

Systems Engineering Research Efforts Supporting Marine Corps Systems Command



RT 111, RT 112, RT 117

By

Daniel C. Browne and Santiago Balestrini, PhD

6th Annual SERC Sponsor Research Review

December 4, 2014

Georgetown University

School of Continuing Studies

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- RT 111 Virtual Collaborative Environment for Conducting
Project Design and Tests
Integration of Simulation Tools with MARCORSSYSCOM's FACT
- RT 112 Development and Application of FACT Portfolio
Management Capability
*Support of the Global Combat Support System – Marine Corps
Trade Study*
- RT 117 Development & Application of FACT
to Support USMC Ground Vehicle Analysis
*Applying Lessons Learned to Improving FACT for USMC's
Next Major Acquisition*

RT 111: VCE for CPD&T



Virtual Collaborative Environment for Conducting Project Design and Tests

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GTRI has been developing the **FACT** with **Marine Corps Systems Command (MARCORSYSCOM)** since 2011 to offer a comprehensive model-based systems engineering toolset for acquisition support.

Naval Air Systems (NAVAIR) has been developing the **Architecture Management Integration Environment (AMIE)** to provide a Government-owned standard for real-time simulation integration.

Naval Undersea Warfare Center (NUWC) has been developing the **Virtual World (VW)** to provide a 3D virtual, interactive environment for collaboration, modeling and simulation support, and displaying of virtual test events.

Army Research Lab (ARL) has been developing **Executable Architecture Systems Engineering (EASE)** for abstracting simulation execution to a web-based interface lowering the bar of entry.

- Integrate USMC's FACT with a distributed simulation environment
 - The goal is to enhance FACT's current hosted surrogate, deterministic models with higher-fidelity simulation tools used by Government analysts
- Display the events of the distributed real-time simulation in Naval Undersea Warfare Center's (NUWV) Virtual World (VW)
- Close the data loop by feeding the simulation data back into FACT to take advantage of the visualization capabilities and allow for design iteration on the system of interest.
- Additionally, allow cached results to be displayed inline with deterministic fact-running models integrated directly within FACT.

- SERC with Government sponsor is current reviewing available technologies for integrating with simulation tools.
 - These tools include AMIE and EASE referenced above.
- Work has already been completed by NAVAIR and NUWC to demonstrate the use of VirtualWorld for viewing and replaying simulation executions managed by AMIE
- GTRI and ARL have already developed a link between FACT and EASE by developing a REST API on top of the EASE capability and implementing the API within FACT in order to:
 - Identify the available simulation tools
 - Link the FACT model representation with the EASE simulation inputs and outputs using a web-base authoring capability
 - Execute simulations within EASE using FACT designs and retrieve the results

RT 112: Development and Application of FACT Portfolio Management Capability



**Support of the Global Combat Support System –
Marine Corps Trade Study**



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- The as-deployed GCSS-MC enterprise system is currently not accessible in all environments in which Marines need access the enterprise system.
 - Specifically, the devices available to Marines in high latency, low bandwidth zones are not providing the capabilities for providing useful access
- A War Room was chartered to review the stated requirements, determine the requirements coverage by the existing capability, and identify other GOTS or COTS solutions to fill the current capability gaps.



- 1 Develop approach for conducting portfolio management in a general sense, informed by the GCSS-MC War Room process, and compare to existing FACT capabilities.**
- 2 Evaluate existing tools and data to enable the approach defined above.**
- 3 Develop and apply methods for incorporating portfolio data and models into a web-based tool and exploring integrating the capability with the existing FACT toolset.**



- 1 Define the Problem and List Alternatives.**
- 2 Develop the Evaluation Framework.**
- 3 Complete the Framework. Populate the data.**
- 4 Test the Framework.**



PMAT applies these Model-Based Systems Engineering standards, a browser-based front-end, and open source software to create a framework for portfolio development and analysis.

PMAT separates the portfolio management process into modules; this allows the user and a facilitator to work together to accomplish the following:

- State the problem and define requirements
- Manage data
- Analyze and explore options.

- Means to aggregate high-dimensional data into 3 dimensions so that it can be visualized and inspected by the SMEs.
- Tool and process for evaluating the trustworthiness of data.
- Requirements stop light comparison including filtering for quick identification of requirements coverage for solutions of interest.

DIMENSION 1:

DIMENSION 2:

SELECT A SLICE OF THE DATA

	METRIC 1	METRIC 2	METRIC 3
ITEM 1	0.00	0.00	MISSING VALUES ARE RED
ITEM 2			
ITEM 3	0.00	0.00	0.50

Show Rows Where:

Ctrl-click to hide rows, columns, and categories.

FILTER THE TABLE

Overall portfolio scores:

Group01	Group02	Group03
50.00%	75.00%	90.10%

SUMMARIZE REQUIREMENT COVERAGE

HIDE COLUMNS

	Group01			Group02	
	Item01	Item02	Item03	Item05	Item06
Requirement01	2.00	0.00	N/A	0.00	UNK
Requirement02	1.00	1.00	0.00	0.00	0.00
Requirement03	2.00	2.00	2.00	0.00	0.00

HIDE ROWS



Tool for an SE SME to utilize for walking a team through the effort of defining a high-level problem and decomposing to *good* requirements.

- Captures the process, specifically through versioning text-based artifacts within the tool.
- Offers a *Glossary* for defining terms within the problem context and automatically hyperlinks to the definition for all uses of term throughout the term. Enables consistent use of terms.
- Simple interface for capturing notes and attachments.



- Inner module for capturing Notes within the context of meetings, rather than solely a project-wide capability for capturing notes.
- Versioning of attachments.
- Comprehensive indexing and search capability.
- Export capability for other tools to ingest the final requirement set.

RT 117: Development & Application of FACT to Support USMC Ground Vehicle Analysis



Applying Lessons Learned to Improving FACT for USMC's Next Major Acquisition

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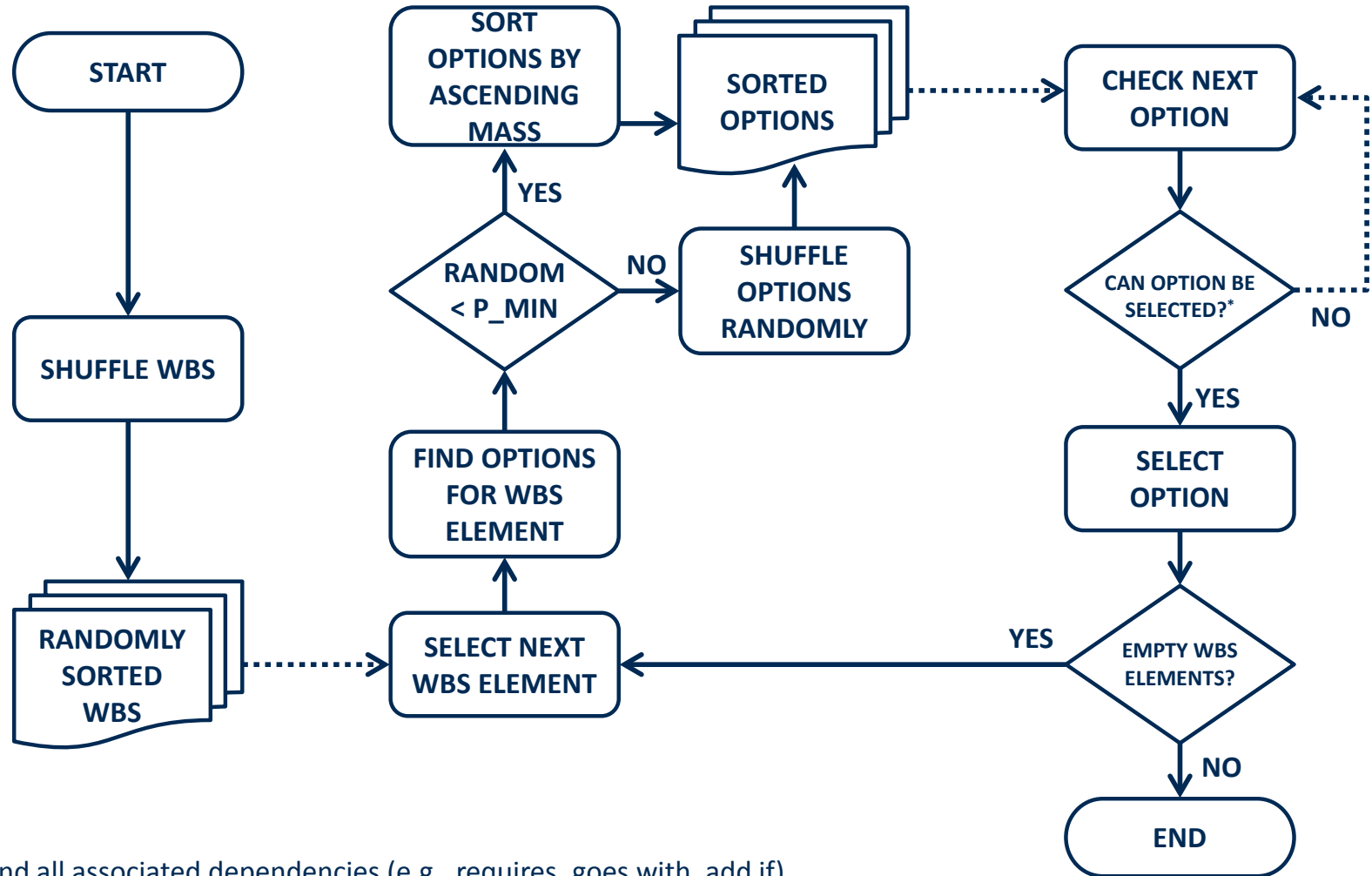
***We were able to complete 2 years
of work in 9 months.***

***paraphrased in reference to FACT
support of USMC ACV Study***

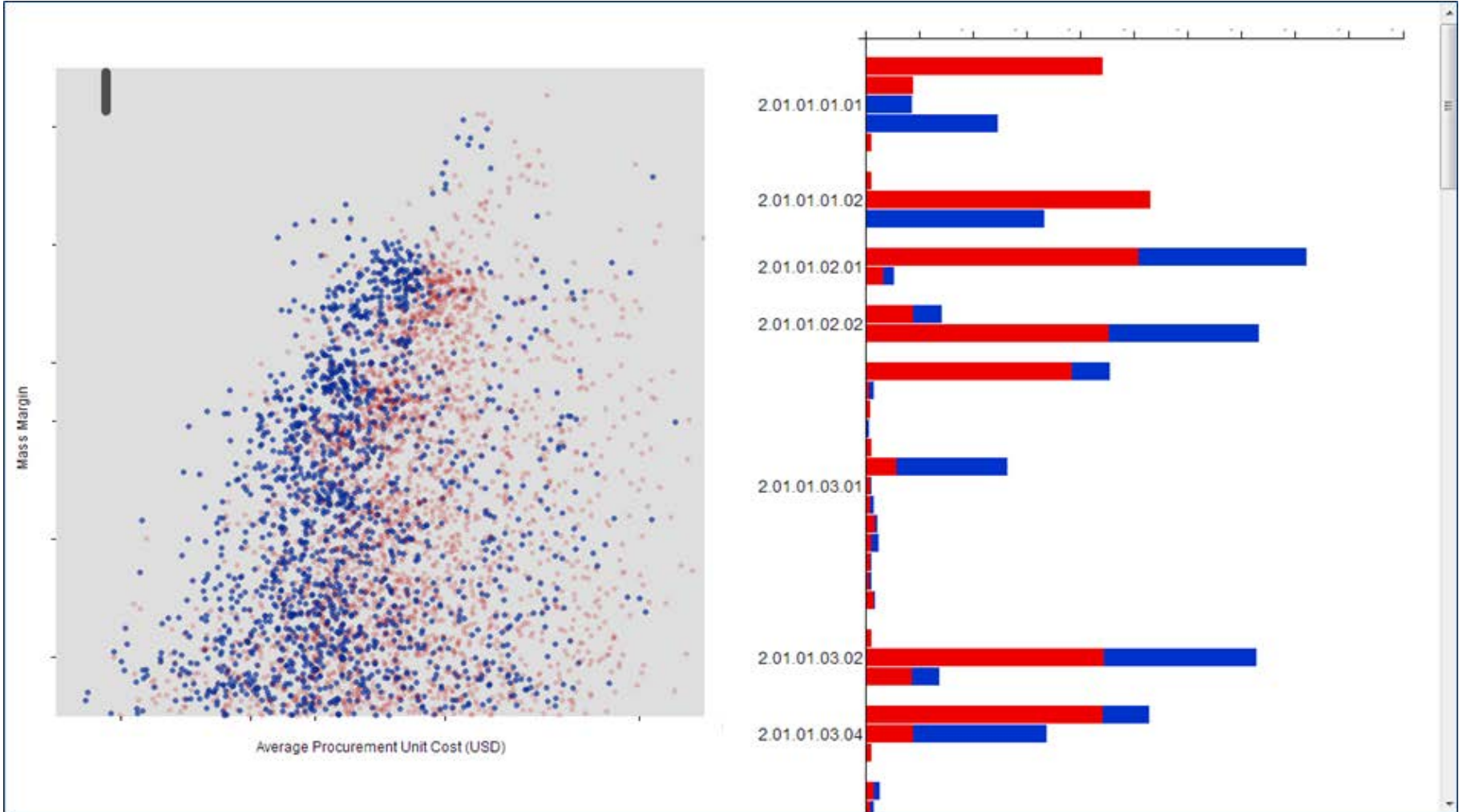
***Dr. Norbert Doerry
Technical Director of the NAVSEA SEA 05 Technology Office***

- Mar-Dec 2013 – Support ACV Phase II team
 - Analyzed approximately 1M configurations vs dozen configuration in Phase I
 - Developed framework for capturing interdependencies between components and algorithm to assemble feasible vehicles
 - Lessons learned:
 - Discrete optimization is more valuable than continuous
 - Maintenance of databases of instances is tedious, error prone, and labor intensive
 - Projects may require custom interactive visualizations
 - Need to facilitate the workflow of expert users to better adapt to a project's changing requirements
 - Must standardize the data structures and the interfaces to facilitate spinning up new users *and* developers
- Incorporate lessons learned and develop new capabilities to better support future USMC ground vehicle analysis teams

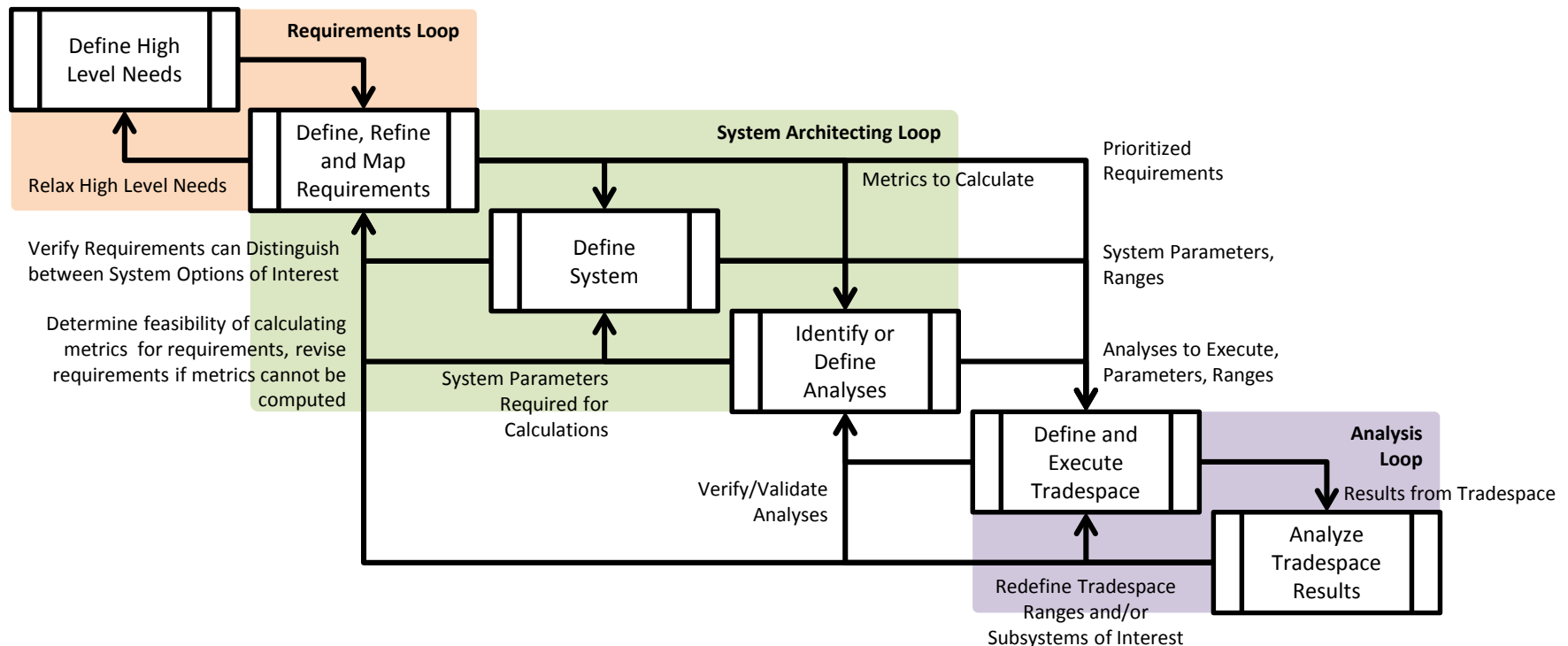
ACV Phase II Solution Generation Process



* and all associated dependencies (e.g., requires, goes with, add if)

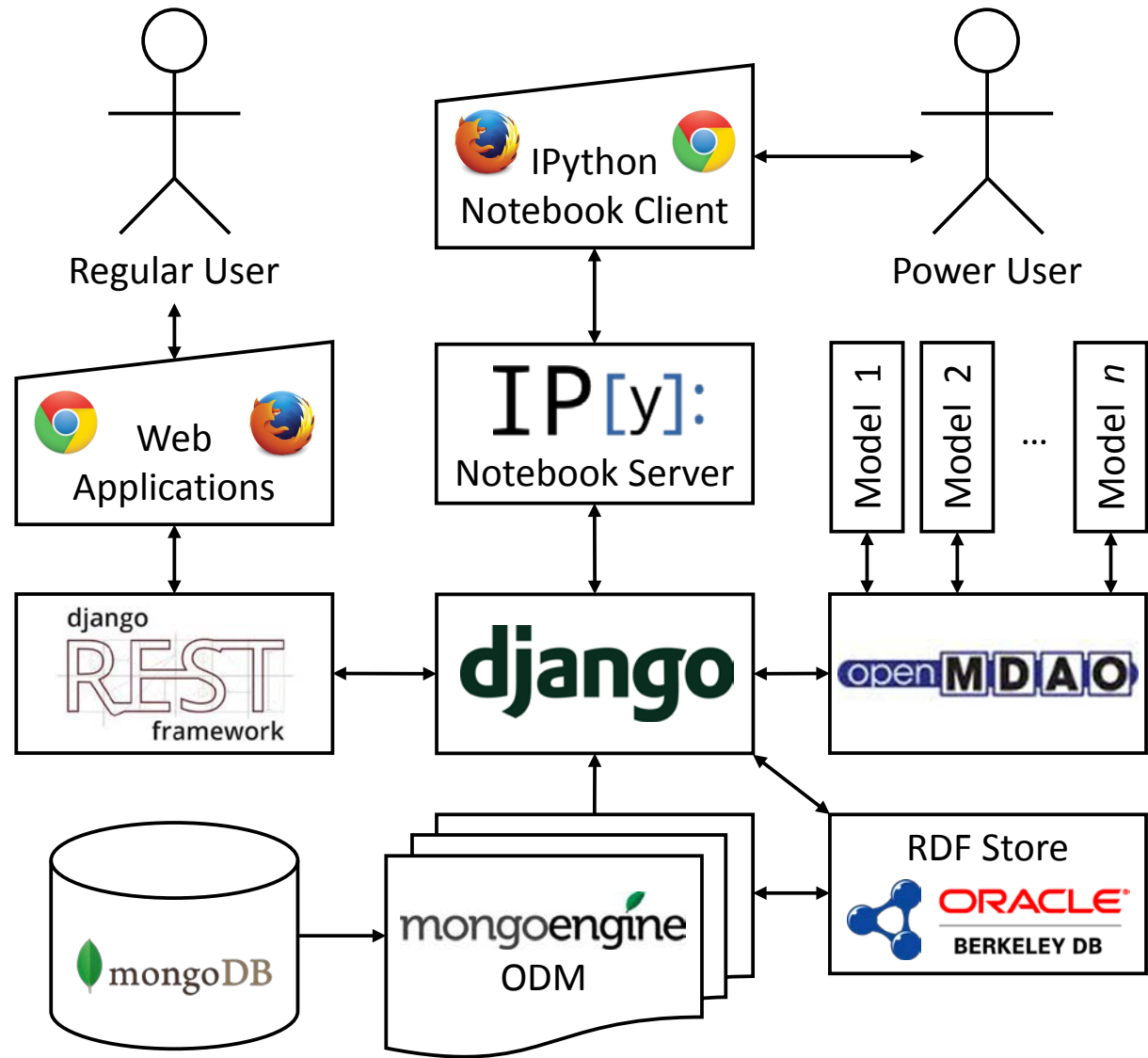


- No one workflow can address all possible projects
- Must support a flexible, customizable workflow, that emphasizes elements as required by each project, and allow users to inject themselves easily as needed

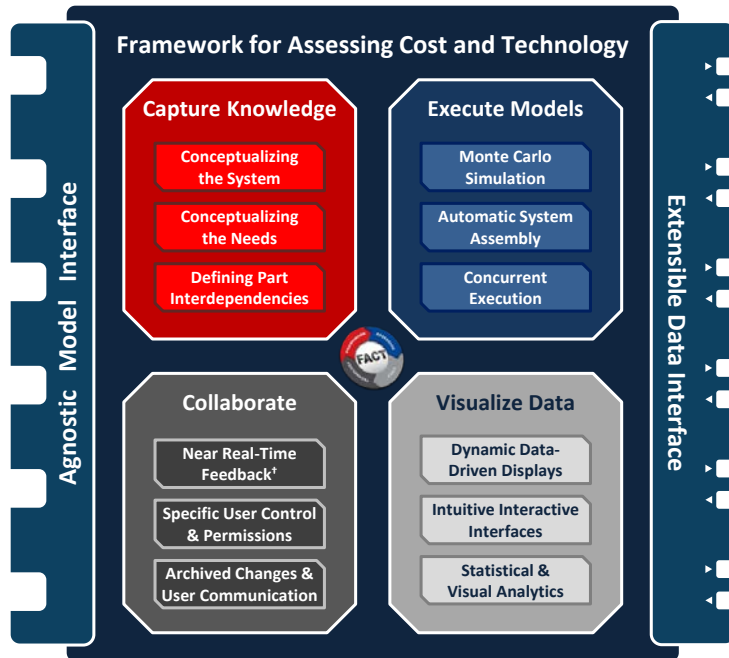




A New Integrated Software Framework



FACT 1.6



VS.

FACT 2.0

APPLICATION	ROLE	BASED ON
Core	Support Decision Making	Utility Theory / Machine Learning
Model Execution	Execute Analyses	MDAO
Versioning and CM	Archive & Version Data	JSON Patch
Architecture Definition	Model Concepts	SysML

- FACT originally was developed as a monolithic application
- RT-117 work is refactoring the code, and creating a more modular framework based on functionally decoupled applications



Architecture Definition Object-Oriented SysML

```
# Define a Car as having two value properties (weight,
# cost)

Car = Block(name='Car', description='A four wheeled
vehicle')

Car.weight = ValueProperty(low='0', units='lbm')

Car.cost = ValueProperty(low='0 USD')

# Define a car as containing an engine

Car.Engine = Block()

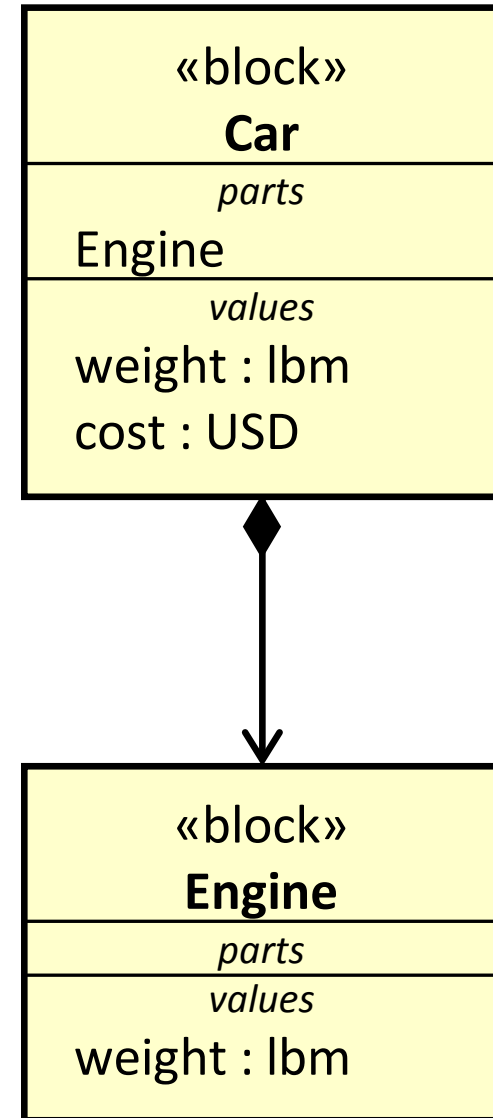
Car.Engine.description = "The prime mover for a vehicle"

Car.Engine.weight = ValueProperty(low='0 lbm',
default='550 lbm')

# Define Pinto as an instance of a Car

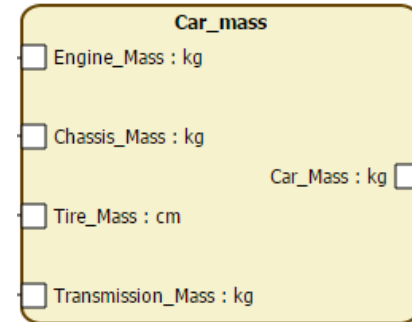
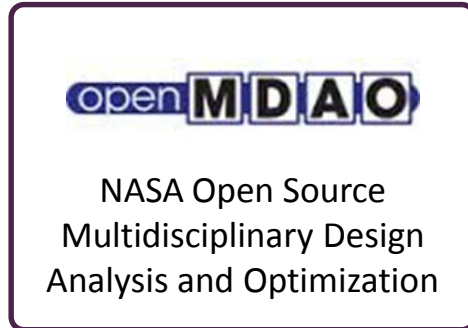
Pinto = Car(weight=2200, cost=8500)
```

Architecture Definition →
A pythonic interface for defining and storing SysML





MBSE meets MDAO



- Translate OpenMDAO Components and Assemblies into SysML Constraint Blocks
- Create OpenMDAO Architecture Assemblies based on SysML Parametric Diagrams
- Execute OpenMDAO assemblies and store data

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