A Rapid, Flexible Approach to Tradespace Definition and Exploration

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Presentation Overview

The Mission Tradespace Tool (MTT) is a methodology and software framework to improve JPL's early design process by offering a rapid way to separate feasible from infeasible architectures.

- Purpose
- Scope
- Process
- Framework
- Conclusions

Mission Tradespace Tool Purpose

- Growing demand for large tradespace explorations
- Time and cost to assemble suite of integrated, customized models can often exceed resources available
- MTT designed to address this shortcoming
  - Rapidity
  - Flexibility (Multiple Mission Types)
  - High level

Mission Tradespace Tool Purpose (continued)

- MTT is capable of:
  - Quickly assessing alternative architectures from multiple perspectives (i.e., cost, risk, science return,…)
  - Handling some of the key trade studies that any project might face (*universality*)
  - Identifying and analyzing options that a project hasn't yet looked at (*staying ahead of the curve*)

MTT Objectives

1) **Capture Tradespace**

2) **Winnow Tradespace**

(identify feasible architectures from a large array of candidate architectures)

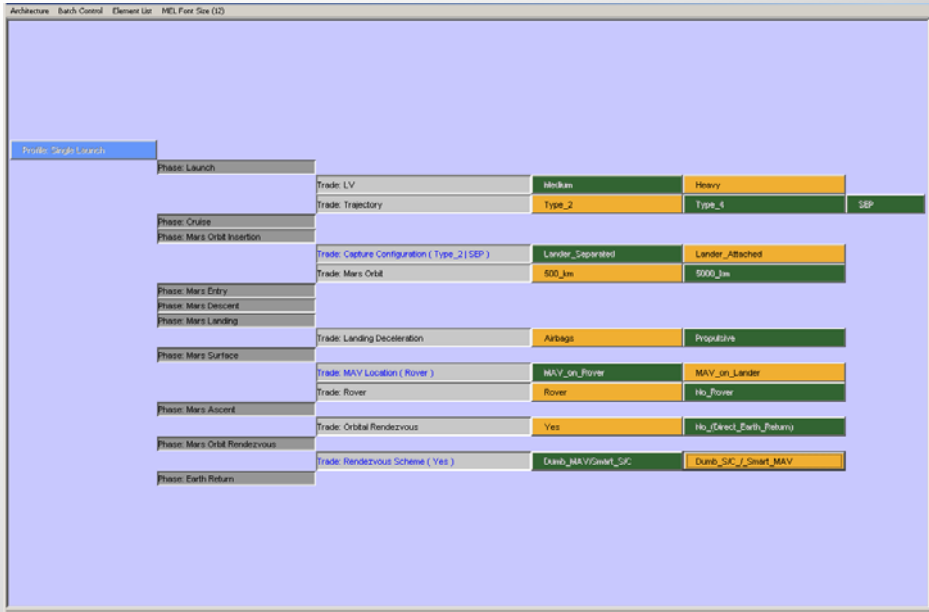
And do it rapidly!

Objective 1) Capture Tradespace

- Allows archiveability, traceability, repeatability, consistency
- Introduces standard format
- Clarifies thinking through structure
- Displays option context and rationale to team members

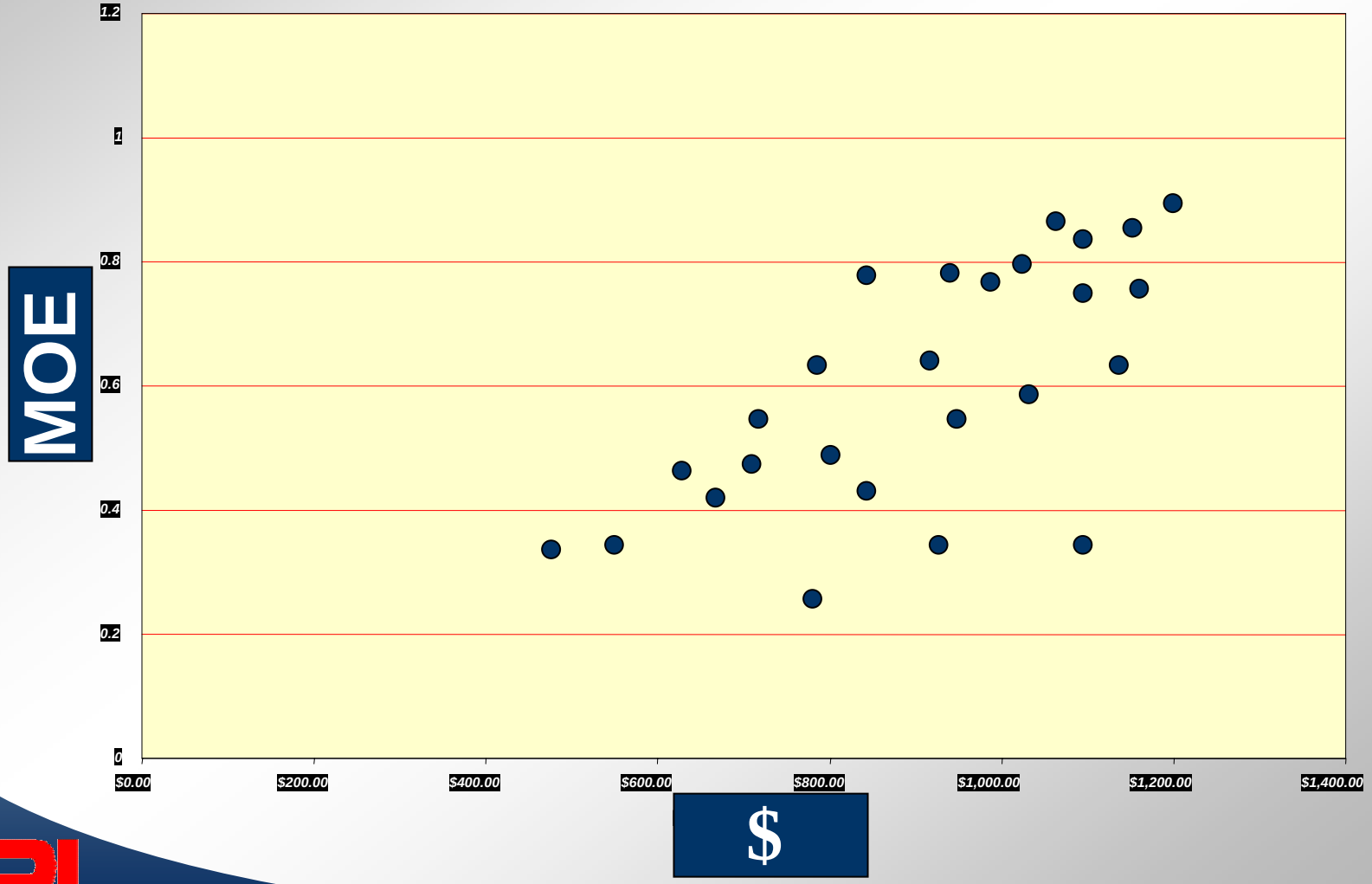
Stakeholders want this capability.

NPG 7120.5 requires it.



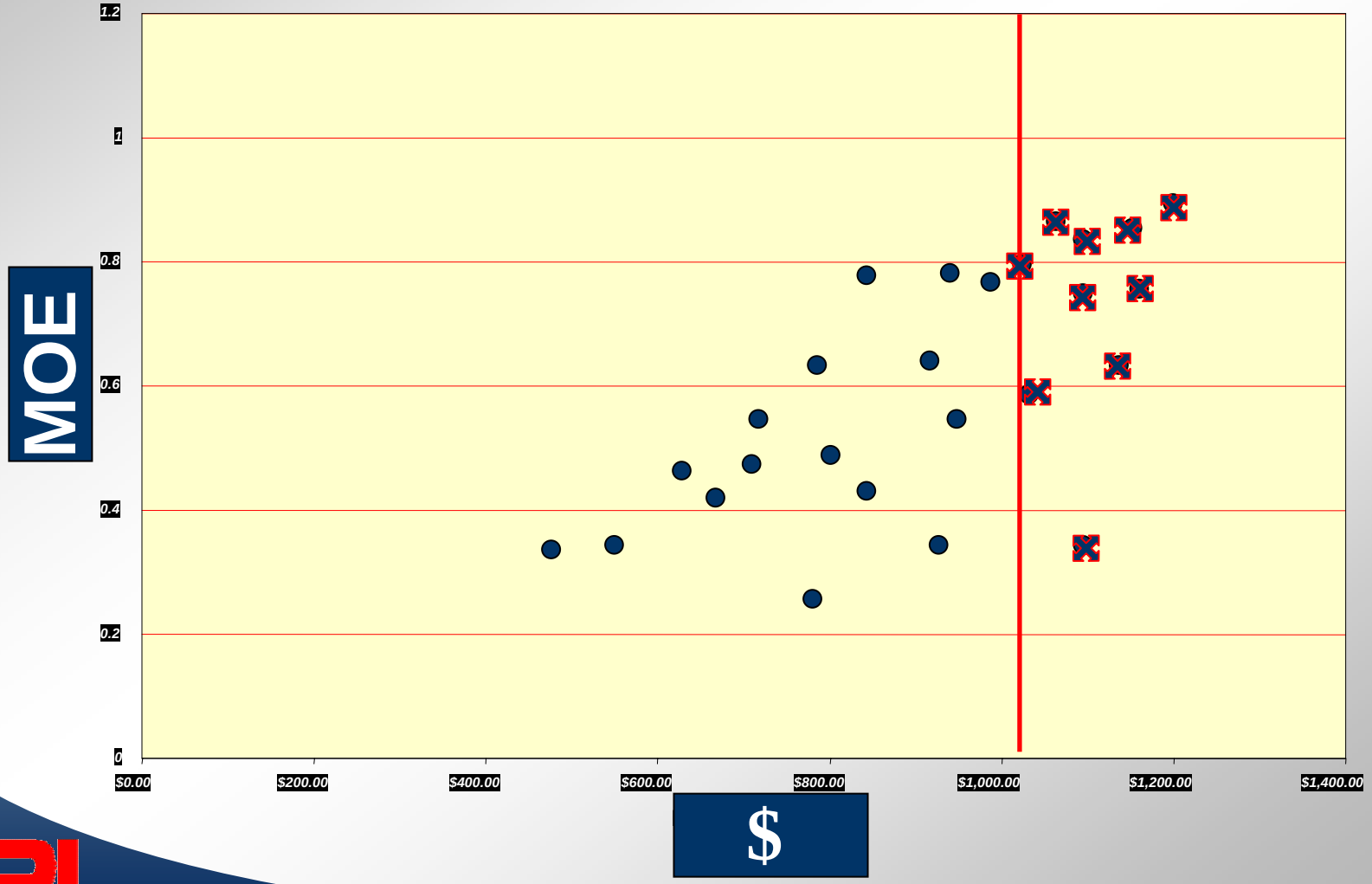
Objective 2) Winnow Tradespace

Generate Tradespace



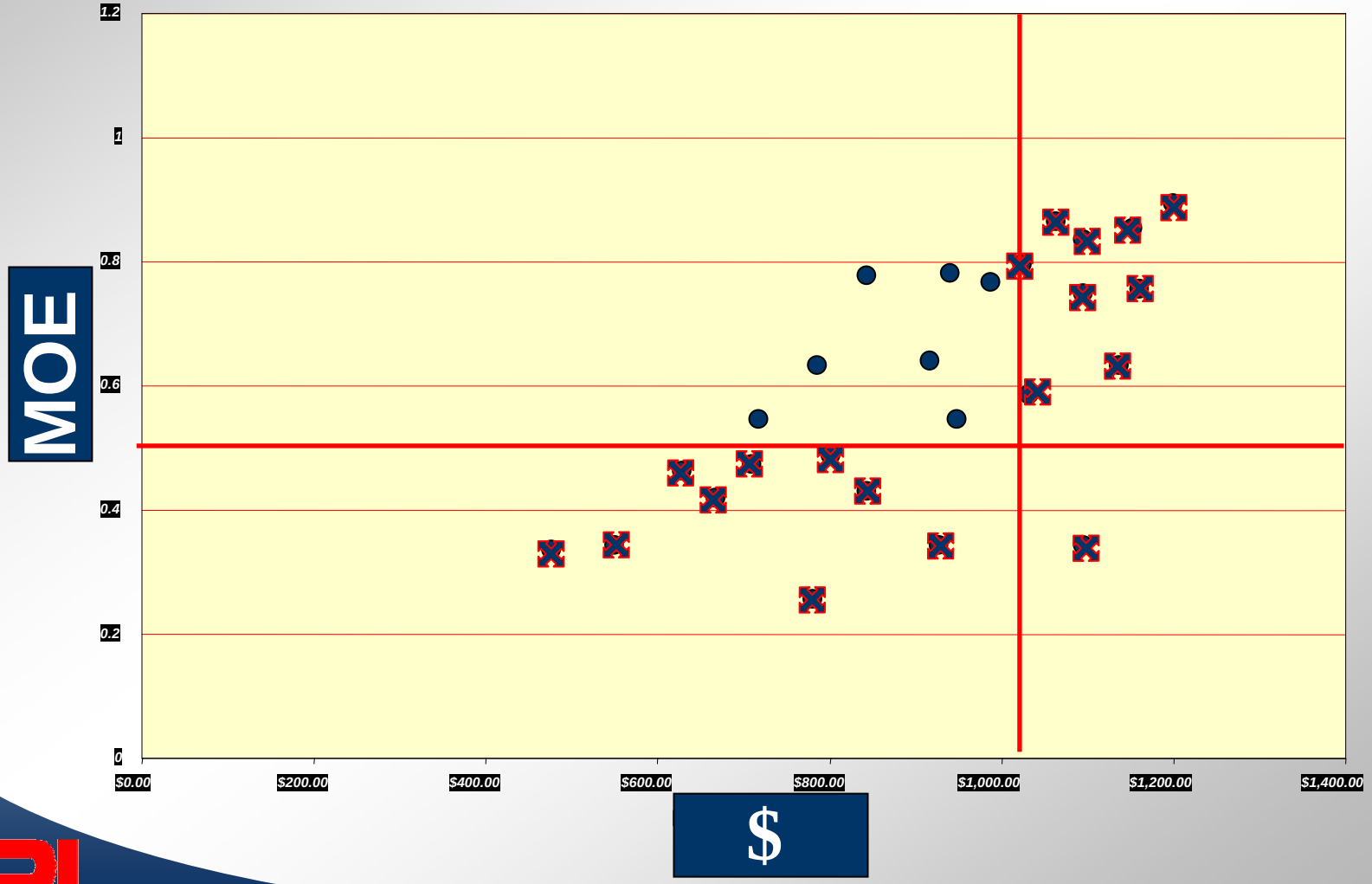
Objective 2) Winnow Tradespace

Apply cost cap



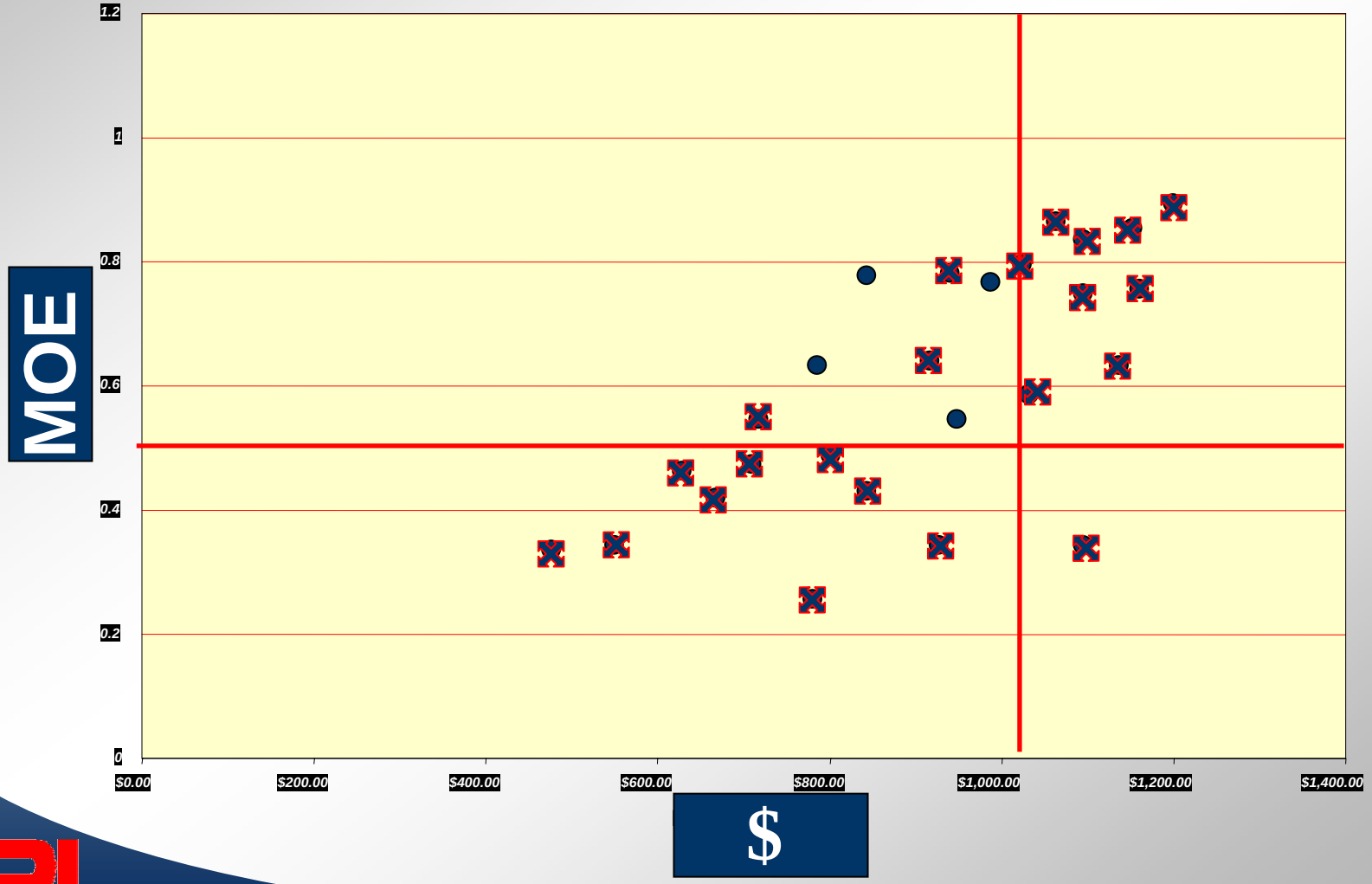
Objective 2) Winnow Tradespace

Apply MOE requirement



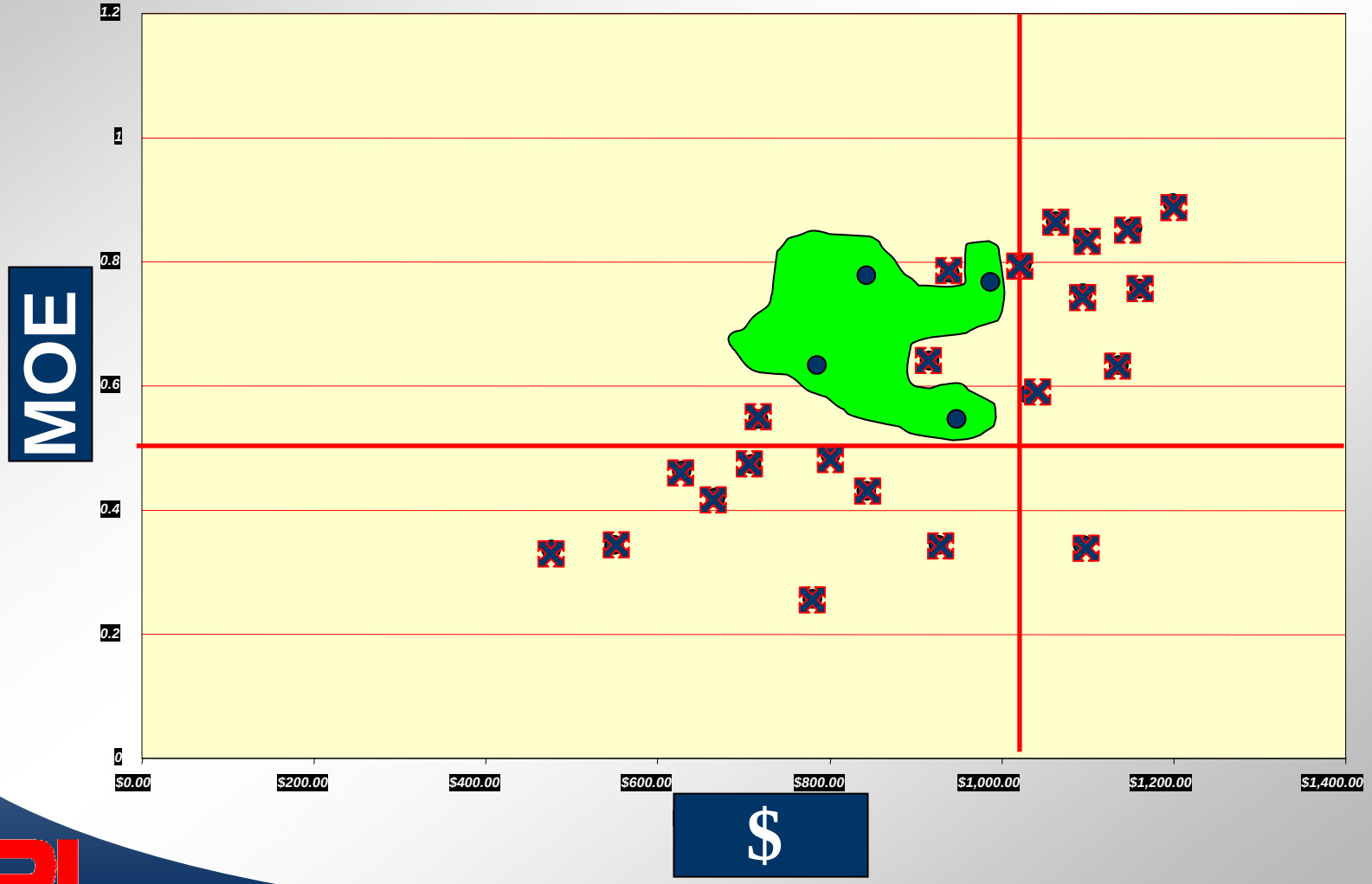
Objective 2) Winnow Tradespace

Filter infeasible options

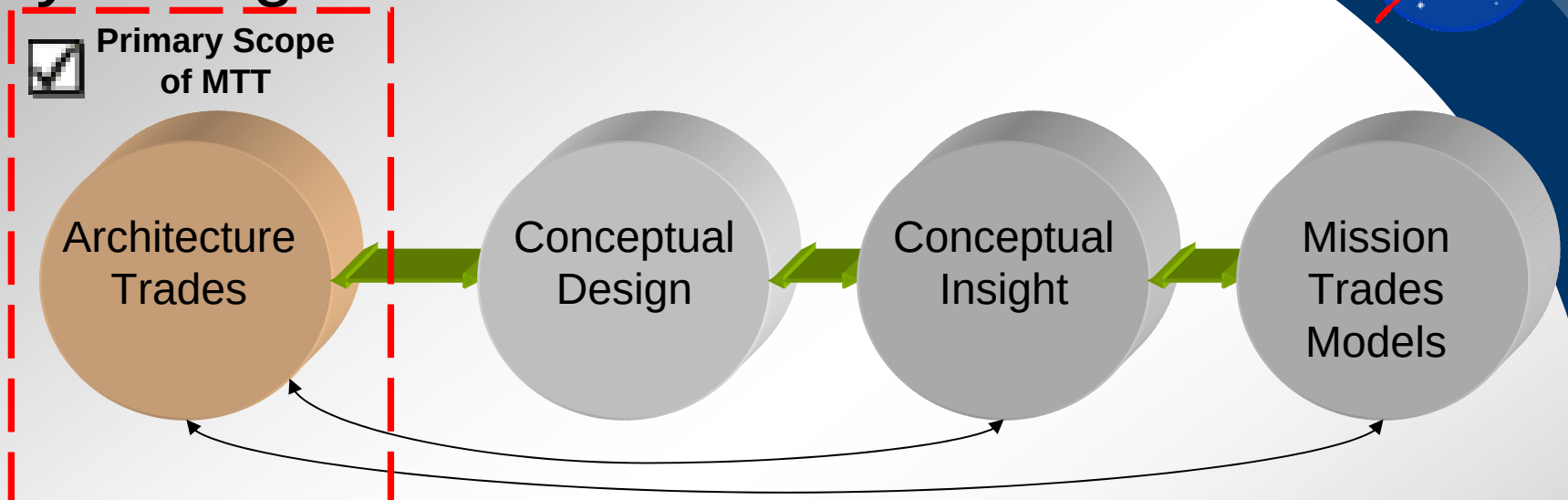


Objective 2) Winnow Tradespace

Identify feasible options

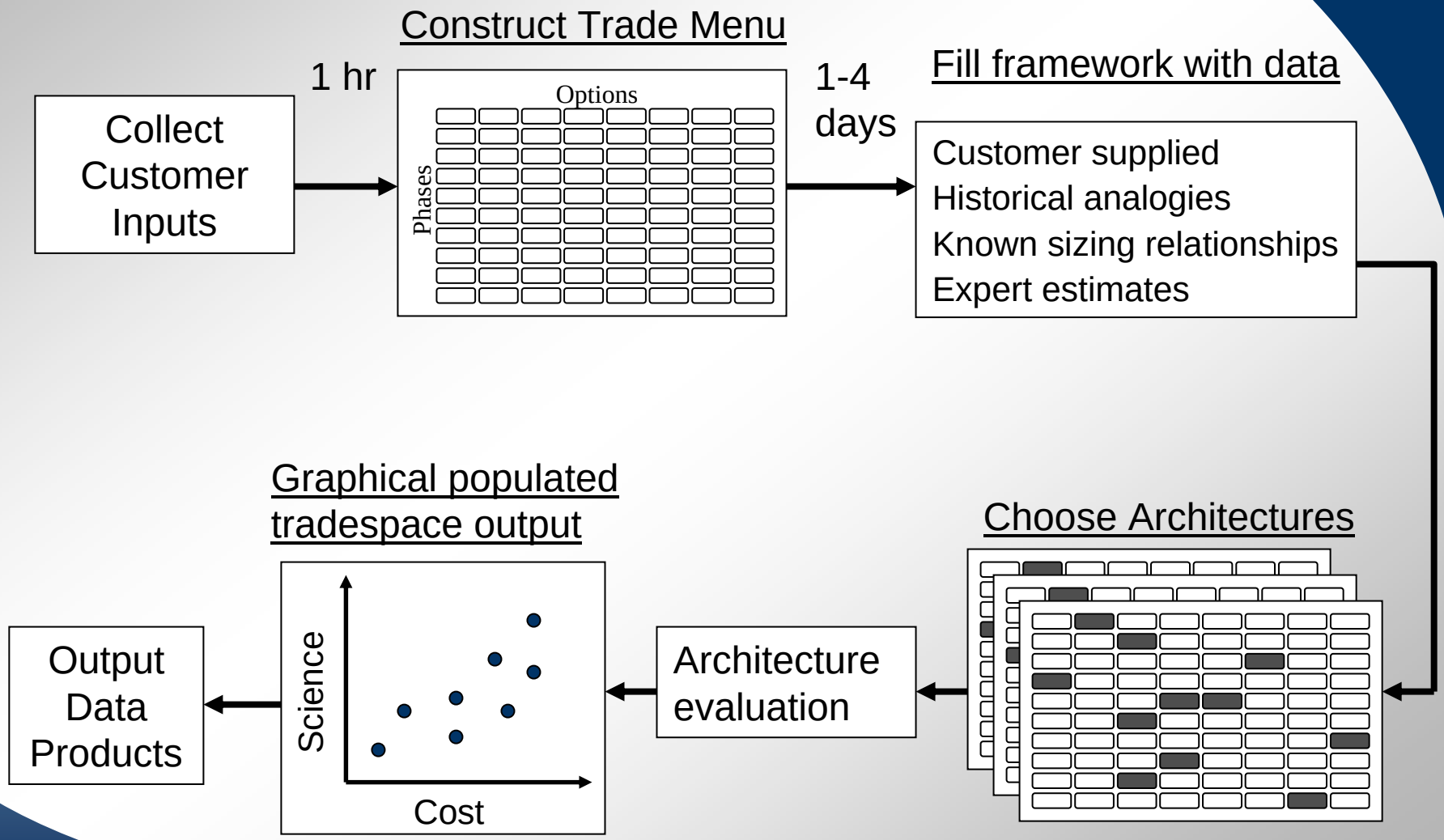


MTT Scope within Greater Early Design Process

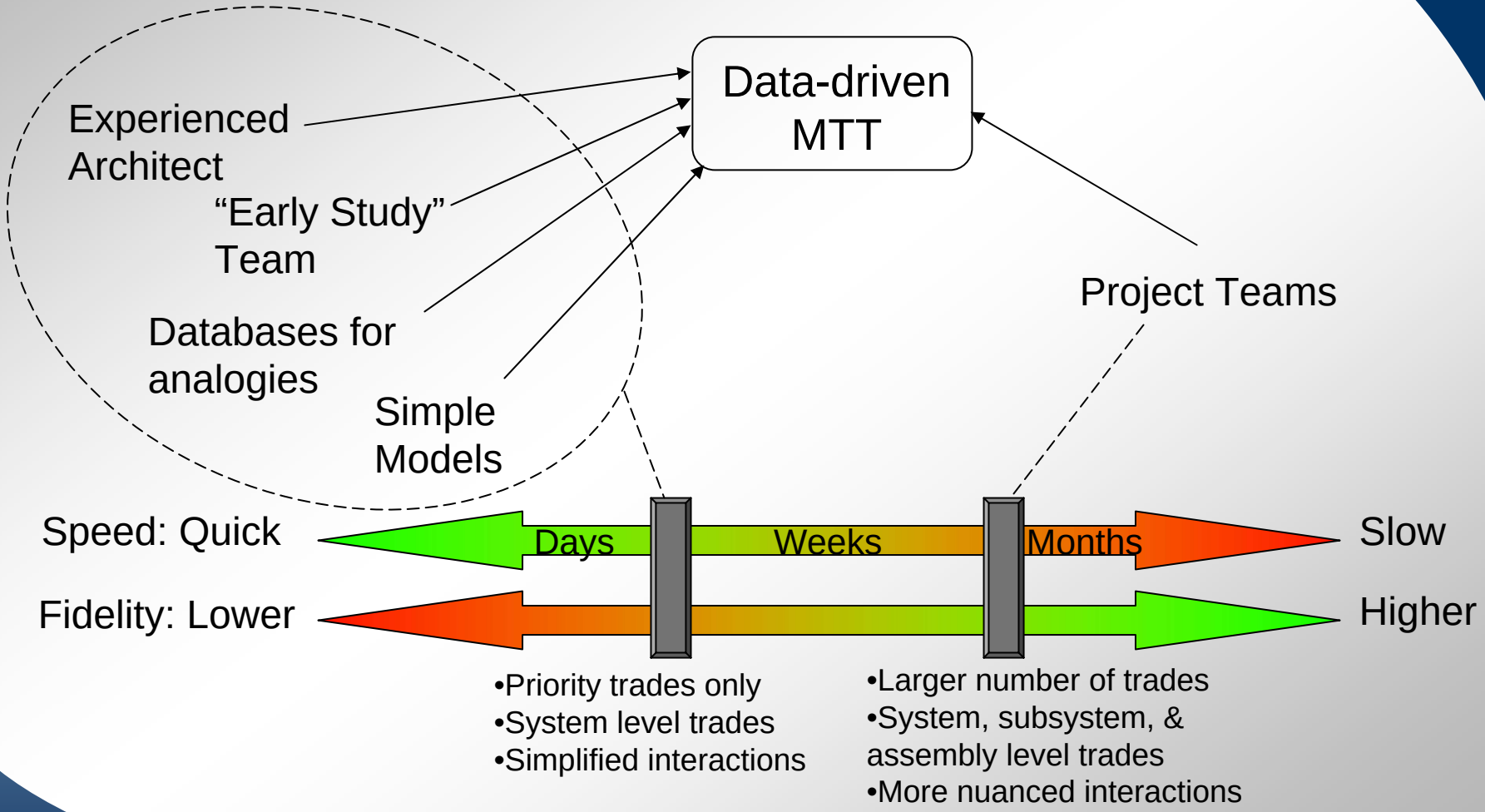


	Architecture Trades	Conceptual Design	Conceptual Insight	Mission Trades Models
Speed	<1 week	~2 weeks	~1week following conceptual design	<2 months
Effort	<40 FTE hours	~300 FTE hours	~40 FTE hours	Varies by mission
	High-level tradespace identified and populated with broad range of options. Promising architecture(s) chosen for further evaluation	Conceptual design baseline developed for chosen architecture. Cost and engineering depth added	Tradespace re-expanded and local sensitivities explored around conceptual baseline	Unique mission questions addressed through integrated modeling. Fidelity added

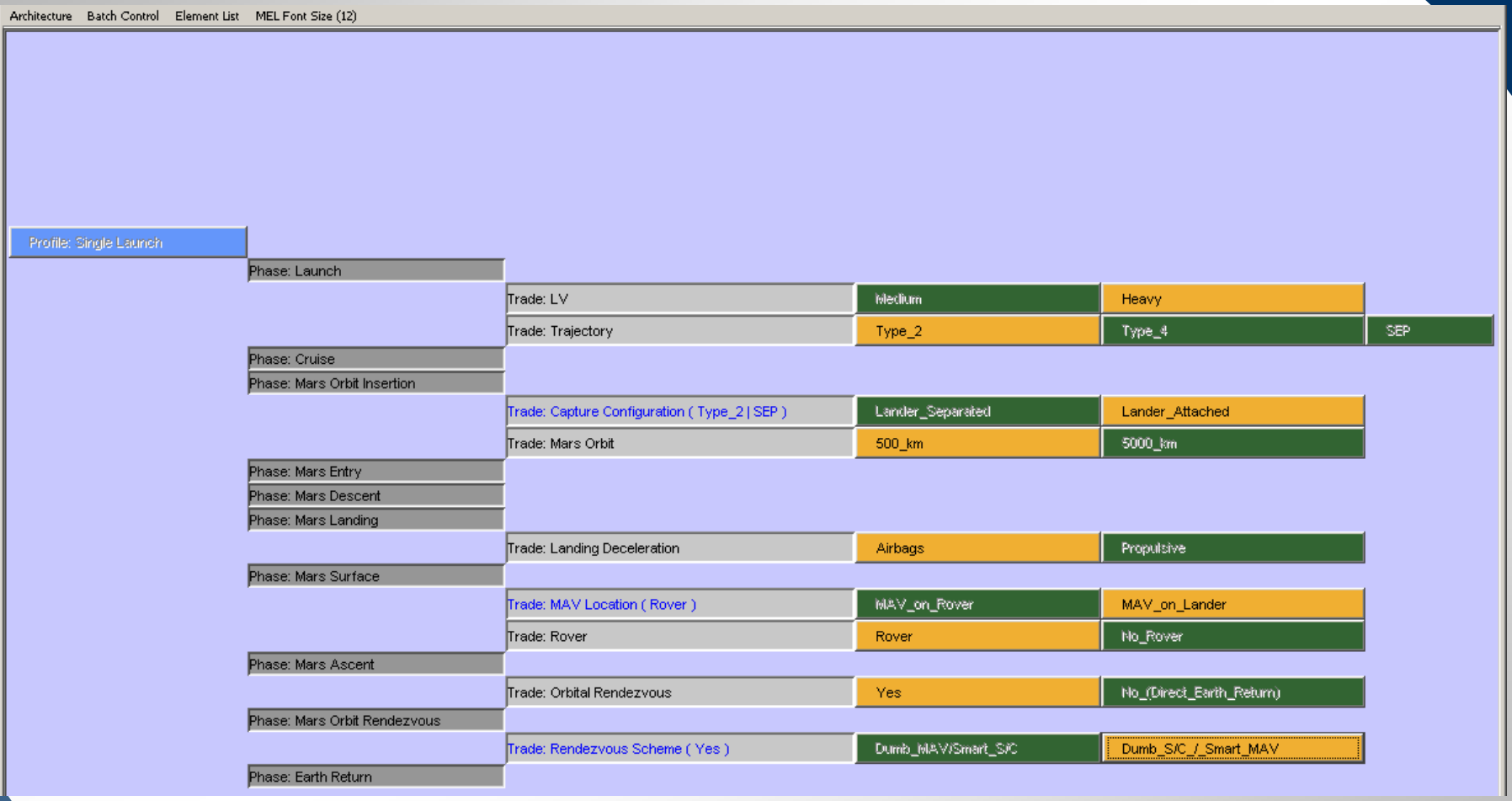
MTT Process Flow



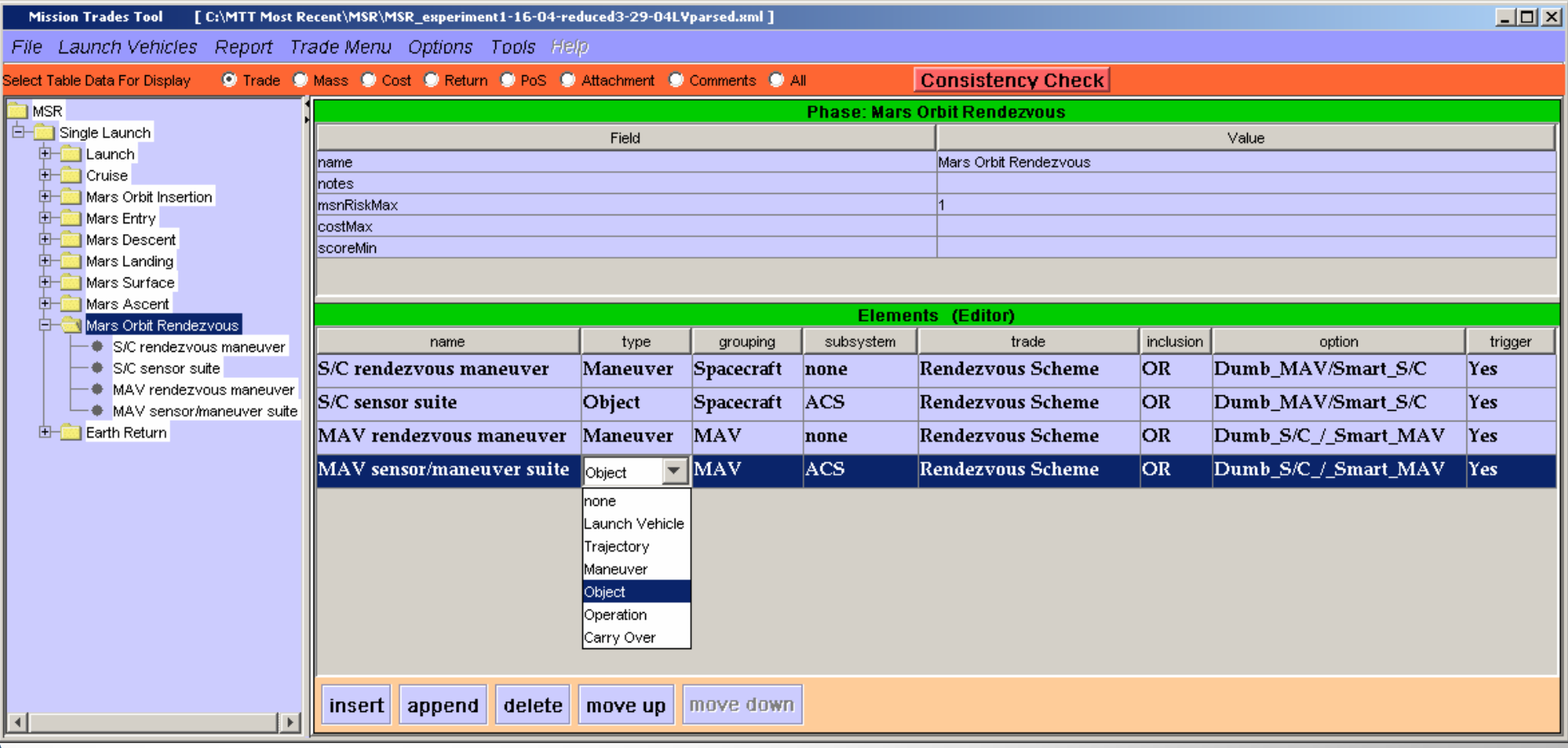
MTT data sources



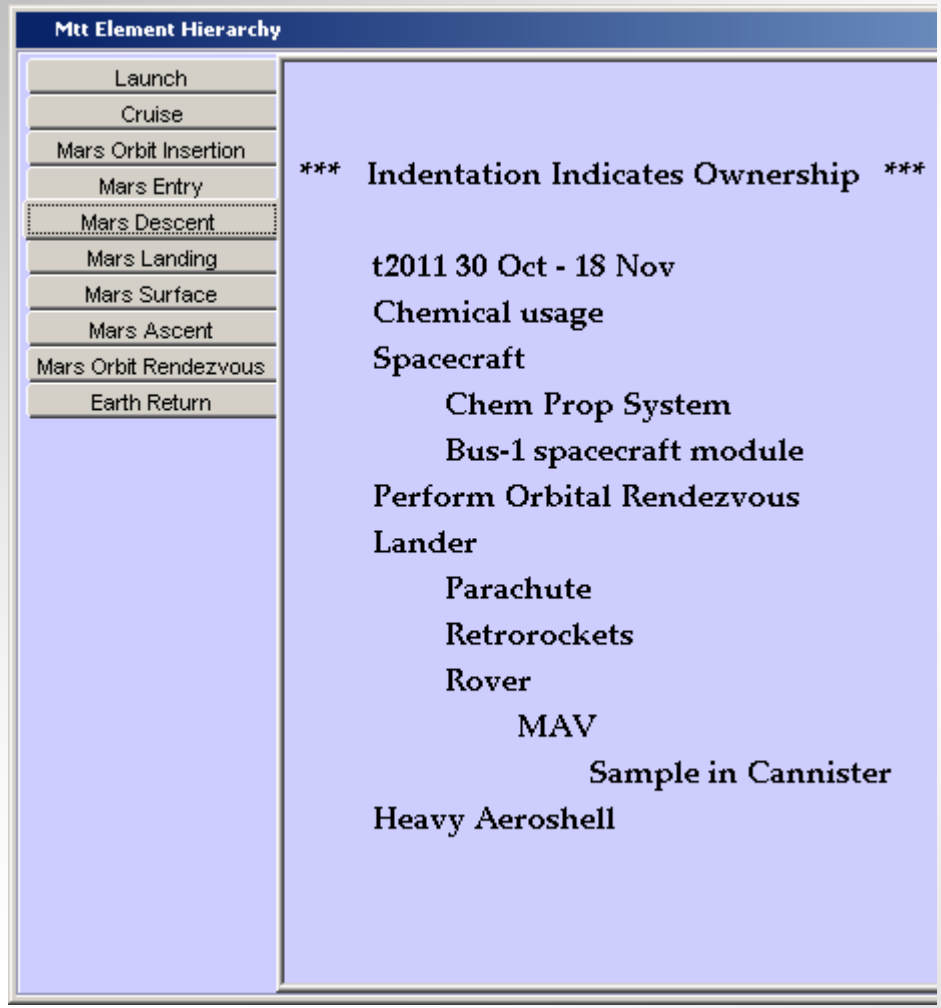
Framework: Example Trade Menu



Framework: Data Entry Interface



Example Segment Hierarchy Display



Example Segment Maneuver & Mass Display

Mtt Element Mass

Mass Data (Dry Mass,Prop Mass)

Maneuver Data [DeltaV,ISP]	Segments			
Phases	Spacecraft	Lander	Rover	MAV
Launch	1430.0 2147.8	795.0 12.0	245.0 .0	170.0 41.8
Cruise	1430.0 2147.8	795.0 12.0	245.0 .0	170.0 41.8
	[100 325.0]			
Mars Orbit Insertion	635.0 2035.5	795.0 12.0	245.0 .0	170.0 41.8
	[1200 325.0]			
Mars Entry	635.0 1197.2	795.0 12.0	245.0 .0	170.0 41.8
Mars Descent	635.0 1197.2	695.0 12.0	245.0 .0	170.0 41.8
Mars Landing	635.0 1197.2	655.0 12.0	245.0 .0	170.0 41.8
		[50 300.0]		
Mars Surface	635.0 1197.2	655.0 .0	245.0 .0	170.0 41.8
Mars Ascent	635.0 1197.2	485.0 .0		170.0 41.8
				[700 325.0]
Mars Orbit Rendezvous	635.0 1197.2	485.0 .0		170.0 .0
	[112 325.0]			
Earth Return	655.0 1133.9	485.0 .0		150.0 .0
	[3200 325.0]			
DeltaV Totals	*** 4612.0 ***	*** 50.0 ***	*** 0.0 ***	*** 700.0 ***

Steps in the Tradespace Investigation Process

Time to understand customer needs

Time to architect a trade tool

Time to gather data and relationships

Time to enter data & relationships into trade tool

Time to troubleshoot

Time to compute populated tradespace

Time to extract meaningful results

Conclusions

- MTT offers rapid, flexible method:
  - To define a high-level tradespace
  - To explore a high-level tradespace
- Dependent on knowledgeable system engineer/analyst
  - Necessary to exploit open framework
  - Not necessarily a drawback
- Trustworthiness
  - Verified algorithms
  - Challenge of validation
- Reduced trade study cycle time

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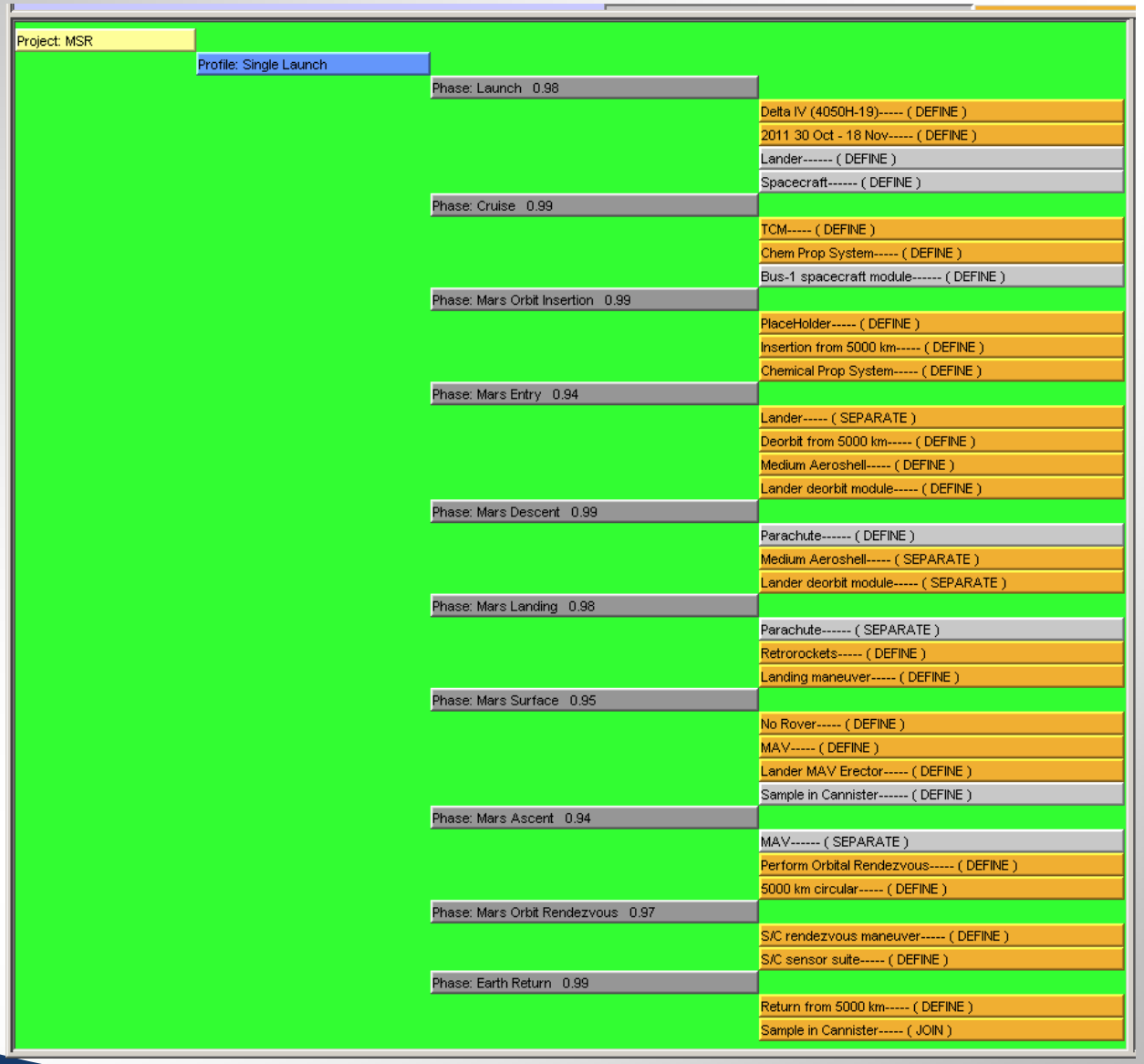
Backup Slides

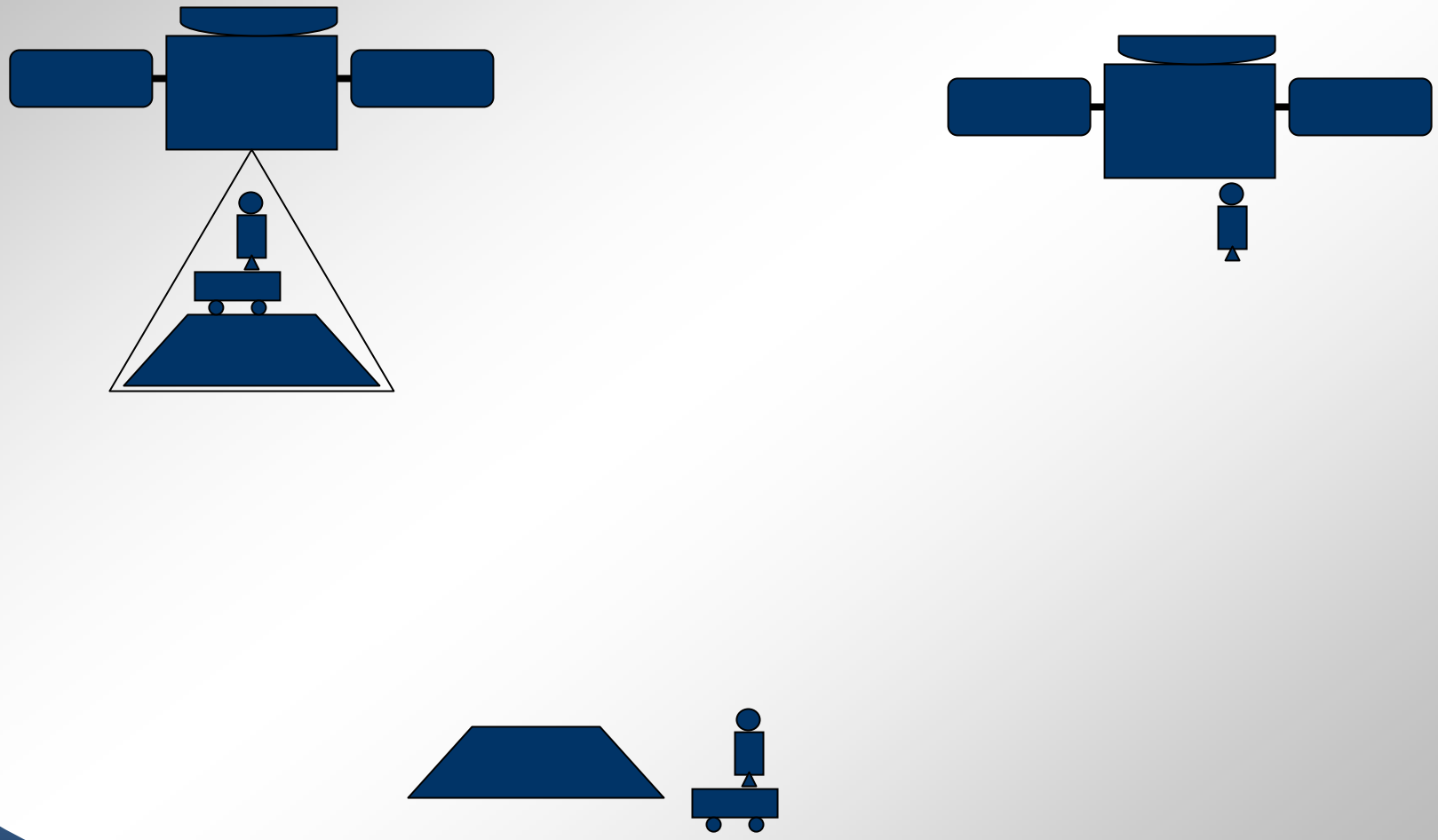
Embedded Features

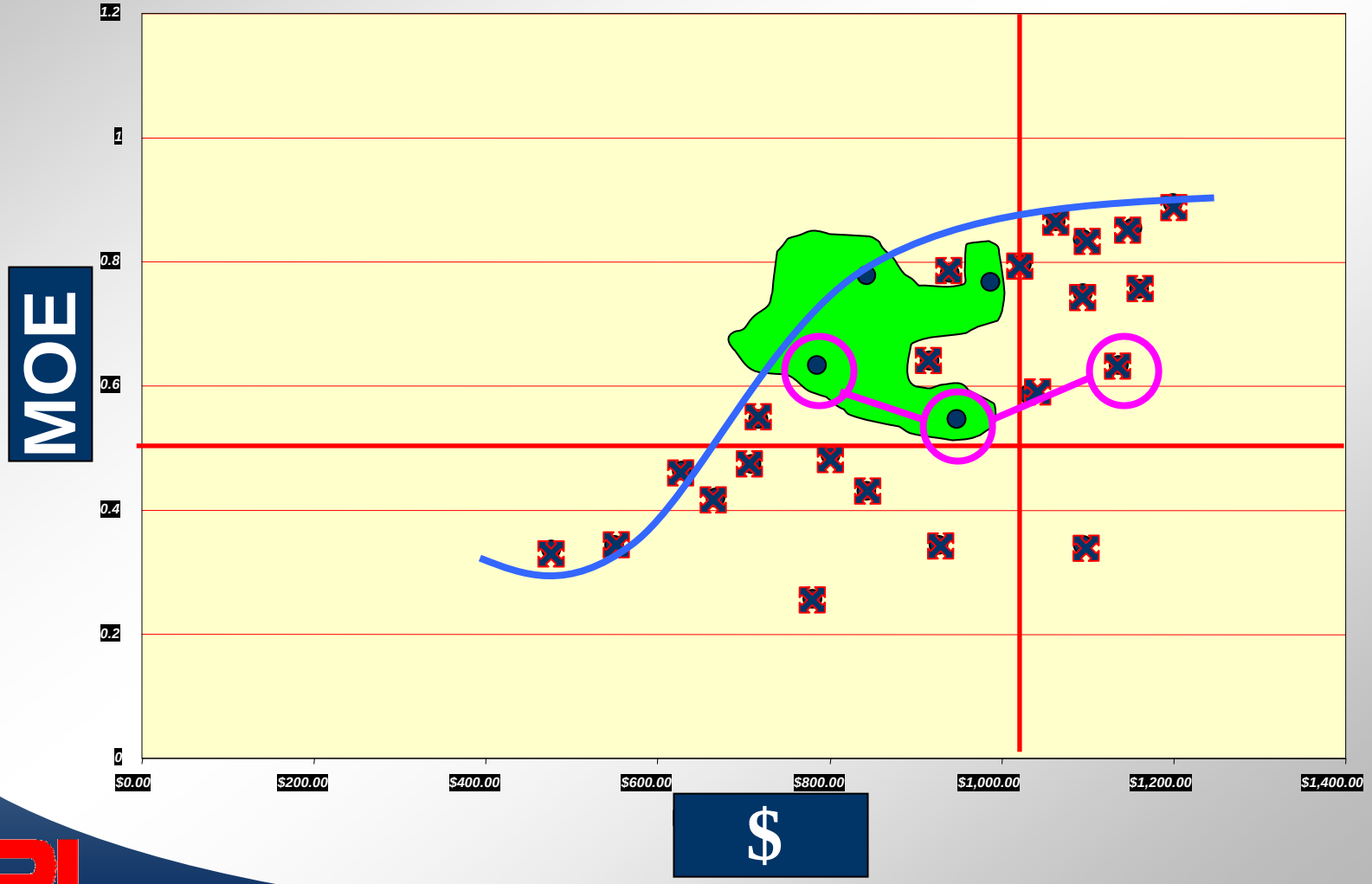
- Automatic convergence of user-supplied simultaneous equations
- Unlimited attribute creation
- Embedded propellant bookkeeping
- Equation builder
- Cost wrapping, fiscal year conversion
- Launch vehicle solver
- Selectable feasibility constraints
- Option filtering
- Automatic data consistency checking
- Output file sharing to Excel and visualization software

Example System Architecture Screen



Multi-Segment Linkage Problem



Objective 2) Winnow Tradespace

Identify Architectural Trends