
Lecture 6:
Integrated Concurrent Engineering (ICE) and MATE-CON
Space Systems Architecture
Prof. Daniel Hastings
Dr. Hugh McManus

Integrated Concurrent Engineering

A process creating preliminary designs very fast

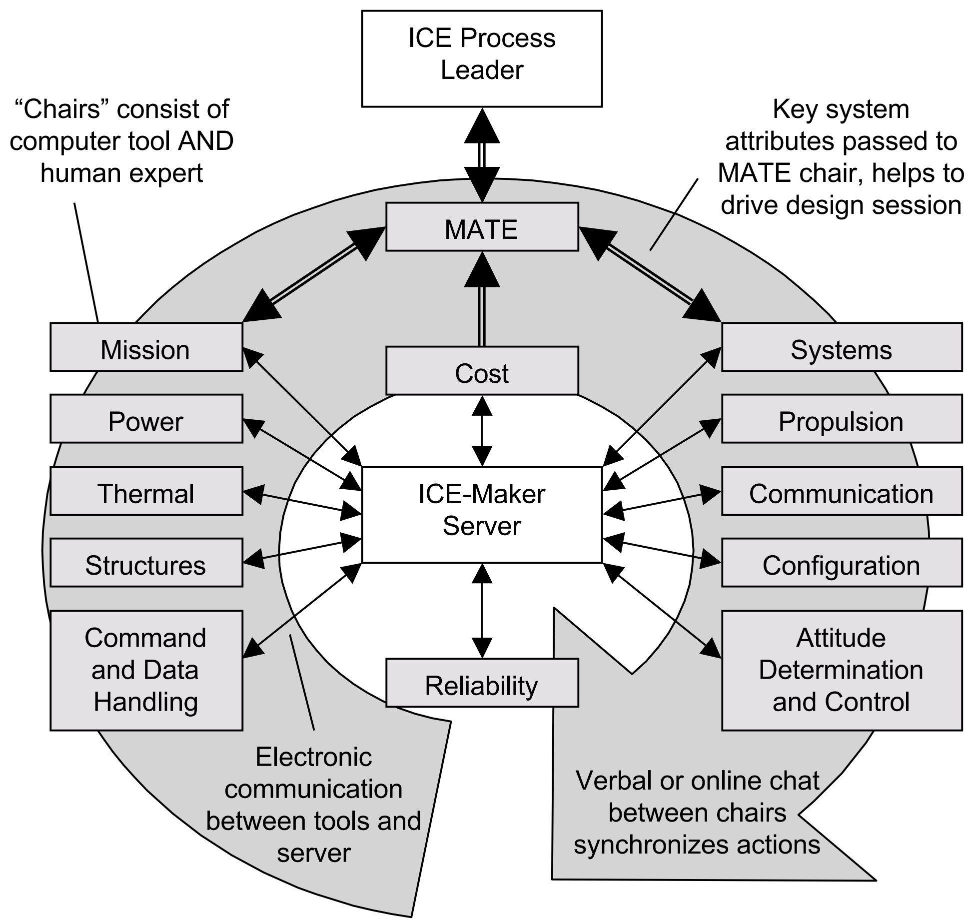
- ICE (and other names) practiced at Caltech, JPL, Aerospace, ESA, and many other places
- Linked analytical tools with human experts in the loop
- Very rapid design iterations
- Result is conceptual design at more detailed level than seen in architecture studies
- Allows understanding and exploration of design alternatives

Relation to MATE:

Allows rapid reality check on chosen architectures

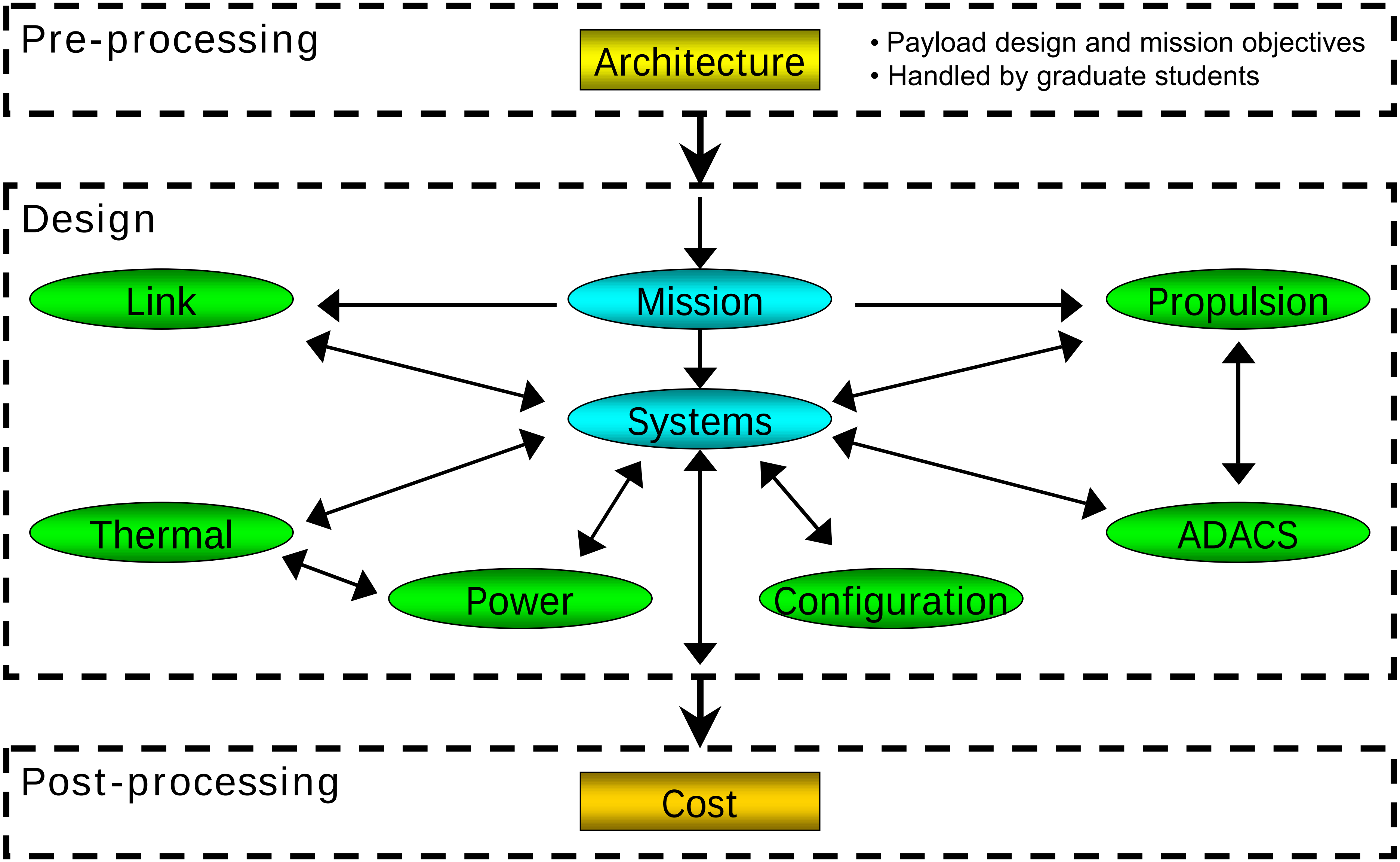
Aids transition to detailed design

ICE Process (CON with MATE)



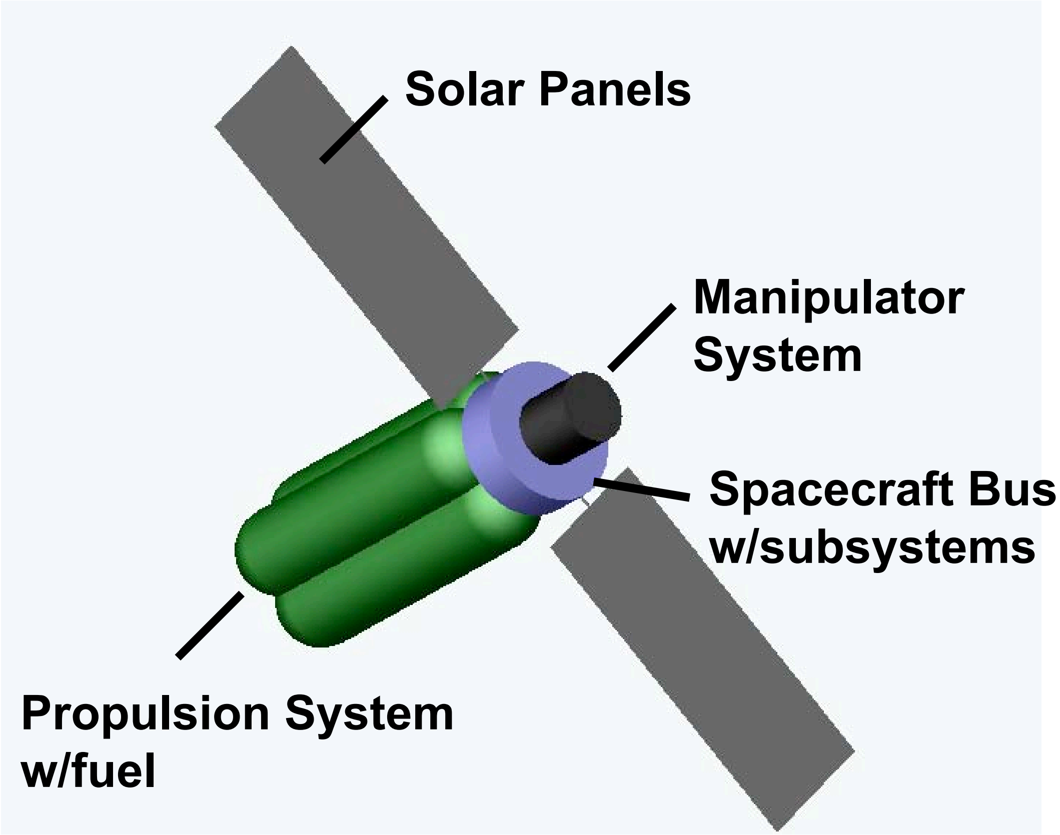
- Directed Design Sessions allow very fast production of preliminary designs
- Traditionally, design to requirements
- Integration with MATE allows *utility* of designs to be assessed real time

Example ICE Analysis Block Diagram



Typical Result: Bipropellant GEO Tug

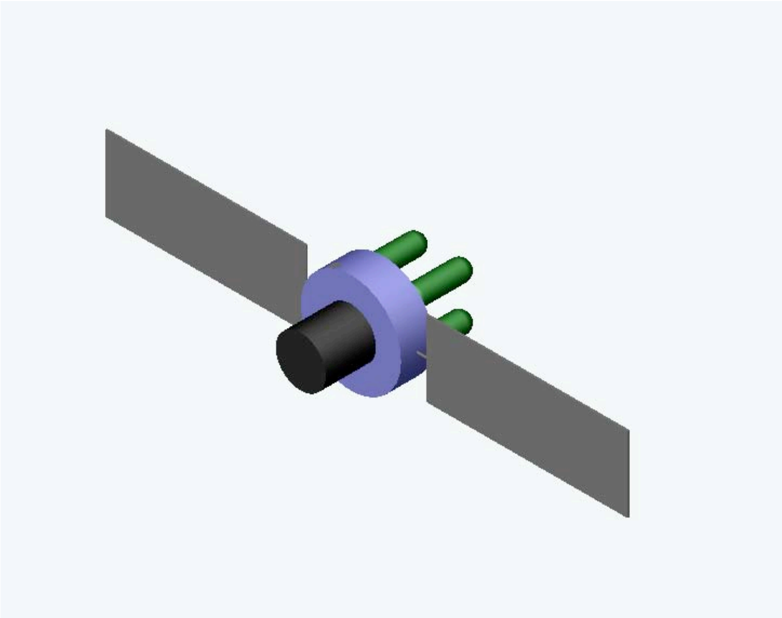
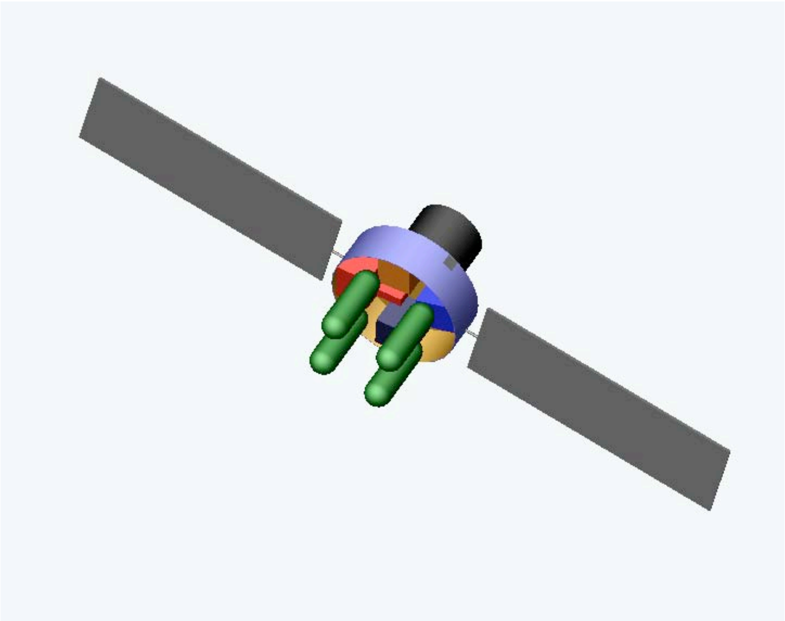
- Approx. 1300 kg dry mass, 11700 kg wet mass
- Quite big (and therefore expensive); not very practical (?);



Scale for all images: black cylinder is 1 meter long by 1 meter in diameter

Electric Propulsion RT GEO Tug

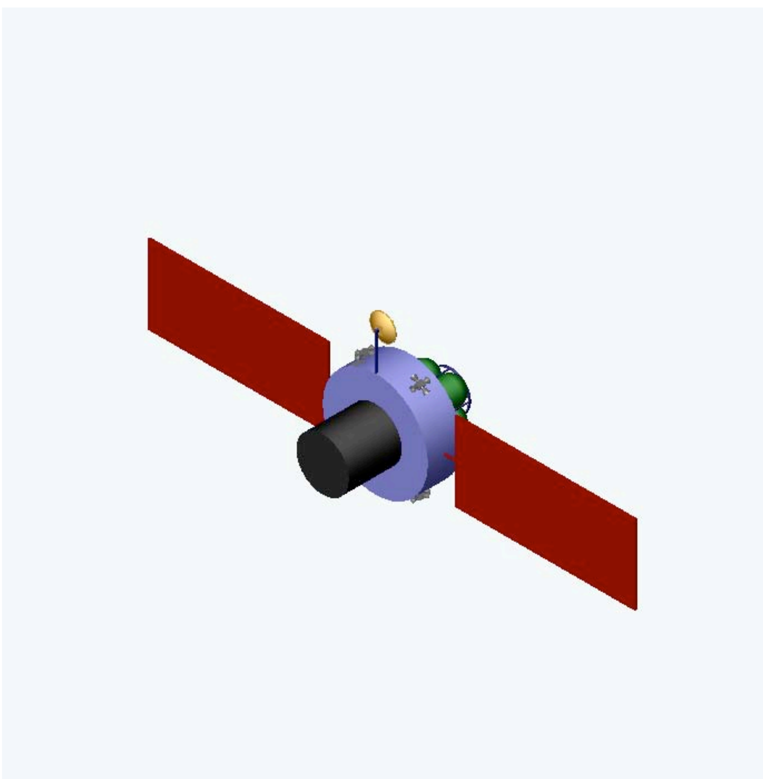
- Approx. 700 kg dry mass, 1100 kg wet mass
- Includes return of tug to safe orbit
- A reasonable, versatile system

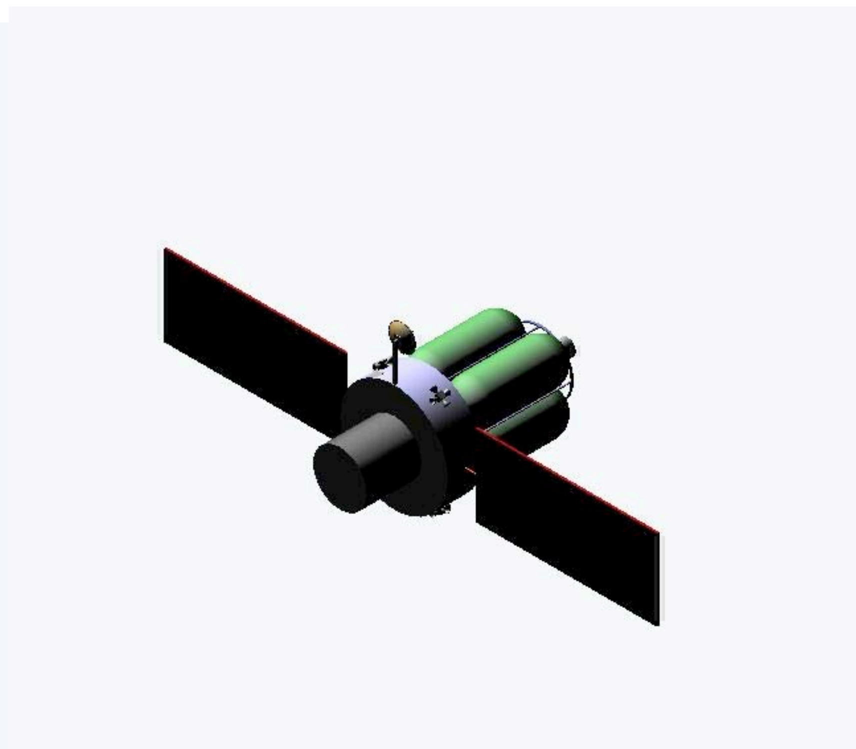



The "Electric Cruiser"

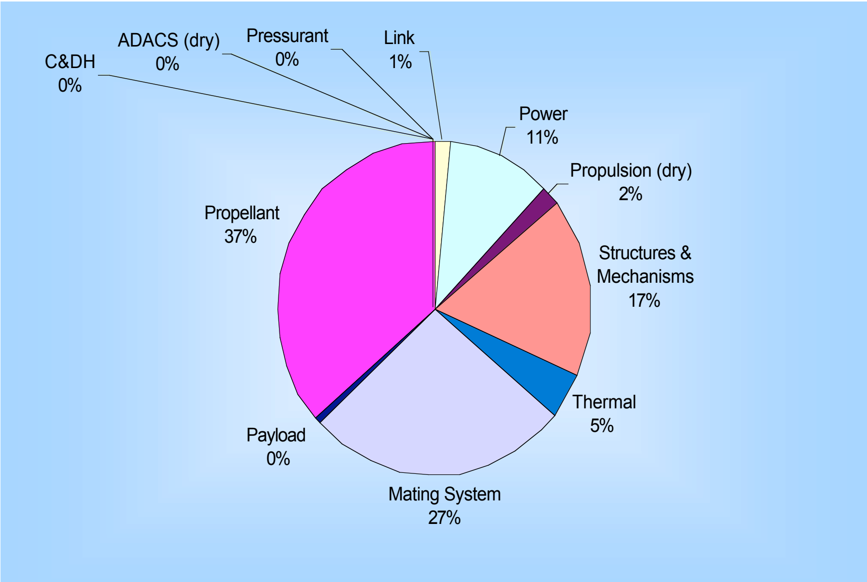
Bi-prop Tender Designs

- Lower Utility, lower cost systems
- Can’t go to GEO (though can work there if inserted)
- 700-1000 kg dry mass; 1000-4000 kg wet mass
- A family of potential vehicles with reasonable sizes and mass fractions

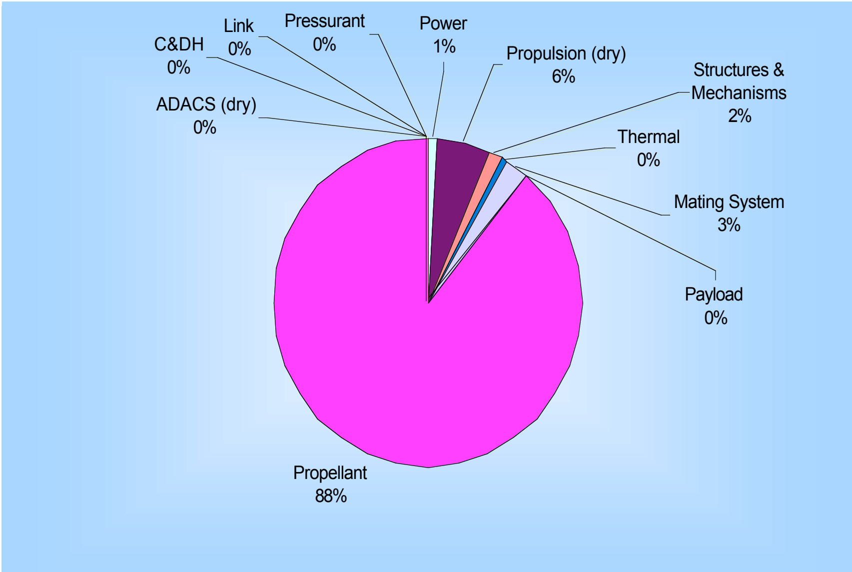




Mass Distribution Comparison



Electric Cruiser

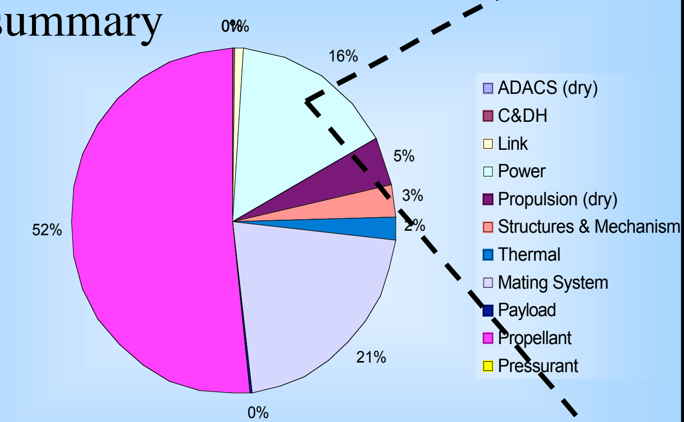


Biprop one-way

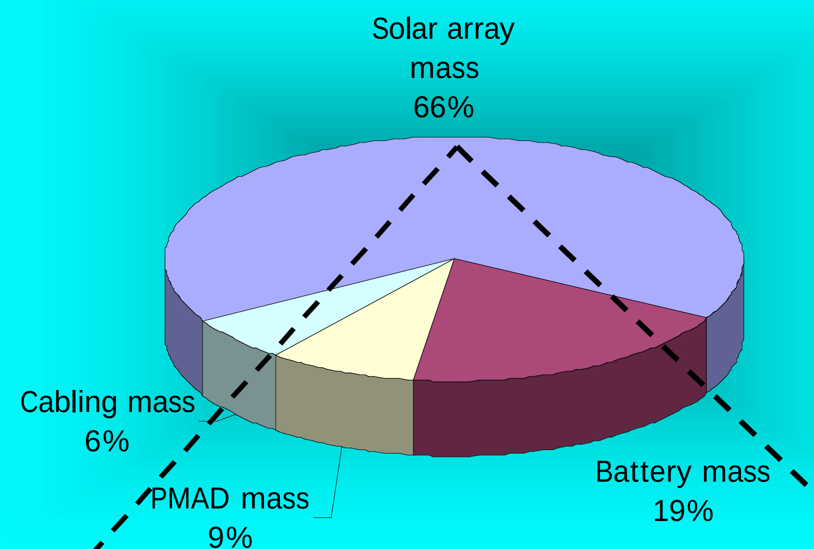
- Low ISP fuel requires very large mass fraction to do mission
- Other mass fractions reasonable, with manipulator system, power system, and structures and mechanisms dominating

More Than Mass Fractions

LEO Tender 1 mass summary



Power System Mass Breakdown



Select solar array material:	Triple Junction (InGaP/GaAs/Ge)	
Minimum efficiency	24.5	%
Maximum efficiency	28.0	%
Nominal temperature	28.0	C
Temperature loss	0.5	%/deg C
Performance degredation	2.6	% / year
Minimum temperature	0.5	C
Maximum temperature	85.0	C
Energy density	25.0	W / kg
Solar array mass	150.6685167	kg
Total solar array area	9.965098159	m^2
# of solar arrays	2	#
Individual solar array area	4.98254908	m^2

Detailed information can be drawn from subsystem sheets, including efficiencies, degradations temperature tolerances, and areas

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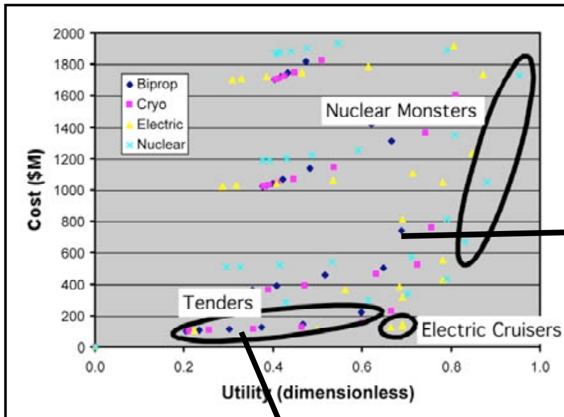
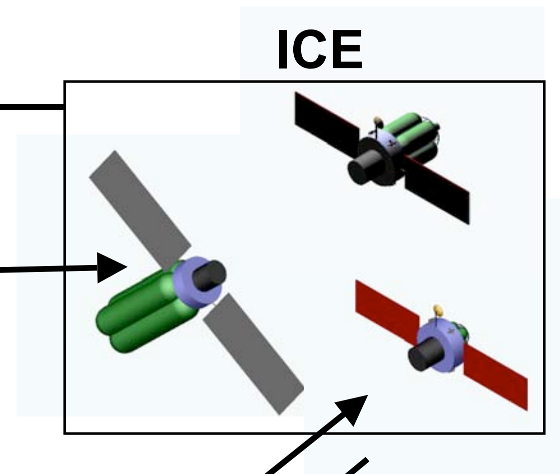
Synergies Between Methods Results in Powerful Conceptual Design Capability

MATE



ICE

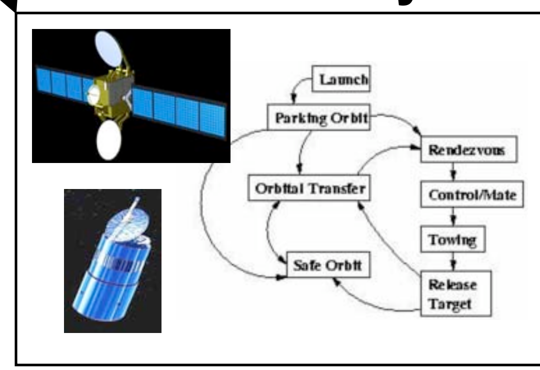


Validation and understanding

Design attributes & sensitivities

Feasible mission concepts

Mission Analysis

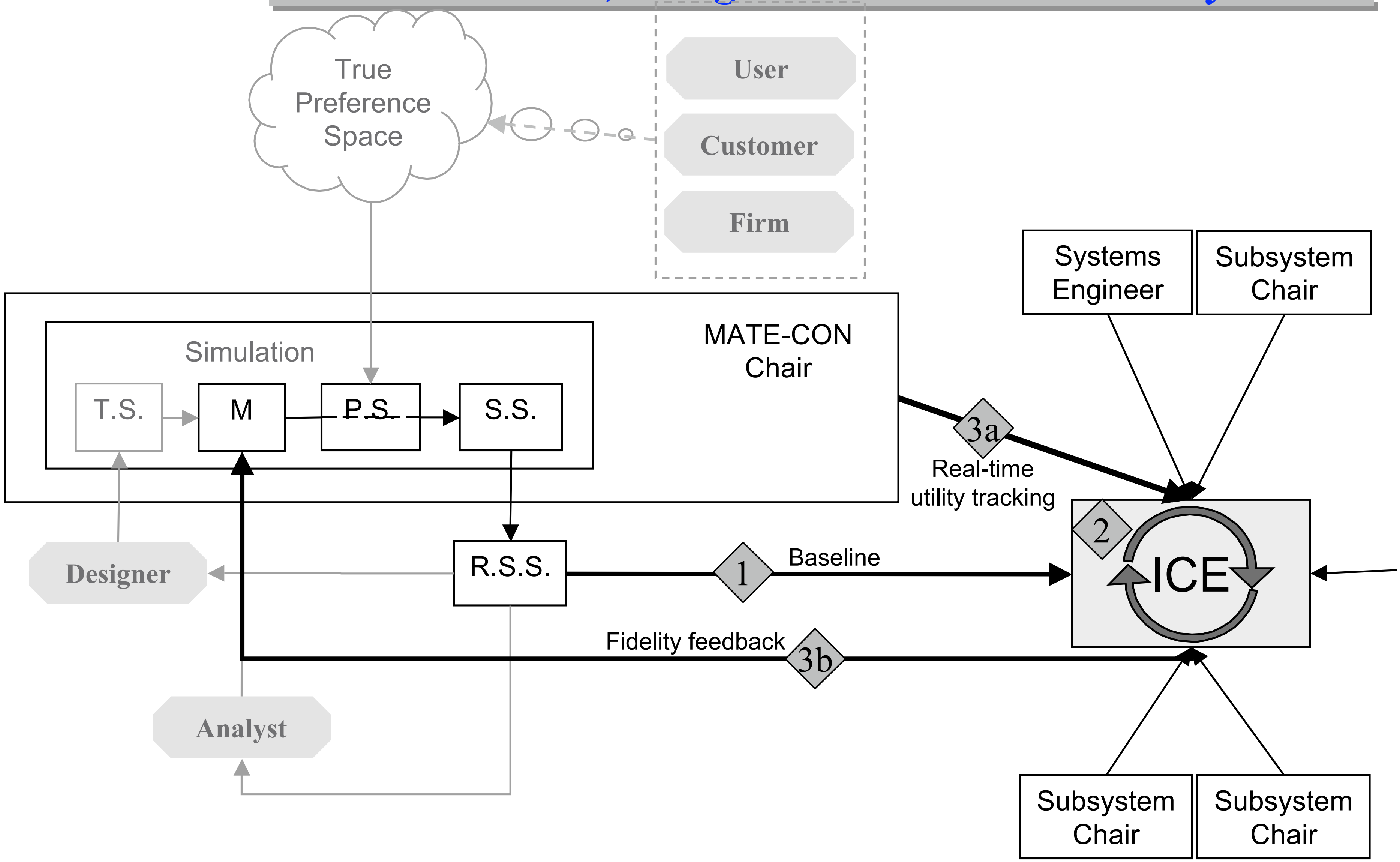


Point design requirements

Family concepts, multi-mission tender

Right Design(s) for the Right Mission(s)

MATE-CON is the merging of MATE and ICE, using a MATE-CON or Utility Chair



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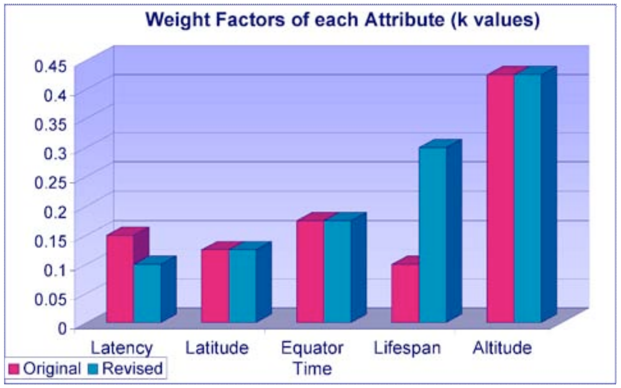
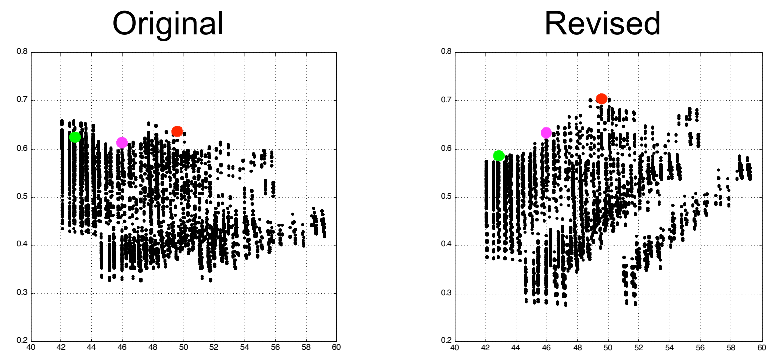
MATE-CON Benefits



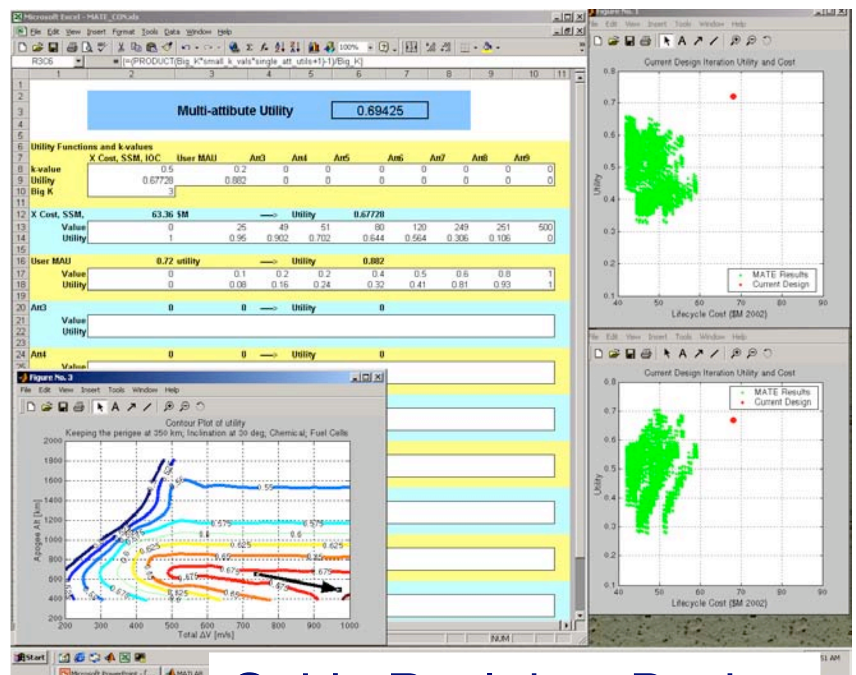
Capture Preference Change



Re-evaluate Solution Spaces

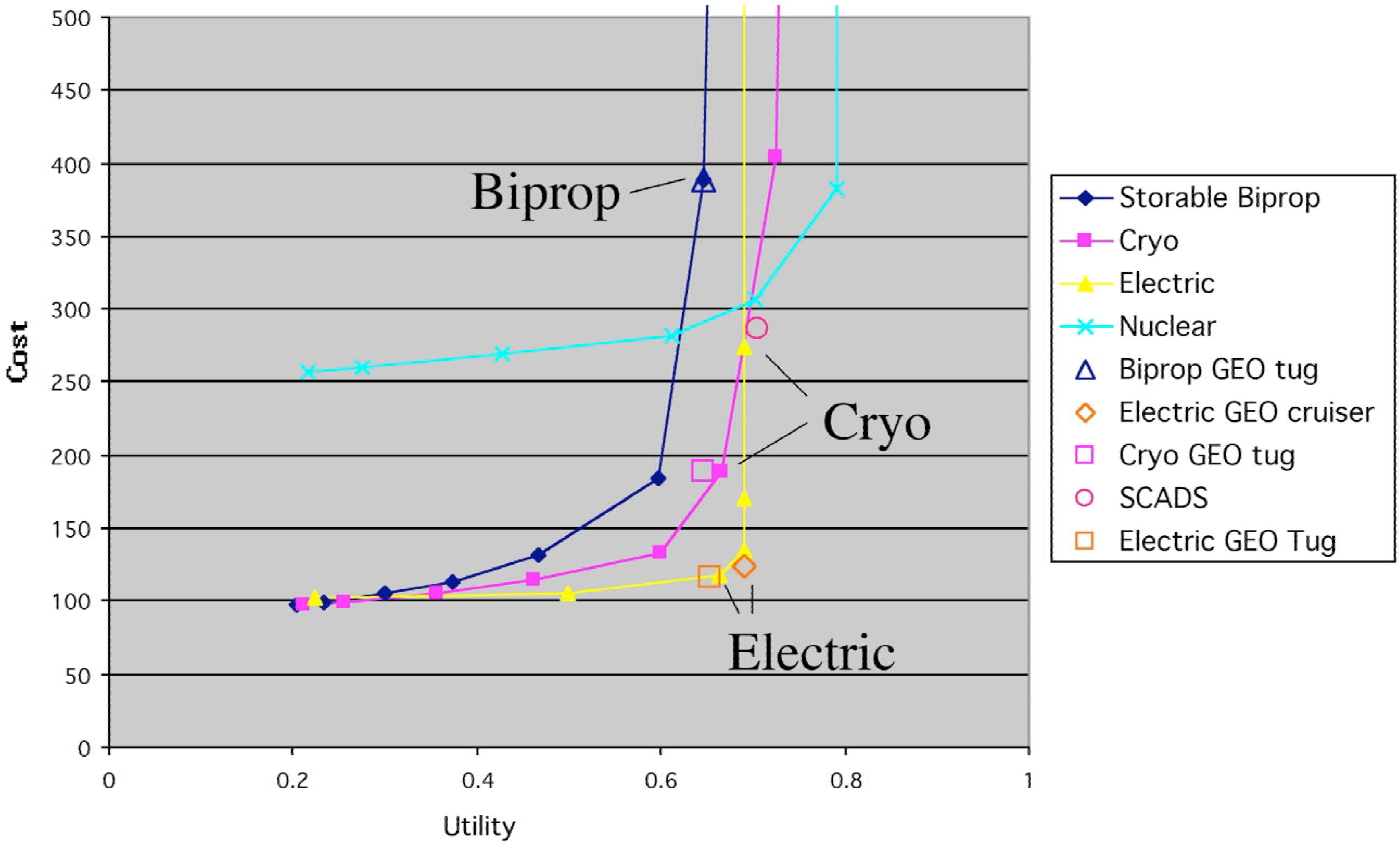
MATE-CON can…

- Guide engineers to higher value solutions in a concurrent environment
- Allow for rapid re-evaluation in the face of changing preferences
- Enable direct comparisons of vastly different concepts



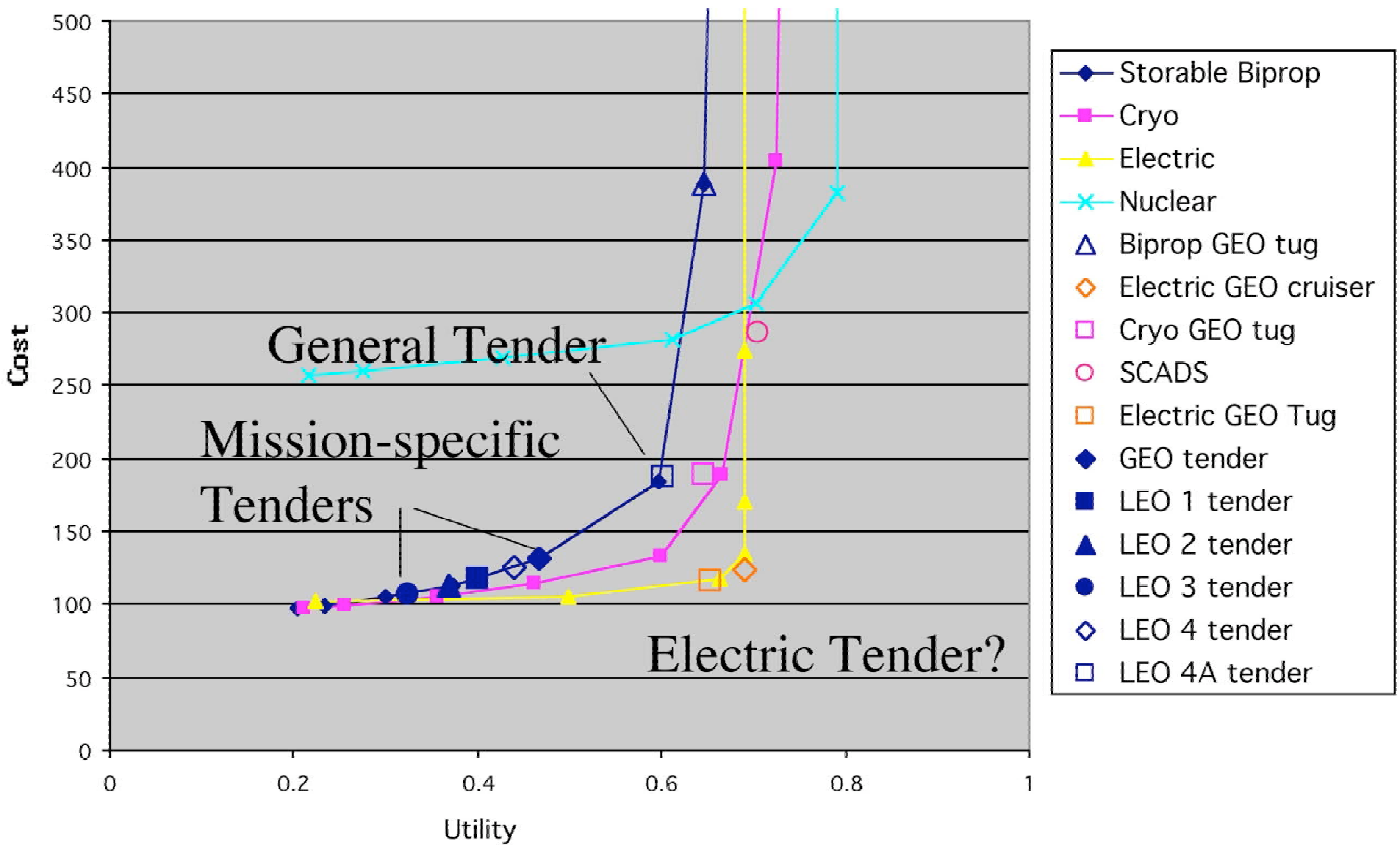
Guide Real-time Design

Trade Space Check - GEO missions
ICE results plotted on MATE tradespace



The GEO mission is near the "wall" for conventional propulsion

Trade Space Check - Tender missions



The Tender missions are feasible with conventional propulsion

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MATE-CON: Emerging Capability

- Linked method for progressing from vague user needs to conceptual/preliminary design very quickly
- MANY architectures, several/many designs considered
- Understanding the trades allows selection of robust and adaptable concepts, consideration of policy, risk.