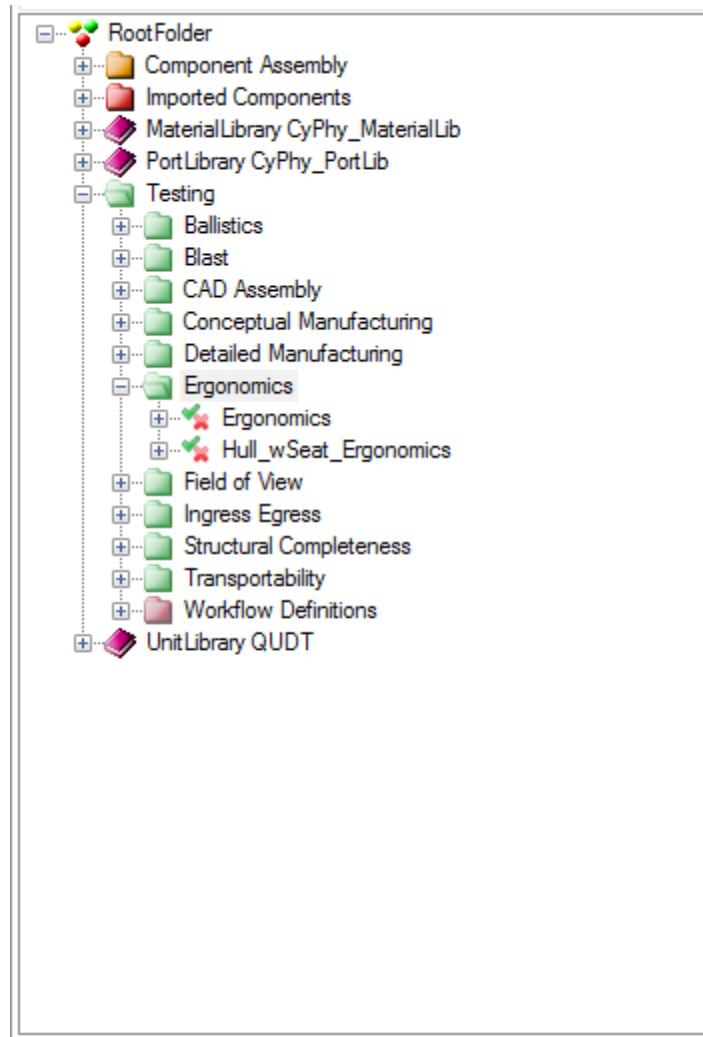

Figure 1: Ergonomics after being added to Testing

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.

VANDERBILT
UNIVERSITY

Next, create a test bench called "Ergonomics" by inserting a new test bench model under the Ergonomics test bench folder.
An assembly now needs to be added to the test bench. In the "Ergonomics" test bench Copy/Paste...As Reference the assembly to be tested.
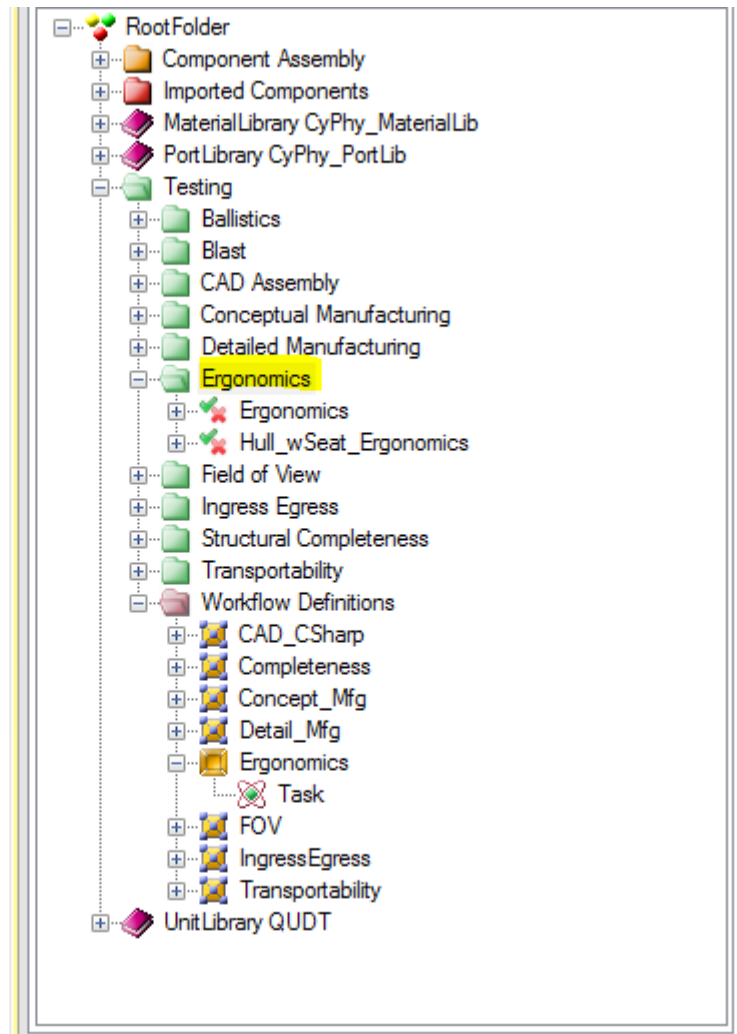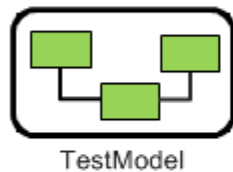

Figure 2: Ergonomics and model

Step 3

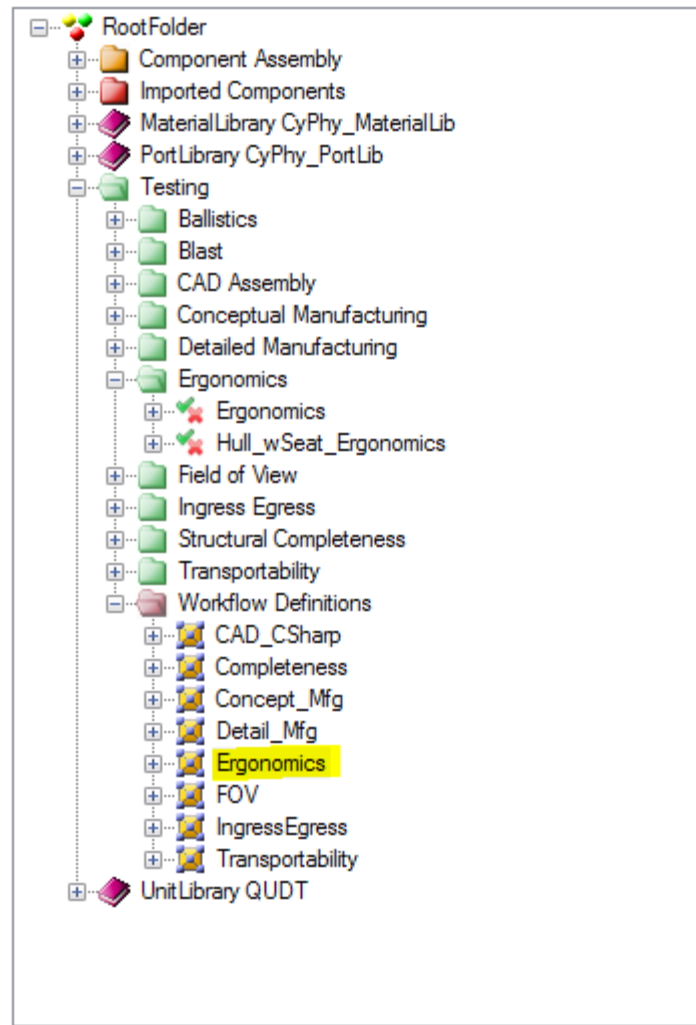In GME, within the Workflow Definition subfolder create a new **workflow model** named "Ergonomics".

Figure 3: Ergonomics added to workflow

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.

VANDERBILT
UNIVERSITY

Step 4

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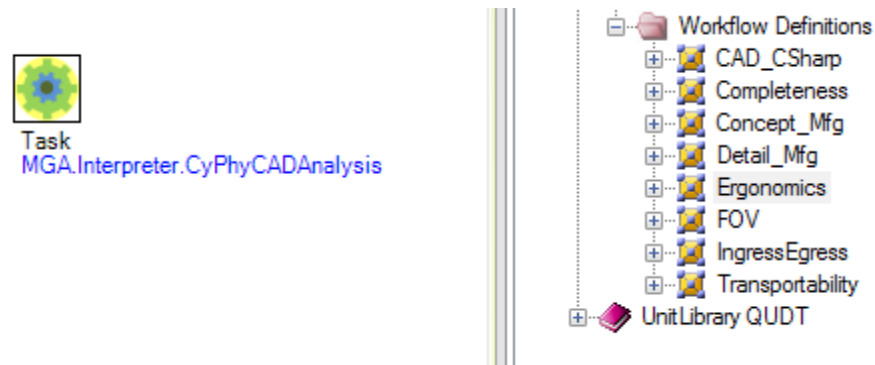

Figure 4: Ergonomics workflow model with task

Step 5

Double click the newly created task and select "ergonomics" as the analysis tool. Set the Workflow Parameters as shown in Figure 5.
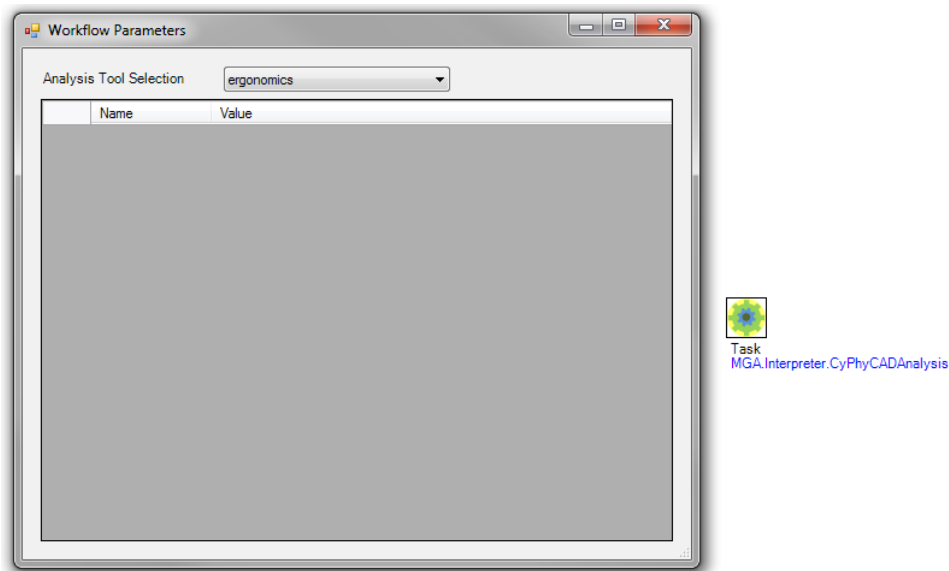

Figure 5: Set Analysis Tool Selection to "ergonomics for the new task

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.

Step 6

Open the "Ergonomics" test bench drag and drop the "Ergonomics" workflow definition and 5 metrics. From the Part Browser, drag in 5 metric blocks and name them in accordance to Figure 6.
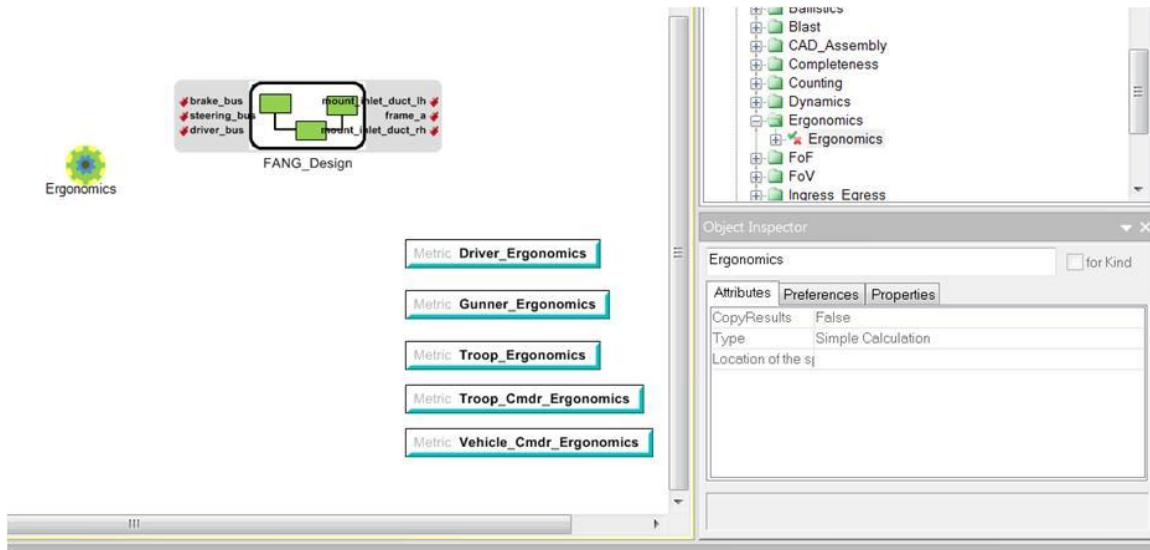

Figure 6: Test bench with metrics

Step 7

To exercise the test bench, run the Master Interpreter. For the ergonomics 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.
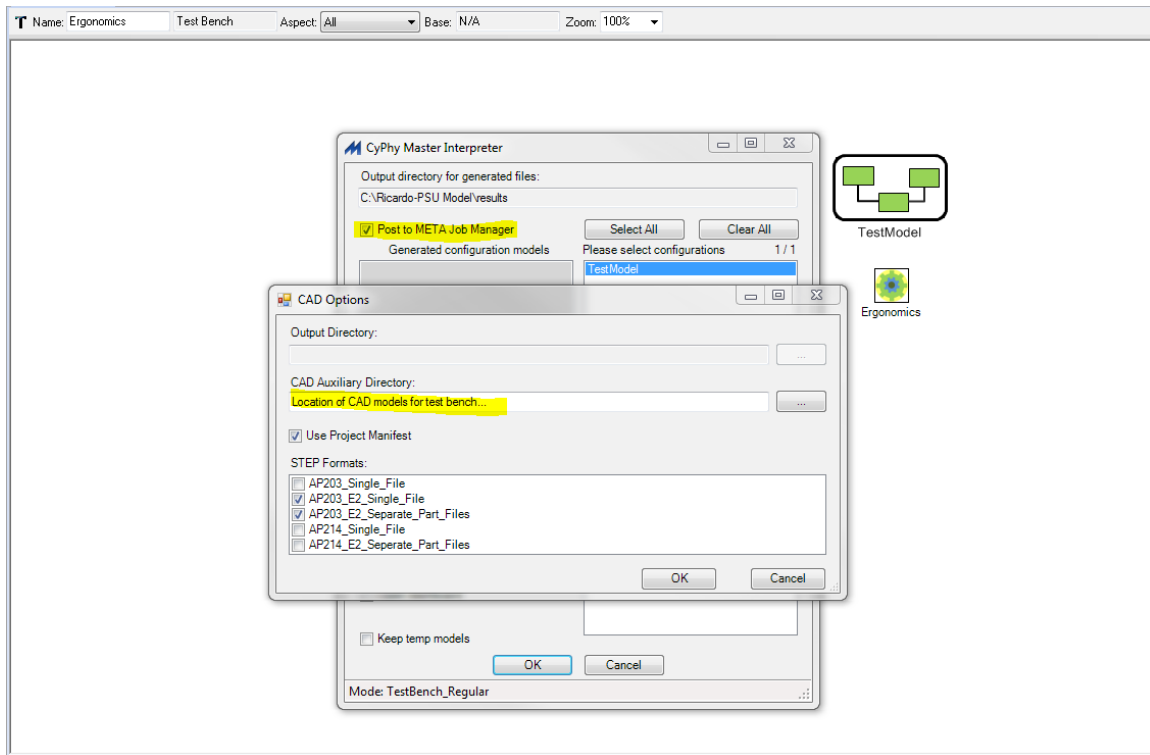

Figure 7: Running the test bench

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".
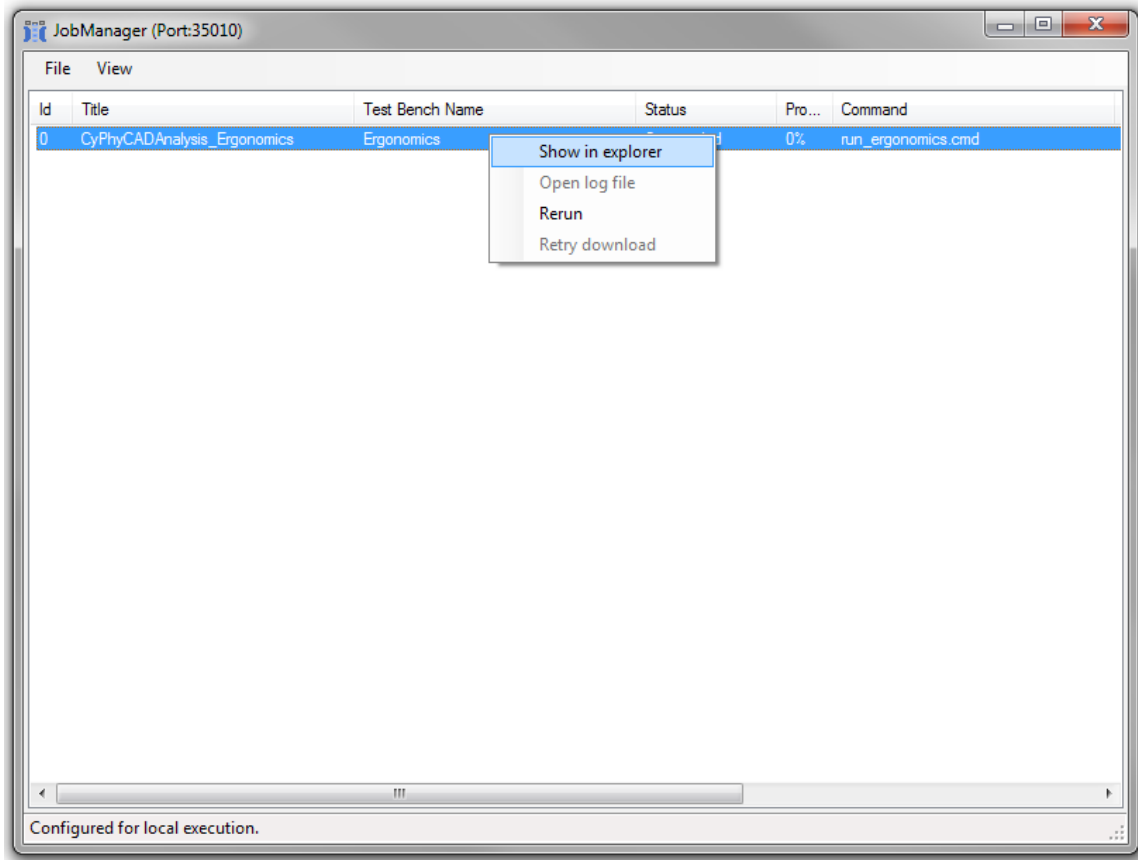

Figure 8: Accessing the test bench results folder

7.0 Description

Ergonomics analysis calculates the straight line distance, the angle with respect to the horizontal, and the angle with respect to the vertical of components from each crew member. The distance and angles are then compared to each crew members visual and reach zone. As long as the component is within the necessary zone if will pass the test for that crew member.

The Ergonomics tool also evaluates selected distances for each manikin in each vehicle role, in a series of tests derived from MIL-STD 1472. (see Table 1) If the calculated values are within the ranges specified in the file settings.js, then that role will be marked as passing the test. (Table 2)

Criteria	Description	Roles evaluated	Range (mm)
01_SRP_to_roof	The distance from the seat reference point to the roof	All	960-1173
02_seat_to_steering_wheel	The distance between the seat back and the steering wheel	Driver only	366-447
03_seat_to_dash	The distance between the seat back and the dash (gear select panel)	Driver only	663-810
04_seat_to_under_steering_wheel	The vertical distance between the seat pan and the underside of the steering wheel	Driver only	217-265
05_seat_height	The height of the seat pan above the floor	All	152-381
06_seat_to_accel	The distance between the seat front and the accelerator pedal	Driver only	320-391
08_brake_to_under_steering_wheel	The distance between the normal of the brake pedal and the underside of the steering wheel	Driver only	594-726
09_driver_center_to_brake_right	The lateral distance between the driver's center and the right side of the brake pedal	Driver only	137-168
10_brake_right_to_accel_right	The distance between the right side of the brake pedal and the right side of the accelerator	Driver only	137-168

Table 1: Description of distance checks used in <role>_Ergonomics metric

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

The final output metrics evaluated by GME are saved in a file named "testbench_manifest.json" and "output.json"; these metrics are described in Table 2.

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.

VANDERBILT
UNIVERSITY

.1 Metrics

Type	TB #	Metrics	Description
Visibility		Visible Evaluation of Interior Components	For each vehicle role, indicates (True or False) whether each device can be seen by the manikin assigned to that role
Reach		Reach Evaluation of Interior Components	For each vehicle role, indicates (True or False) whether each device can be reached by the manikin assigned to that role
Troop_Ergonomics	173.1		True or False: all distances measured for all manikins in the role "troop" are within the allowed ranges
"Driver_Ergonomics	173.2		True or False: all distances measured for all manikins in the role "driver" are within limits
Gunner_Ergonomics	173.3		True or False: all distances measured for all manikins in the role "gunner" are within limits
Vehicle_Cmdr_Ergonomics	173.4		True or False: all distances measured for all manikins in the role "vehicle_commander" are within the allowed limits
Troop_Cmdr_Ergonomics	173.5		True or False: all distances measured for all manikins in the role "troop_commander" are within the allowed limits

Table 2: List of GME output metrics

Three image files are also generated for visual verification of the data. See the section "Output", below.

6.2 Required Connection to System Under Test

NONE

6.3 Outputs

The output of the test bench is a summary results file, "testbench_manifest.json" that displays the metrics, results, and status of the test bench run.

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.

VANDERBILT
UNIVERSITY

```json
{
  "AnalysisStatus": "OK",
  "Design": "Ergonomics.metadesign.json",
  "DesignID": "{def04a1e-dc80-4852-a2df-52bb7a66cdfd}",
  "DesignName": "Ergonomics",
  "TestBench": "Ergonomics",
  "Time": "2013-10-23T18:43:49.5971904Z",
  "Details": "",
  "Metrics": [
    {
      "Name": "04_seat_to_under_steering_wheel",
      "ID": "8bb4a8d4-07e4-4509-affc-b9053f952fe6",
      "DisplayedName": null,
      "Unit": "",
      "Value": "True",
      "GMEID": "id-0067-00001e36"
    },
    {
      "Name": "05_seat_height",
      "ID": "709445f1-59dd-4684-a6de-88b2af1c3e76",
      "DisplayedName": null,
      "Unit": "",
      "Value": "True",
      "GMEID": "id-0067-00001e35"
    },
    {
      "Name": "02_seat_to_steering_wheel",
      "ID": "57c328a3-6c89-4d5a-b209-9268a0a2fd04",
      "DisplayedName": null,
      "Unit": "",
      "Value": "True",
      "GMEID": "id-0067-00001e39"
    },
    {
      "Name": "01_SRP_to_roof",
      "ID": "077bb4d8-ec22-44b9-920f-5fda348b4ce3",
      "DisplayedName": null,
      "Unit": "",
      "Value": "False",
      "GMEID": "id-0067-00001e3b"
```

Figure 9: testbench_manifest.json sample

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.

VANDERBILT
UNIVERSITY

To visually check the placement of components and understand the scores, the test bench renders several helpful images: "driver ergonomic_zones.png" (Figure 10) representing reach zones for every device near the driver, and "MIL-STD 1472._<manikin instance name>.png" (Figure 11) - one image file showing ergonomics metrics for every occupant.

The image file "MIL-STD 1472_<manikin instance name>.png" shows the occupant's assigned seat, with markers indicating relevant dimensions. The legend on the side of the image file displays the calculated distances in meters. The vehicle role of that manikin will appear in the title over the image.
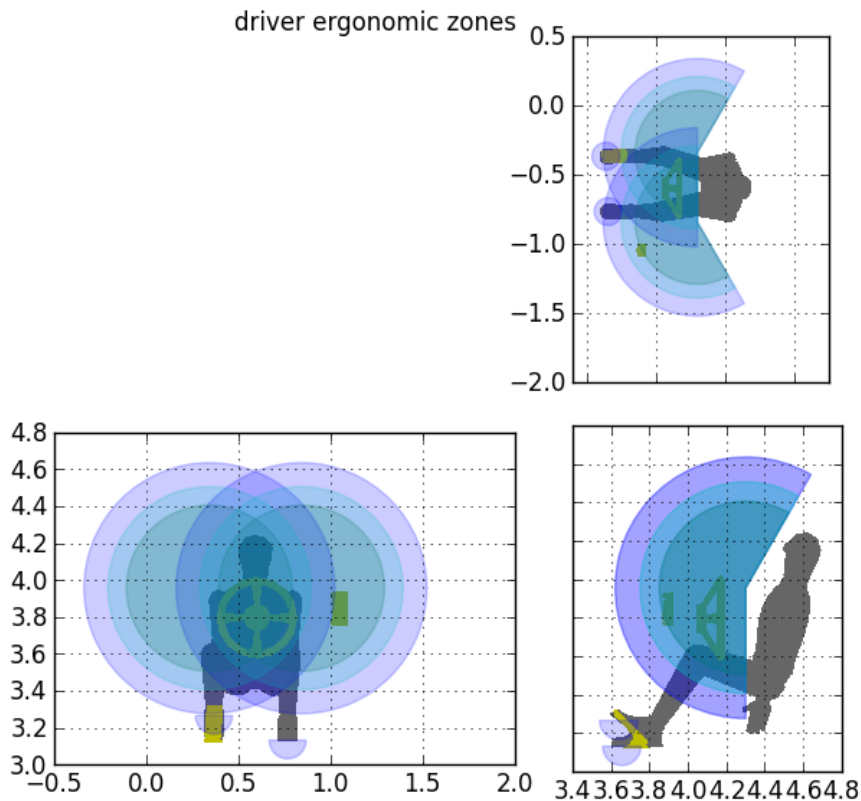

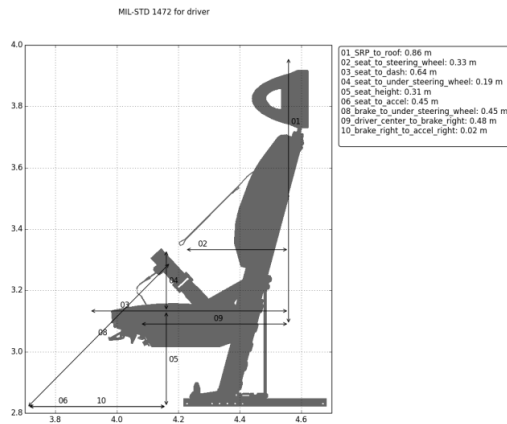**Figure 10: driver_ergonomic_zones.png sample**

MIL-STD 1472 for driver

01_SRP_to_roof: 0.86 m
02_seat_to_steering_wheel: 0.33 m
03_seat_to_dash: 0.64 m
04_seat_to_under_steering_wheel: 0.19 m
05_seat_height: 0.31 m
06_seat_to_accel: 0.45 m
08_brake_to_under_steering_wheel: 0.45 m
09_driver_center_to_brake_right: 0.48 m
10_brake_right_to_accel_right: 0.02 m

Figure 11: MIL-STD 1472_<⬚instancename>.png sample for driver

8.0 Troubleshooting

Information on the calculated metric values can be found in image files rendered for each occupant seat, as well as in the file test_bench_debug.log.
The test bench will support the multi-occupant troop seat provided as part of the default component library (a bench with three seat positions). Custom multi occupant seats with more or fewer positions may encounter problems.

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.

VANDERBILT
UNIVERSITY