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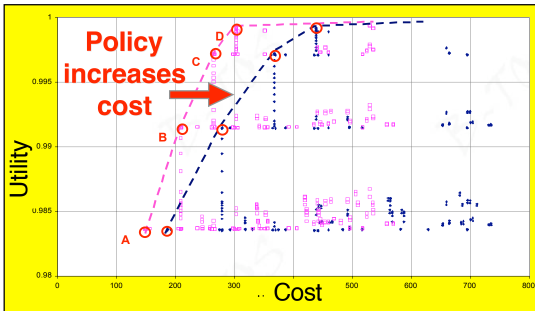
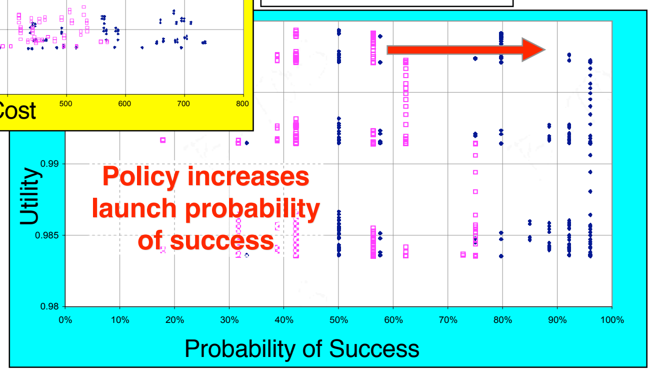
Using Architecture Models to Understand Policy Impacts



100% of B-TOS architectures have cost increase under restrictive launch policy for a minimum cost decision maker

◆ *Restrictive launch policy*
□ *Unrestrictive launch policy*



B-TOS
- Swarm of small sats. doing observation
- Utility for multiple missions

From Weigel, 2002

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Using Architecture Models to Consider Uncertainty

TechSat
- Constellation of satellites doing observation of moving objects on the ground
- Uncertainties driven by instrument performance/cost

[Martin, 2000]

From Walton, 2002

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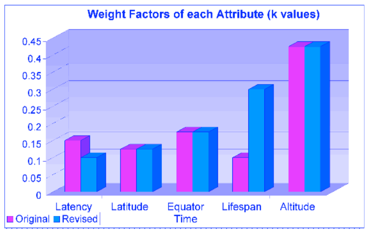
Changes in User Preferences Can be Quickly Understood

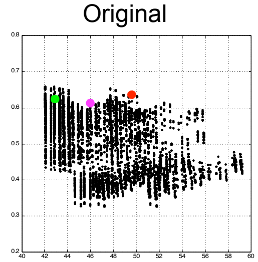


Architecture trade space reevaluated in less than one hour

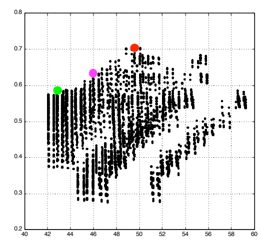
User changed preference weighting for lifespan

X-TOS

Original



Revised



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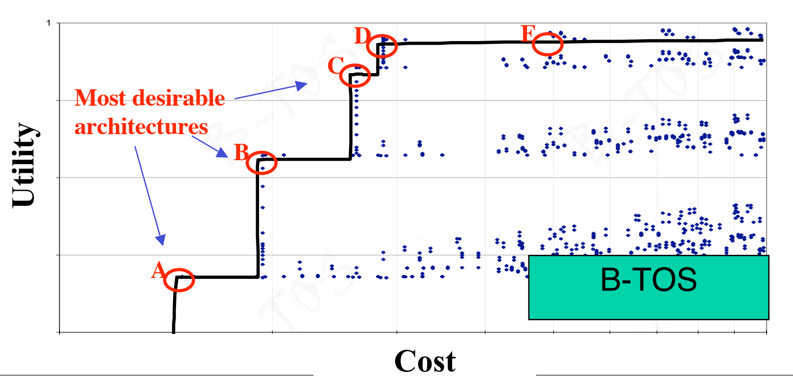
Assessing Robustness and Adaptability

- Pareto front shows trade-off of accuracy and cost
- Determined by number of satellites in swarm
- Could add satellites to increase capability



Questioning User Desires

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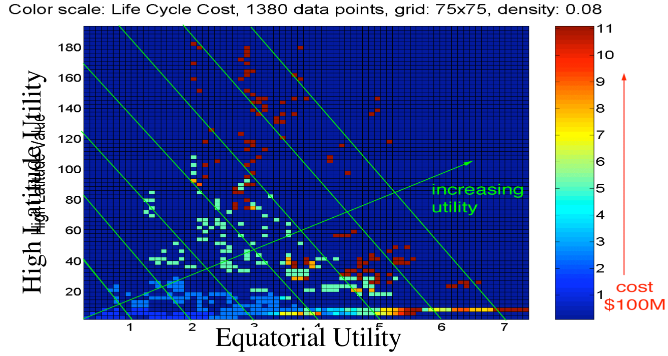
- Best low-cost mission do only one job well
- More expensive, higher performance missions require more vehicles
- Higher-cost systems can do multiple missions
- Is the multiple mission idea a good one?

A-TOS
- Swarm of very simple satellites taking ionospheric measurements
- Several different missions



Understanding Limiting Physical or Mission constraints

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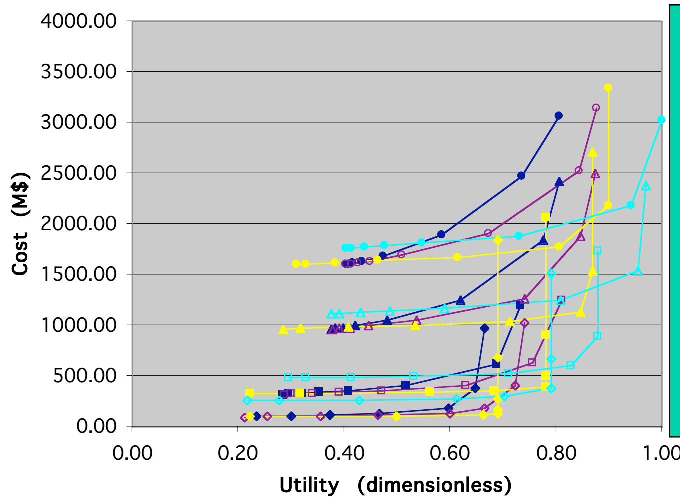

SPACETUG
- General purpose orbit transfer vehicles
- Different propulsion systems and grappling/observation capabilities
- Lines show increasing fuel mass fraction

Hits a "wall" of either physics (can't change!) or utility (can)

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Integrated Concurrent Engineering (ICE)

- ICE techniques from Caltech and JPL
- 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
- A reality check on the architecture studies - can the vehicles called for be built, on budget, with available technologies?

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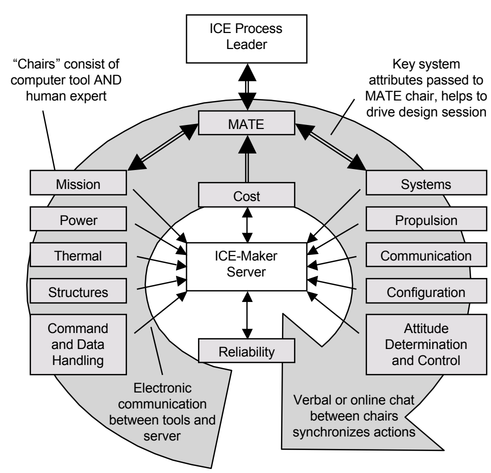
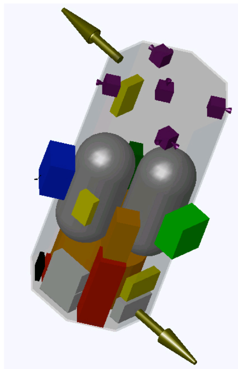
ICE Process (CON with MATE)



- 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

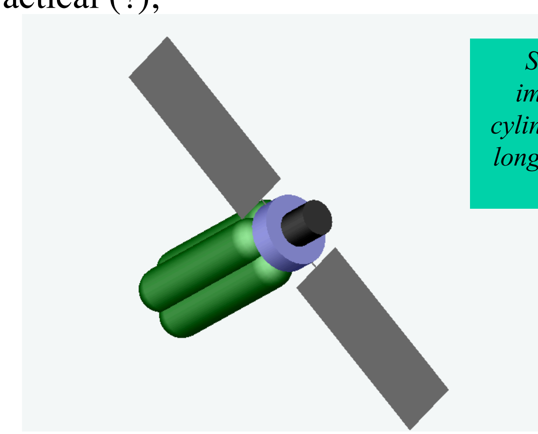
SSPARC — ICE Result - XTOS Vehicle



- Early Designs had excessively large fuel tanks and bizarre shapes
- Showed limits of coarse modeling done in architecture studies
- Vehicle optimized for best utility - maximum life at the lowest practical altitude

SSPARC — SPACETUG Biprop One-Way GEO Tug

- 1312 kg dry mass, 11689 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

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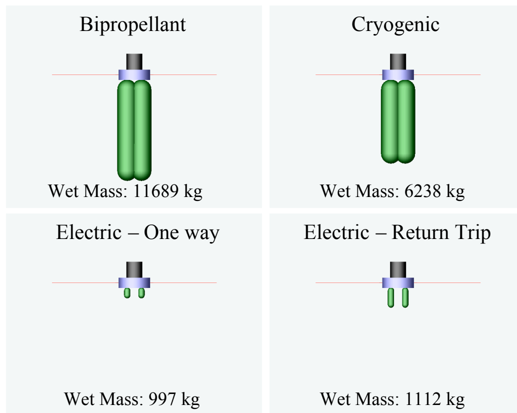
SPACETUG Tug Family (designed in a day)



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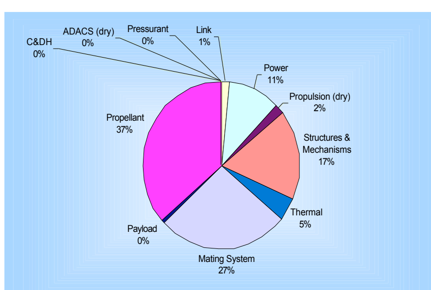
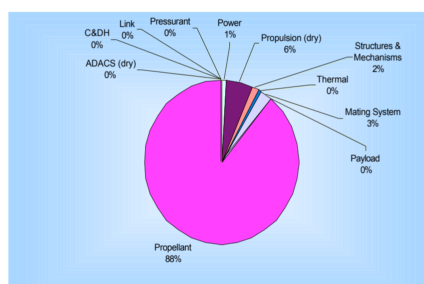
Learning from the ICE results: Mass Distribution Comparison



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

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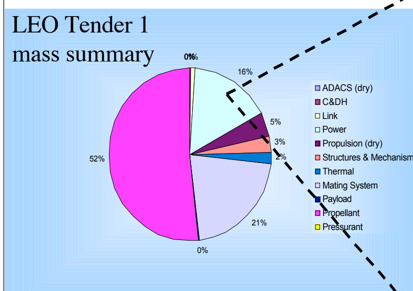
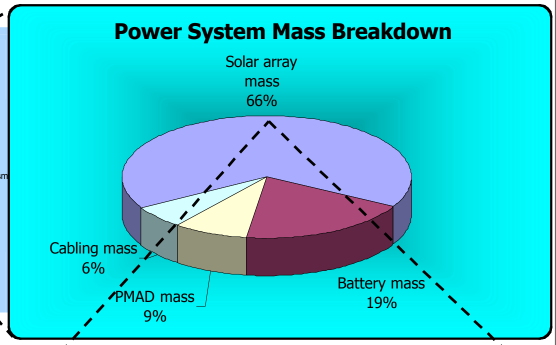
More Than Mass Fractions

LEO Tender 1 mass summary





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

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

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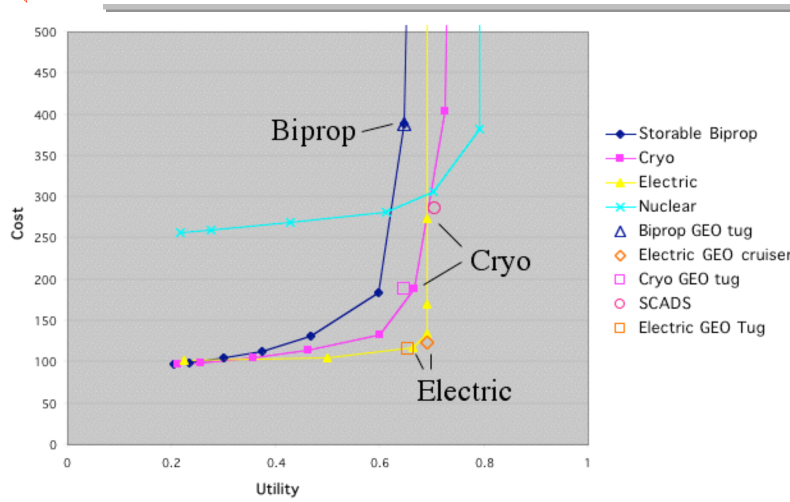
Trade Space Check



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

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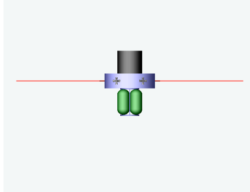
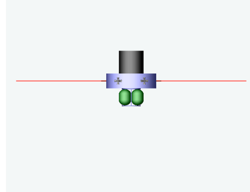
SPACETUG
LEO Tender Family

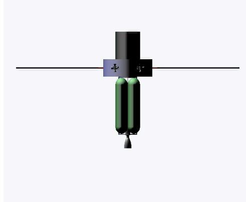
LEO 1 - 1404 kg wet



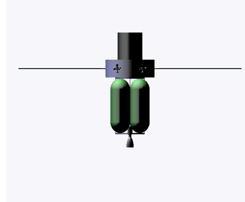
LEO 2 - 1242 kg wet



LEO 4 - 1782 kg wet



LEO 4A - 4107 kg wet



Tenders

- Orbit transfer vehicles that live in a restricted, highly populated set of orbits
- Do low Delta-V transfers, service, observation

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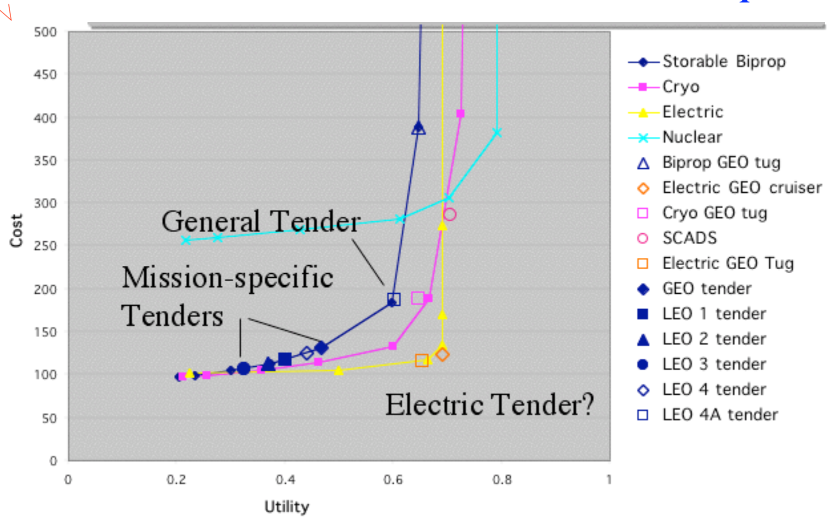
Tenders on the tradespace



The Tender missions are feasible with conventional propulsion

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What you will learn

- Trade space evaluation allows efficient quantitative assessment of system architectures given user needs
- State-of-the-art conceptual design processes refine selected architectures to vehicle preliminary designs
- Goal is the right system, with major issues understood (and major problems ironed out) entering detailed design

Emerging capability to get from user needs to robust solutions quickly, *while considering full range of options, and maintaining engineering excellence*