Concept-Level Manufacturing

User Tutorial for the Concept-Level Manufacturing Tool and Test Bench

May 2, 2014

1.0 Purpose

The purpose of the Concept-Level Manufacturability Analysis Test Bench and Tool is to provide the designer with information about cost and lead time of the design. This test bench is a fast alternative to the detailed manufacturability test bench, but does not analyze the design for feasibility or provide support for custom manufactured components.

2.0 Procedures

The instructions in this manual assume that the user has installed the latest version of GME/CyPhy and has access to Creo, either locally or via the remote server.

2.1 Installation

Initial installation of the Concept-Level Manufacturability Tool will be provided with the installation of the CyPhy tool suite. Future editions of the tool may be packaged as a standalone or combined test bench installation package.
The test bench in GME that engages this tool is provided as a separate download from Vehicle Forge.

2.2 Tool

The Concept-Level Manufacturability Analysis Test Bench is the test bench in GME that the designer uses to interface with the Concept Level Manufacturability Tool which is a software application that accepts a design, analyzes it, and returns estimated cost and lead time results.
Manufacturability analysis is an automated process to estimate the cost and lead time of a design. Specifically, the tool collects cost and lead time information about each component in the design and aggregates that information into overall design cost and lead time metrics. In addition, it analyzes the geometry of the hull to calculate a cost estimate at the various levels of design completeness of the hull.

3.0 Requirements Tested

- **Manufacturing Lead Time (days):** Time required to manufacture the first vehicle, from design release to build completion.
- **Vehicle Unit Cost ($):** Vehicle unit cost based on component costs and production of one vehicle.

4.0 Required Components

There must be at least one component in the system under test; however, this component can be of any type.

5.0 Theory of Operation

The system (design) is assembled into a 3D CAD representation, including the customization / generation of any parameterized components. Data about the purchasing and procurement is also assembled together for analysis by the iFAB Foundry. This information is analyzed to estimate the cost and lead time of the design.

It is intended that the designer will use this test bench often throughout the design process to get quick feedback about the design as it progresses from conceptual to detailed design. To view the results, an html visualization is provided to see the most expensive and longest lead time components contained in the design.

This tool will not provide feedback for custom manufactured components or component assemblies unless they have been separately run through the Detailed Level Manufacturability tool and have a manufacturing model associated with them that provides cost and lead time data. The exception to this caveat is the hull. The hull is considered a custom manufactured component assembly and the software analyzes the CAD model to estimate a cost and lead time.

6.0 Test Bench Structure

This test bench contains a system under test that is to be assembled and analyzed for its cost and lead time. The Concept-Level Manufacturability test bench is included in the Official Test Benches located on gamma.vehicleforge.org. Steps 1-6 below show how to instantiate the test bench if the designer would like to re-create the test bench. Steps 7-8 discuss running the test bench and viewing the output from the tool.

Step 1

In the GME Browser, within the “Testing” Test Bench folder insert a new Test Bench subfolder ("Conceptual Manufacturing"). Then insert a new Test Bench model ("Foundry_Conceptual"). Figure 1 shows the new test bench and model.

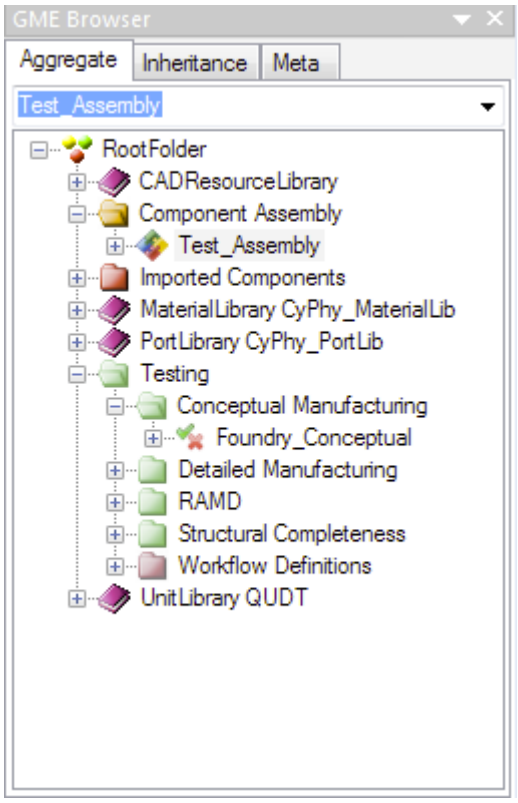


Figure 1: Conceptual Manufacturing Test Bench and Model (Foundry_Conceptual).

Step 2

Now that the test bench container has been created, the design can be added. In the "Foundry_Conceptual" testbench, Copy/Paste…As Reference your assembly. Figure 2 shows the test model in the test bench.

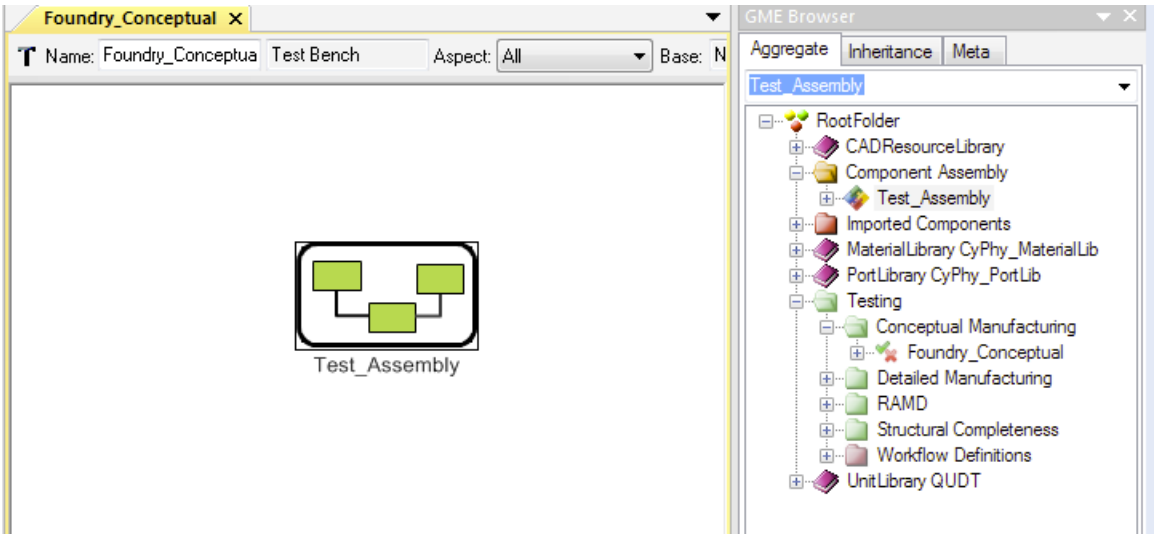


Figure 2: Copy/Paste…as Reference the Design Assembly.

Step 3

In the GME Browser, in the “Workflow Definition” subfolder create a new Workflow Model ("Concept_Mfg") as shown in Figure 3.

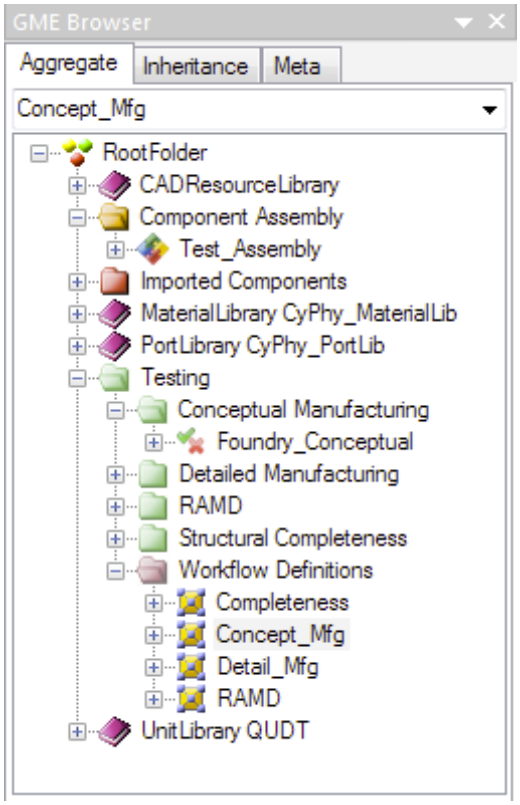


Figure 3: Workflow Definition (highlighted).

Step 4

Open the “Concept_Mfg” Workflow Model, drag a "Task" element into the workspace window, and select "CyPhyCADAnalysis" as the interpreter from the pop-up window. The Concept_Mfg Workflow Model is shown in Figure 4.

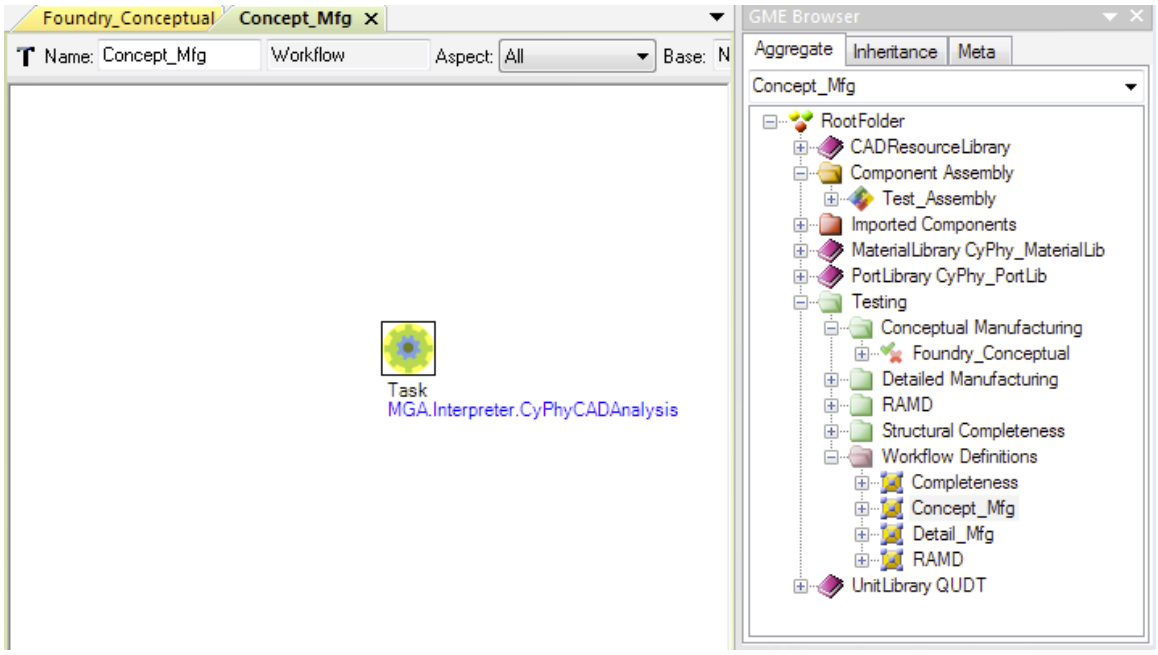


Figure 4: Concept_Mfg Workflow Model with Task.

Step 5

Set up the workflow parameters by Double-clicking on the newly created task, select "Conceptual_mfg" as the analysis tool. The object inspector parameter should mimic Figure 5. Click the “X” in the upper right corner to save/close this dialog box.

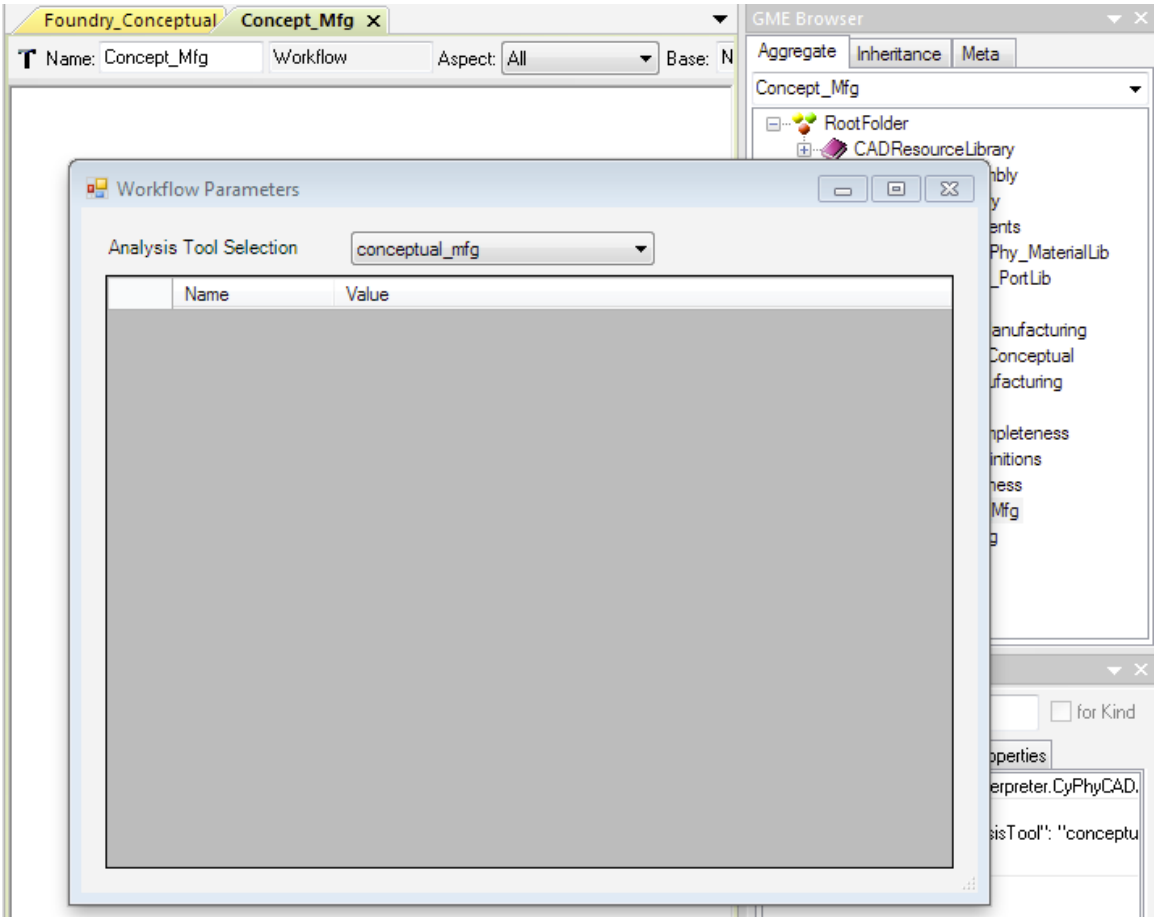


Figure 5: Setting up the Workflow Parameters.

Step 6

Now open the “Conceptual_Mfg” test bench and drag/drop…as Reference the “Concept_Mfg” workflow definition and 2 metrics (from Part Browser) into test bench. Metrics must be named “Vehicle_Unit_Cost” and “Manufacturing_Lead_Time” as shown in Figure 6 (this is what is searched for in the summary.testresults.json file).

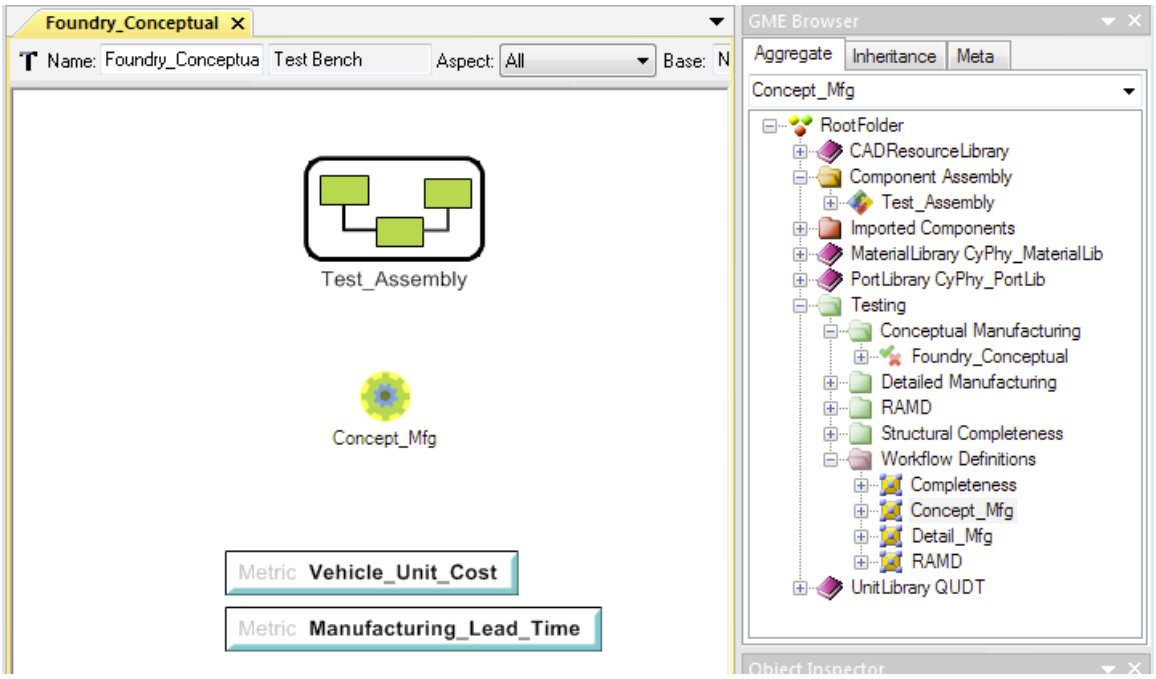


Figure 6: “Foundry_Conceptual” Test Bench.

Step 7

To exercise the test bench, run the Master Interpreter (highlighted in task bar) as shown in Figure 7.
Check the "Post to META Job Manager" in the pop-up shown in Figure 7.

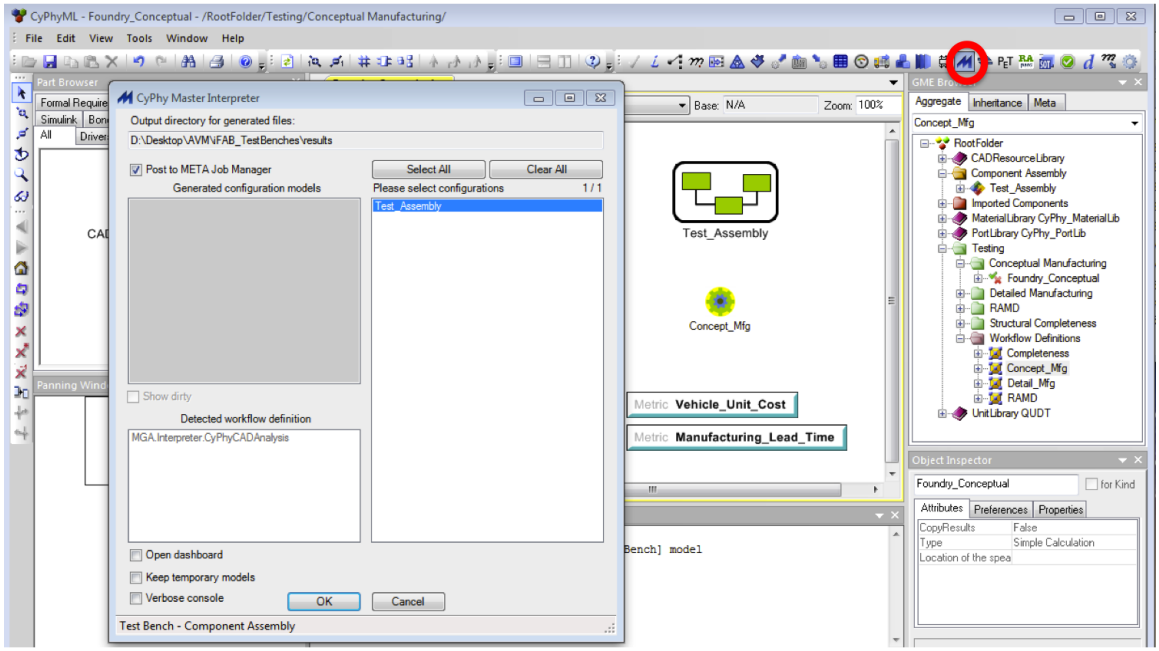


Figure 7: Running the Test Bench.

After selecting “OK”, another pop-up will appear to set up the test bench run. Select the “Use Project Manifest” as well as the “AP203_E2_Single_File” and “AP203_E2_Separate_Part_Files” boxes as shown in Figure 8. Also, for any files created by the user that are not imported into GME, point to the Creo file location for the “CAD Auxiliary Directory:” field. After entering this information, your GME screen should mimic Figure 8.

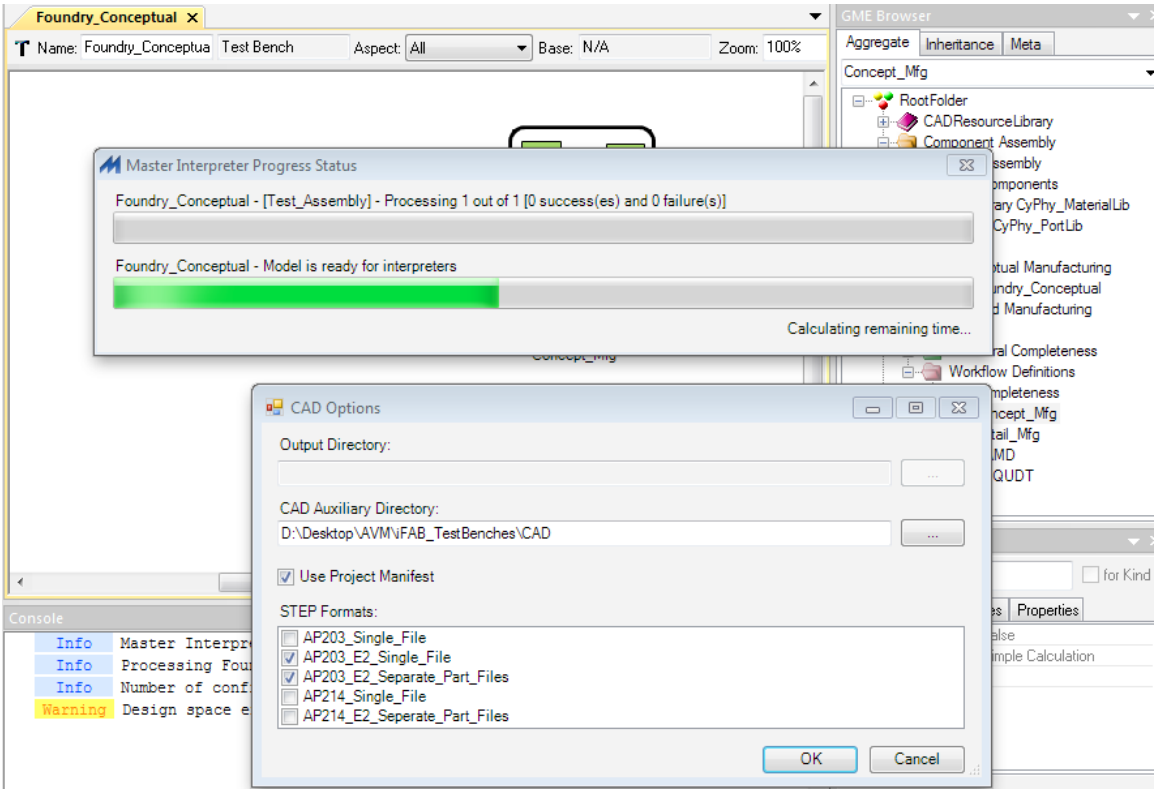


Figure 8: Setting up the Testbench Run.

Select “OK”.
The JobManager Configuraion pop-up window will appear. This test bench can be run either locally (if Creo is installed) or remotely. If running locally, uncheck the “Remote Execution” box and click “Save.” If running on a server, check the “Remote Execution” box and enter your VehicleForge credentials (your URL, user name, and password), as shown in Figure 9. Finally, Click “Save”.

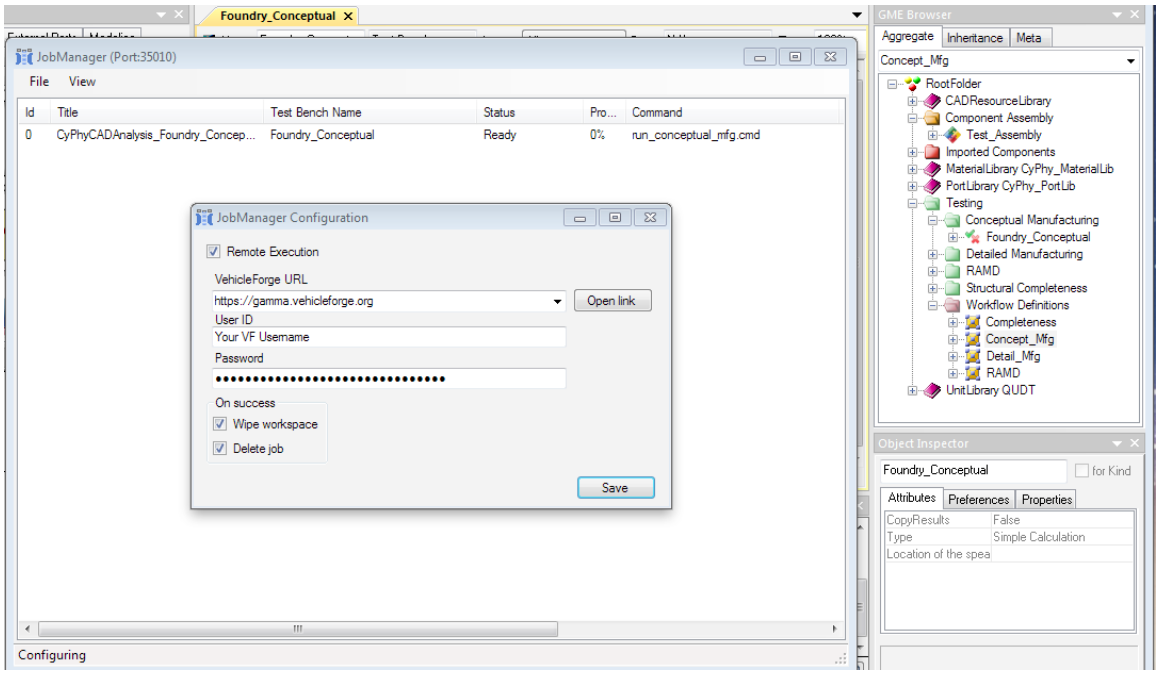
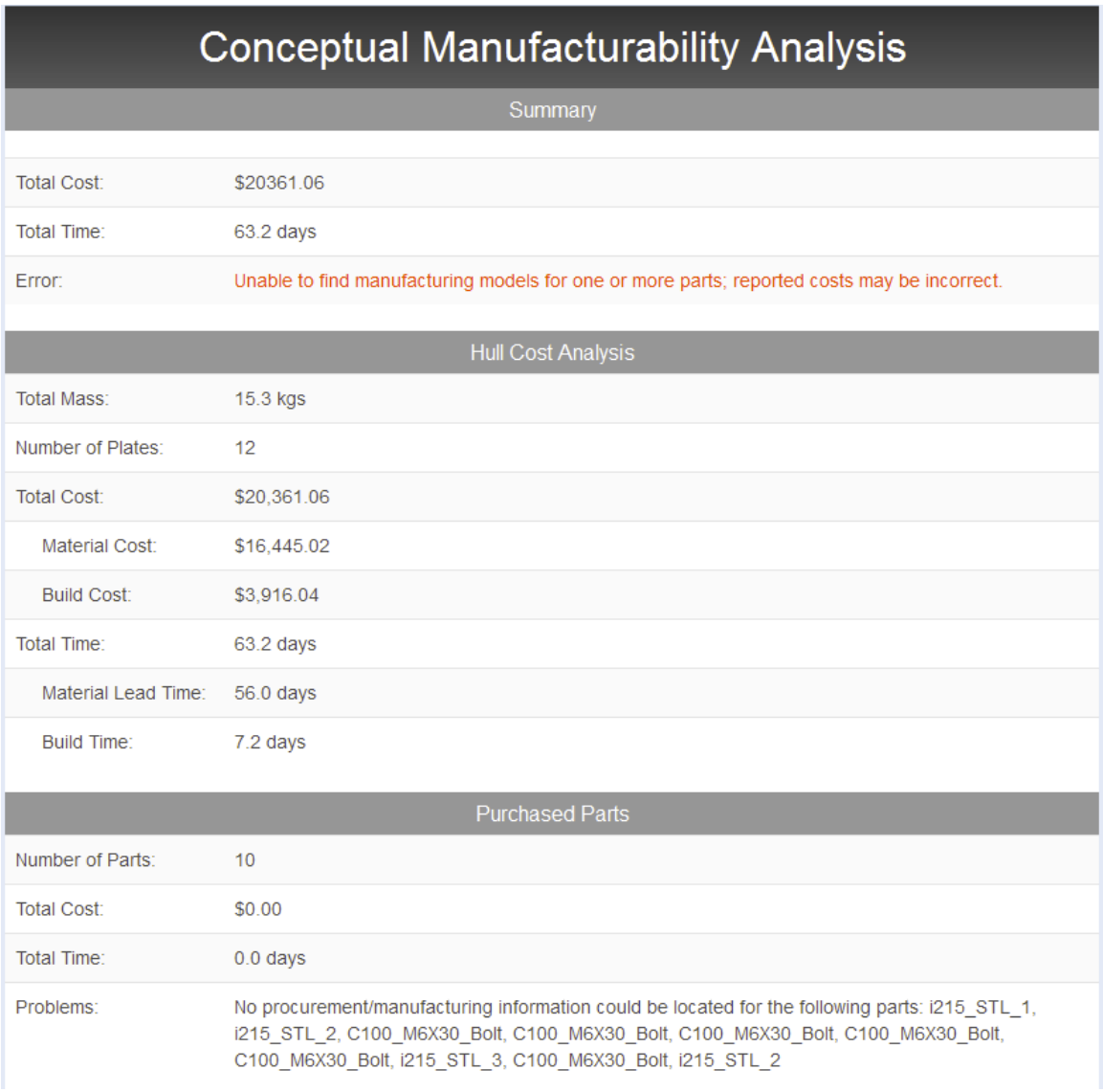


Figure 9: Setting up Remote Execution.

Step 8

The test bench will create a results folder with the manufacturing information about the design. The Job Manager will show the specific results folder which will contain two files of interest: testbench_manifest.json and conceptual_cost.json. The testbench_manifest.json file contains cost and leadtime information that can be used to evaluate the design. The conceptual_cost.json file shows detailed information about the hull and the components in the design. It is intended that the designer would use the results to modify the design to improve the cost and lead time of the design. To get to the results folder, right-click on the analysis in the Job Manager and select “Show in Explorer”.
Typical analysis times are between 10 min and 30 min and increase with the number of components in the design.

Figure 10 shows an example concept level manufacturability output visualizer. There are two ways to use this visualization: on the user's local machine and through VehicleForge.



Conceptual Manufacturability Analysis

Summary

Total Cost:	$20361.06
Total Time:	63.2 days
Error:	Unable to find manufacturing models for one or more parts; reported costs may be incorrect.

Hull Cost Analysis

Total Mass:	15.3 kgs
Number of Plates:	12
Total Cost:	$20,361.06
Material Cost:	$16,445.02
Build Cost:	$3,916.04
Total Time:	63.2 days
Material Lead Time:	56.0 days
Build Time:	7.2 days

Purchased Parts

Number of Parts:	10
Total Cost:	$0.00
Total Time:	0.0 days
Problems:	No procurement/manufacturing information could be located for the following parts: i215_STL_1, i215_STL_2, C100_M6X30_Bolt, C100_M6X30_Bolt, C100_M6X30_Bolt, C100_M6X30_Bolt, C100_M6X30_Bolt, i215_STL_3, C100_M6X30_Bolt, i215_STL_2

Figure 10: Concept-Level Manufacturability Analysis Results in Local Visualizer.

To view the results locally, navigate to the results folder of the detailed level manufacturability test bench output and double click on the CL_Manufacturing_Index.html file. The html viewer works with Firefox and Internet Explorer browsers. Other browsers (Chrome) can be used by setting the "target" for the shortcut startup to: "C:\Program Files

(x86)\Google\Chrome\Application\chrome.exe" –allow-file-access-from-files. You will need to change the file path of the installation location for Chrome is different on your machine.
To view the results through VehicleForge, check-in the results folder to your SVN or GIT repository on VehicleForge and click on the testbench_manifest.json file to get a summary of the results or the conceptual_cost.json file to get the detailed results from this test bench. The view will be identical to the views shown above.

7.0 Description

Concept-Level Manufacturability analysis calculates the cost and lead-time of the design under test. This tool analyzes the information provided in the design, specifically the components (engine, transmission, etc.) and the hull. The test bench is designed to analyze designs from initial conceptual hull through detailed design. This test bench is used as a tool to get a cost and lead time estimate of the design quickly, but lacks the detail analysis capability found in the Detailed Manufacturability Test Bench.
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 Concept-Level Manufacturability Analysis Tool as a post-processing step.
Results are returned in two files "testbench_manifest.json" and "conceptual_cost.json" containing summary results and more detailed results, respectively. The summary results can be viewed in the dashboard and the detailed results can be viewed in the local and VF manufacturability visualization tool.

8.0 Metrics

- **Manufacturing Lead Time (days):** Time required to manufacture the first vehicle, from design release to build completion.
- **Vehicle Unit Cost ($):** Vehicle unit cost.

Test Bench #	Metric	Description
61	Vehicle_Unit_Cost	Vehicle unit cost
66	Manufacturing_Lead_Time	Time required to manufacture the first vehicle, from design release to build completion

9.0 Required Connections to System Under Test

NONE

10.0 Outputs

The output of this test bench is two results files “testbench_manifest.json” and “conceptual_cost.json”. The summary results summarize the cost, and leadtime and can be viewed/interpreted in the dashboard. A portion of the summary results is shown in Figure 11.


```
{
    "Status": "OK",
    "CopyTestResults": false,
    "Parameters": [],
    "TierLevel": 1,
    "Artifacts": [],
    "Created": "2014-01-06T20:28:21.4163131Z",
    "DesignName": "Test_Assembly",
    "Metrics": [
        {
            "Unit": "Dollars",
            "Name": "Vehicle_Unit_Cost",
            "Value": "20361.0643885"
        },
        {
            "Unit": "Days",
            "Name": "Manufacturing_Lead_Time",
            "Value": "63.1763365464"
        }
    ],
    "DesignID": "{5ab9dda1-0960-4f0d-8bd6-8581962416ed}",
    "Steps": [
        {
            "ExecutionCompletionTimestamp": null,
            "Description": null,
            "Parameters": [],
            "ExecutionStartTimestamp": null,
            "Invocation": "run_conceptual_mfg.cmd",
            "PostProcess": null,
            "PreProcess": null,
            "Type": null
        }
    ],
    "TestBench": "Foundry_Conceptual"
}
```


Figure 11: Portion of Summary Results.

The summary results can be seen and compared with other system metrics in the Dashboard. For further information on using the dashboard, please go to https://beta.vehicleforge.org/fang_beta2/resourcesf2/Local%20Dashboard.
The detailed results file contains information about the overall design including detailed information about each component in the design. It also includes a detailed estimate of the cost of the hull.

11.0 Testbench Tier Information

Attribute	Tier 1 (Concept Level Manufacturability)	Tier 2 (Detailed Level Manufacturability)
Test Bench Name	Foundry_Conceptual	Foundry
Description	Concept-Level Manufacturability analysis calculates the cost and lead-time of the design under test. This tool analyzes the information provided in the design, specifically the components (engine, transmission, etc.) and the hull. The test bench is designed to analyze designs from initial conceptual hull through detailed design. This test bench is used as a tool to get a cost and lead time estimate of the design quickly, but lacks the detail analysis capability found in the Detailed Manufacturability Test Bench.	Detailed Manufacturability analysis is an automated process to determine if the design is manufacturable. If the design is manufacturable, the analysis will determine the cost and lead-time to make the design. If it is not manufacturable with the capabilities available in the iFAB Foundry, feedback will be provided as to why it is not. Several analysis tools are employed to determine the feasibility and metrics for the assembly and the purchase or manufacture of the individual components.
Estimate Run Time	~2min Data preparation	~2min Data preparation
	0.5s average run time (0.166s - 0.893s)	27min average run time (5min - 12hrs) Max is unknown at this time.
Error Margin	In-Process	This test bench is the Standard
Results Provided	Vehicle Unit Cost	Vehicle Unit Cost
	Manufacturing Lead Time	Manufacturing Lead Time
		Manufacturable
Local/Remote	local and remote	remote only
Tool Used	concept level mfg analysis (python)	detailed level mfg analysis (iFAB server)
How to Interpret Results	locally - CL_Manufacturing_Index.html	locally - DL_Manufacturing_Index.html
	VF - visualization	VF - visualization

Attribute	Tier 1 (Concept Level Manufacturability)	Tier 2 (Detailed Level Manufacturability)
		3D PDF for individual components
		3D PDF for detailed mfg report
Model Requirements	STEP AP203 separate files	STEP AP203 separate files
	.adm file - META design file	.adm file - META design file
	acm files - Component Definition Files	acm files - Component Definition Files
	manufacturing models (COTS and Custom)	manufacturing models (COTS and Custom)
	Manufacturing Manifest	Manufacturing Manifest
	Submission.json	Submission.json

12.0 Future Work and Planned Enhancements

The current Concept-Level Manufacturability Tool assess welding for cost and lead time, however the tool does not currently check for compatibility between the materials. The iFAB Foundry team will be implementing a weld compatibility analysis to this tool.