LAI
LEAN
AEROSPACE
INITIATIVE

Introduction to MATE-CON

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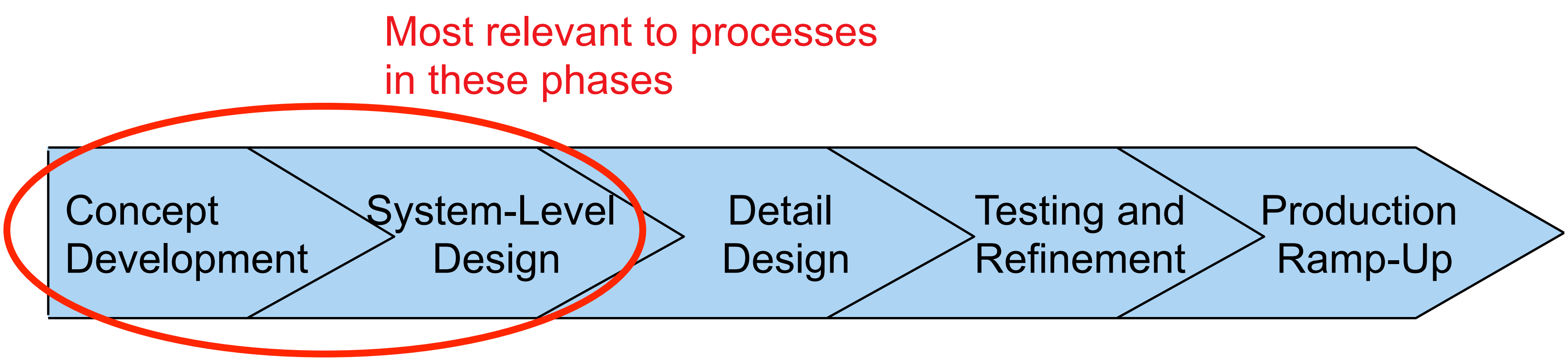
3/27/03

A method for the front end

- **MATE Architecture Tradespace Exploration**
  - **A process for understanding complex solutions to complex problems**
- **ICE Integrated Concurrent Engineering**
  - **Rapid Conceptual/Preliminary Design Method**
- **Allows informed upfront decisions and planning**

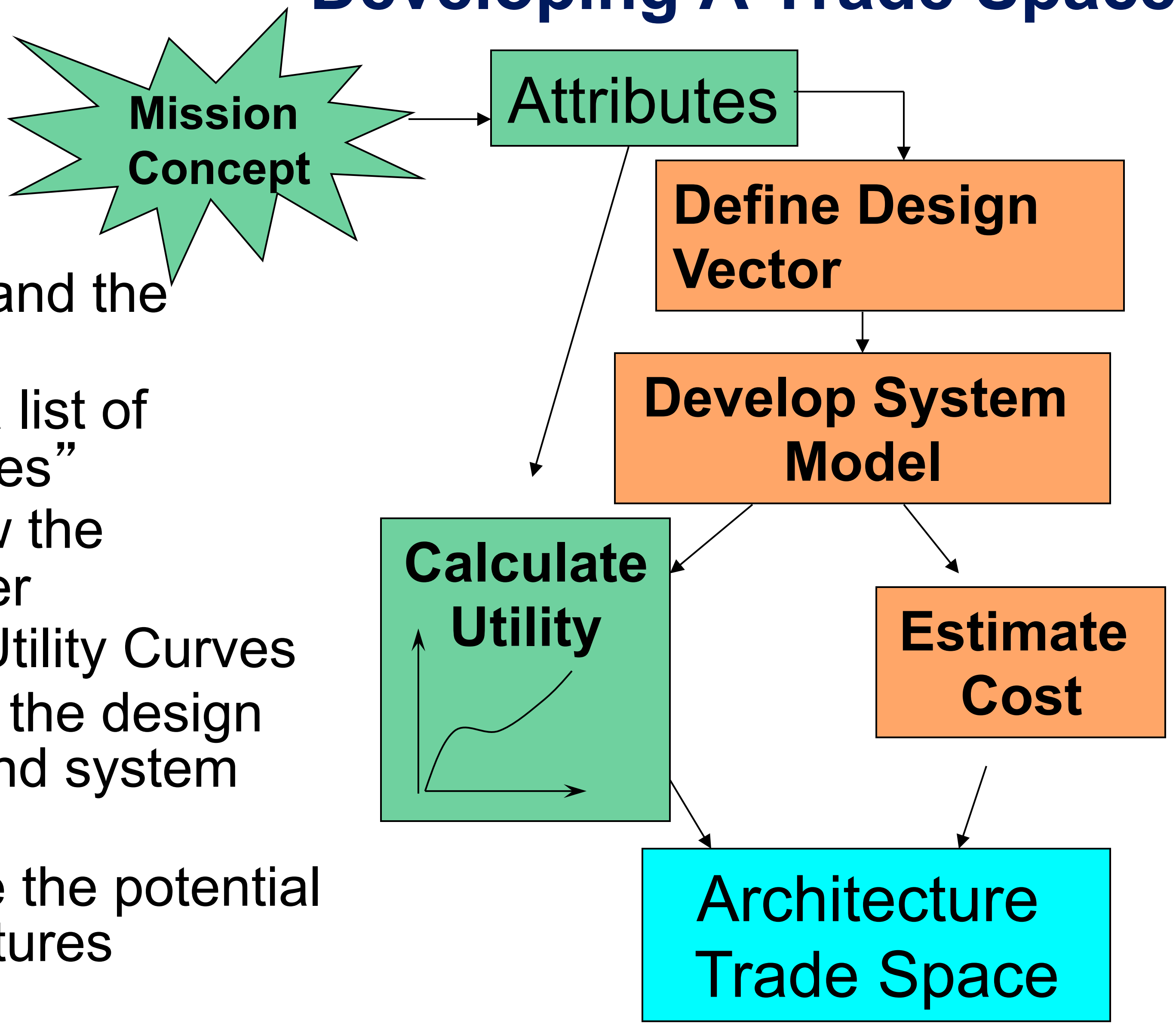


Phases of Product Development

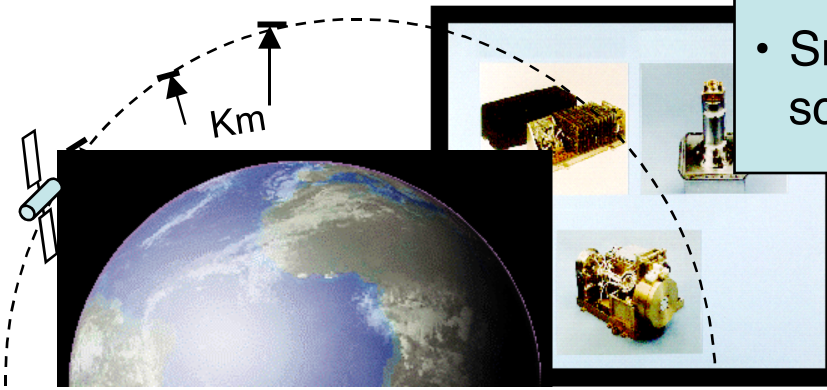
From Ulrich & Eppinger, *Product Design and Development*, 1995

Developing A Trade Space

- Understand the Mission
- Create a list of "Attributes"
- Interview the Customer
- Create Utility Curves
- Develop the design vector and system model
- Evaluate the potential Architectures

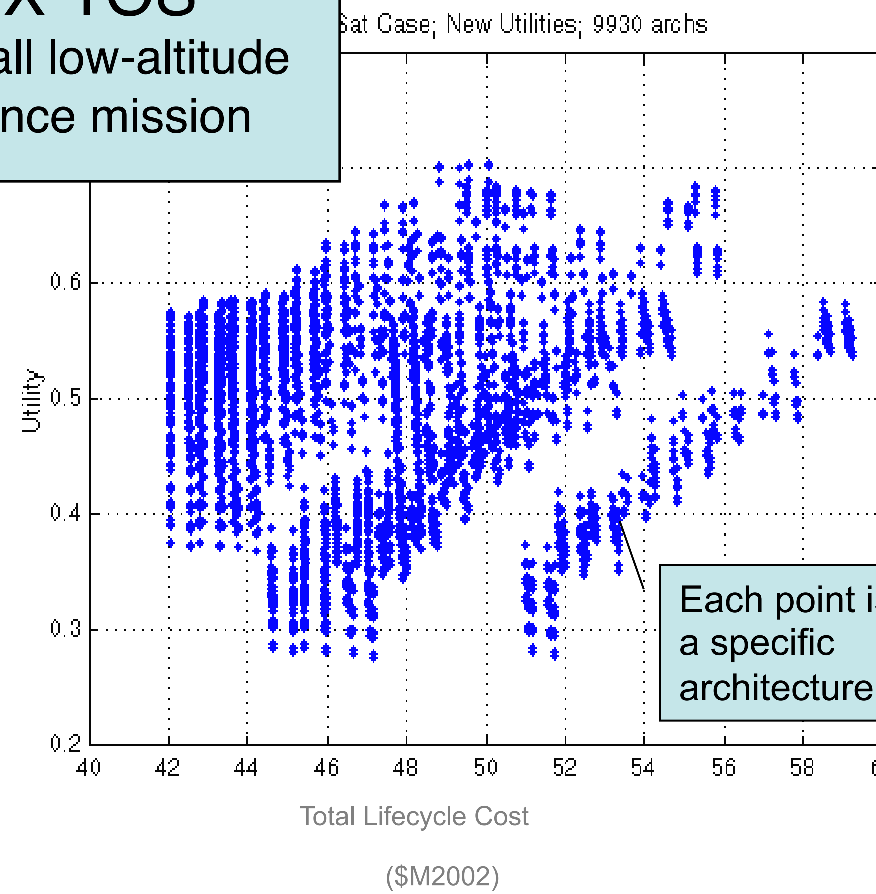


What is an Architecture Trade Space?



X-TOS

- Small low-altitude science mission



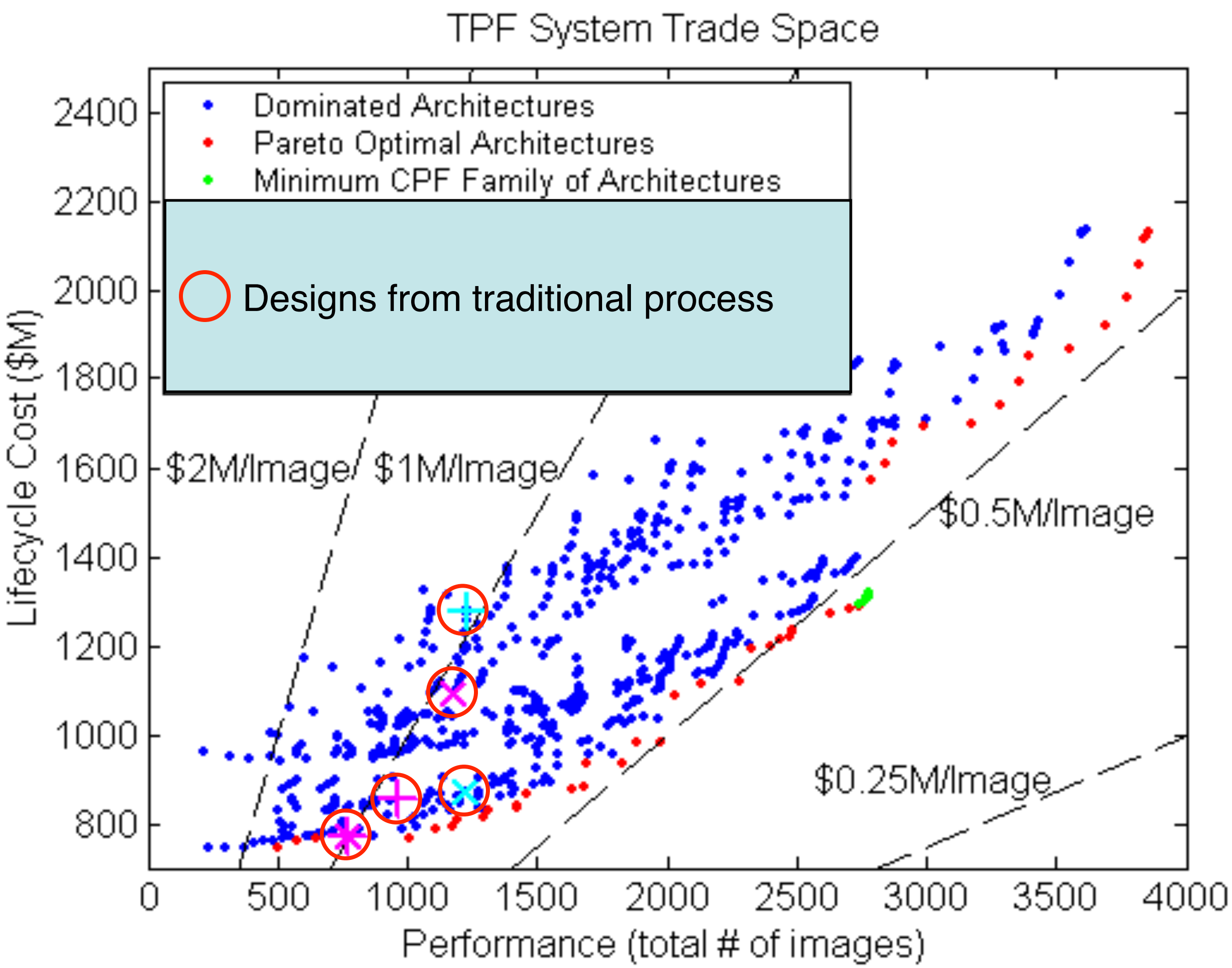
Each point is a specific architecture

DESIGN VARIABLES: The architectural trade parameters

- Orbital Parameters
  - Apogee altitude (km) 150-1100
  - Perigee altitude (km) 150-1100
  - Orbit inclination 0, 30, 60, 90
- Physical Spacecraft Parameters
  - Antenna gain
  - communication architecture
  - propulsion type
  - power type
  - delta_v

Assessment of the utility and cost of a large space of possible system architectures

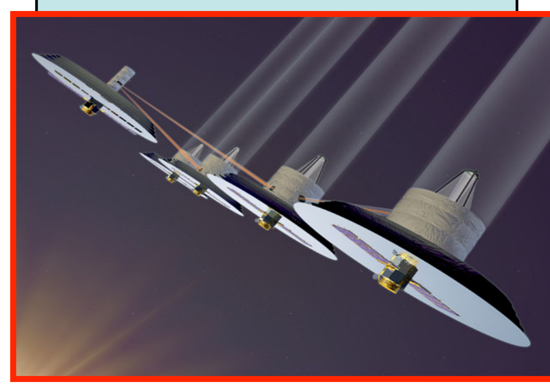
Using the Trade Space to Evaluate Point Designs



From Jilla, 2002

TPF

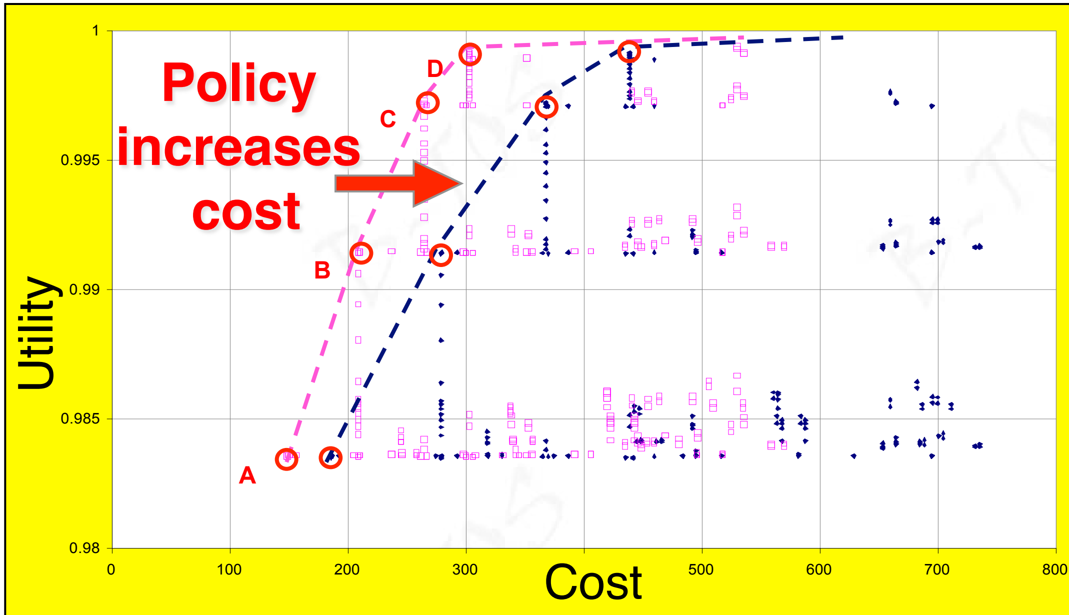
- Terrestrial Planet Finder - a large astronomy system
- Design space: Apertures separated or connected, 2-D/3-D, sizes, orbits
- Images vs. cost



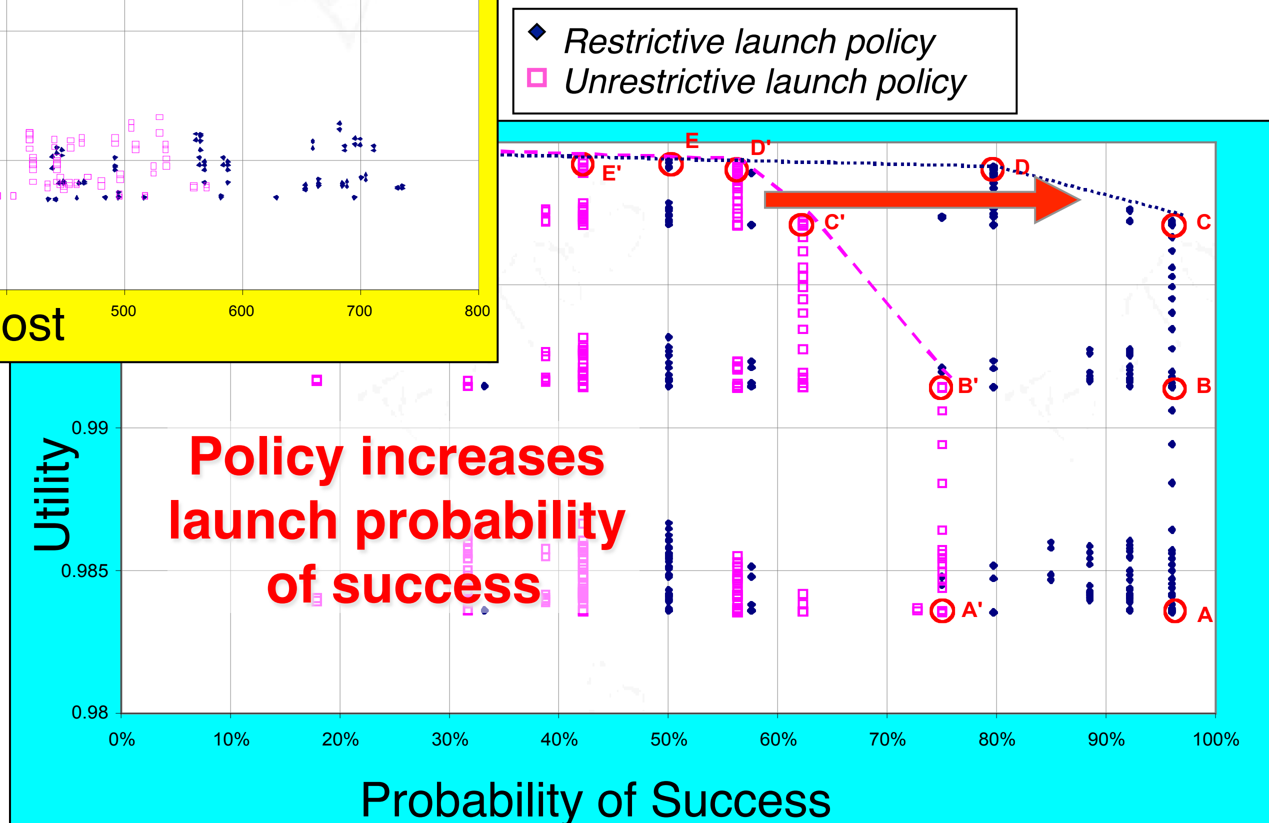
[Beichman et al, 1999]

Using Architecture Models to Understand Policy Impacts

LEAN AEROSPACE INITIATIVE



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

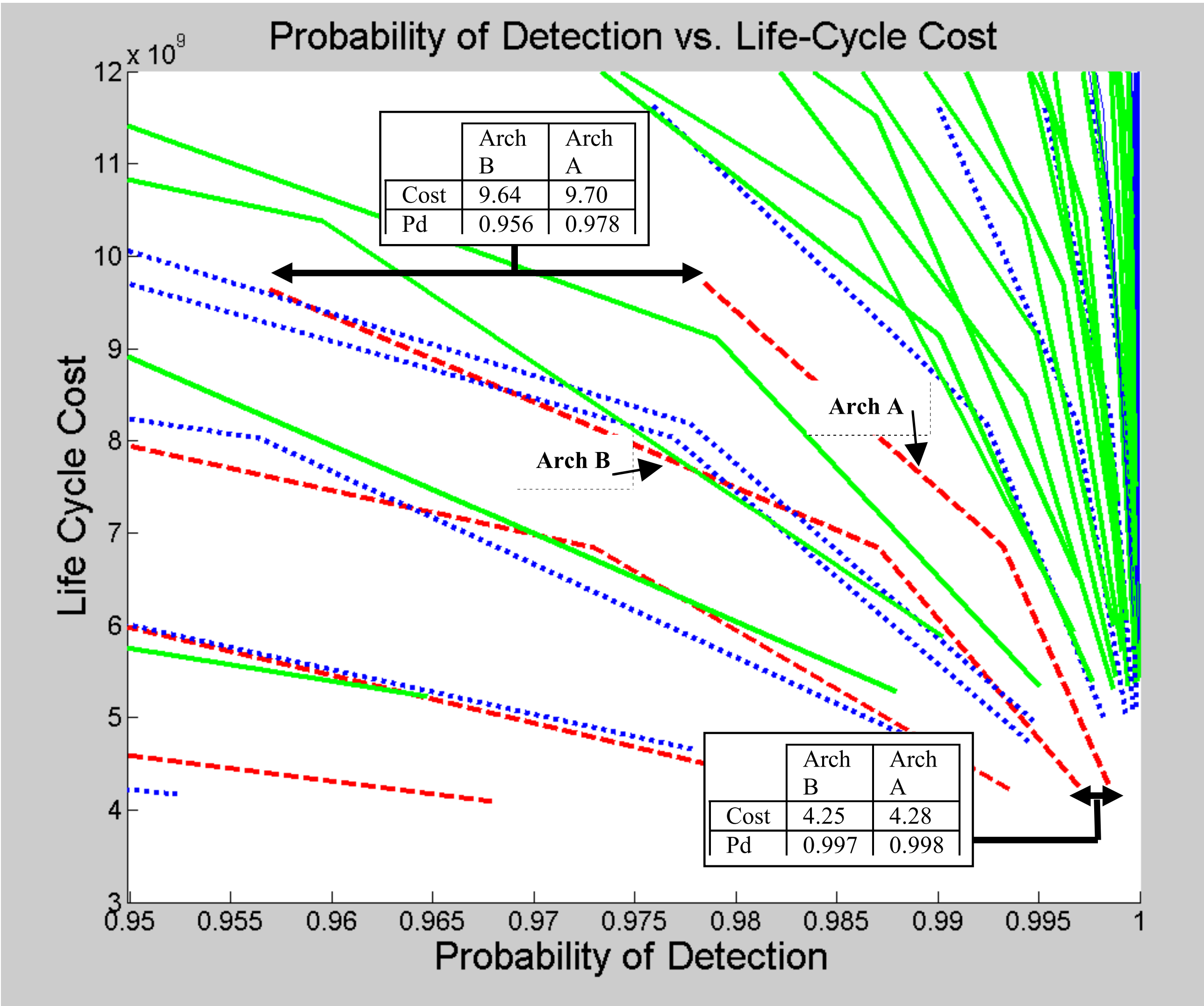


B-TOS

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

From Weigel, 2002

Using Architecture Models to Consider Uncertainty



	Arch B	Arch A
Cost	9.64	9.70
Pd	0.956	0.978

	Arch B	Arch A
Cost	4.25	4.28
Pd	0.997	0.998

TechSat

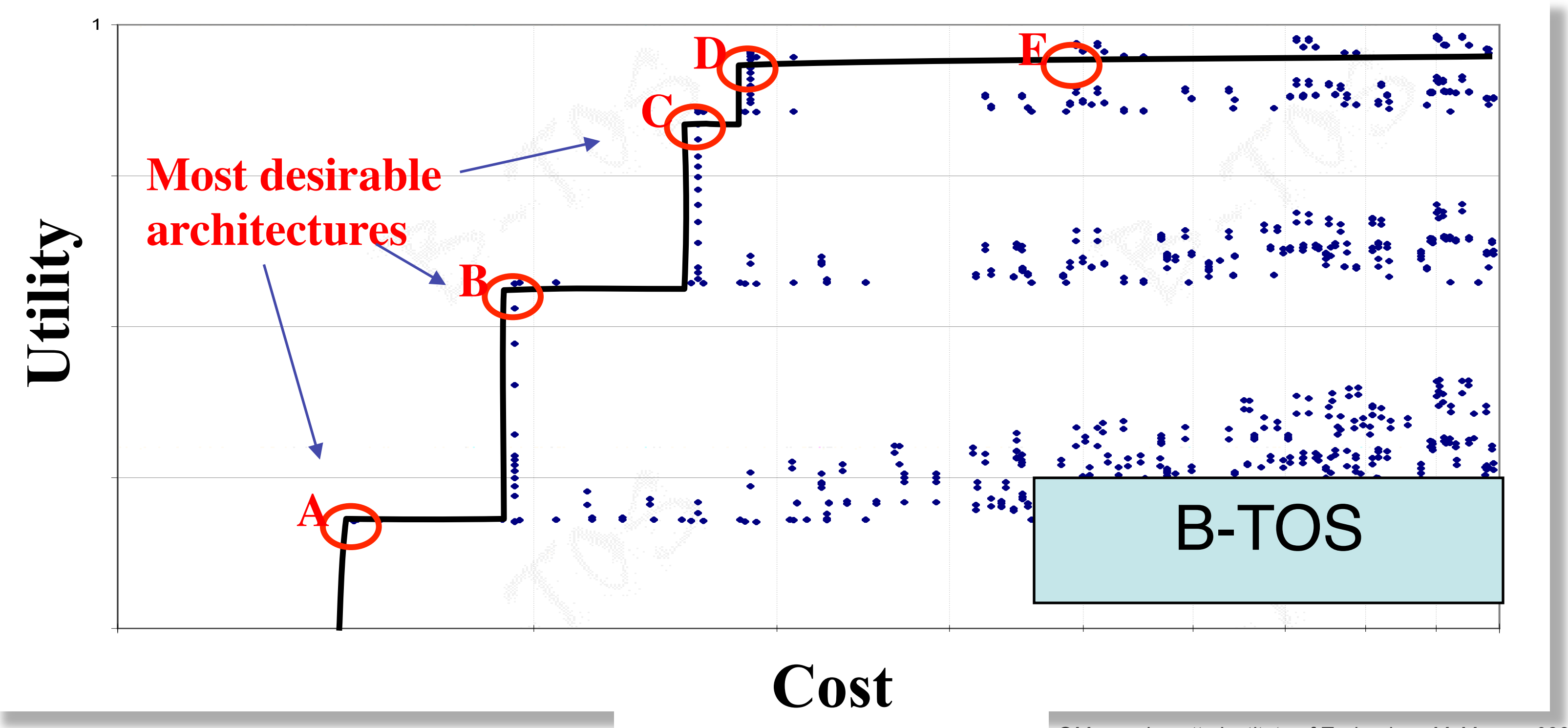
- Constellation of satellites doing observation of moving objects on the ground
- Uncertainties driven by instrument performance/cost

[Martin, 2000]

From Walton, 2002

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

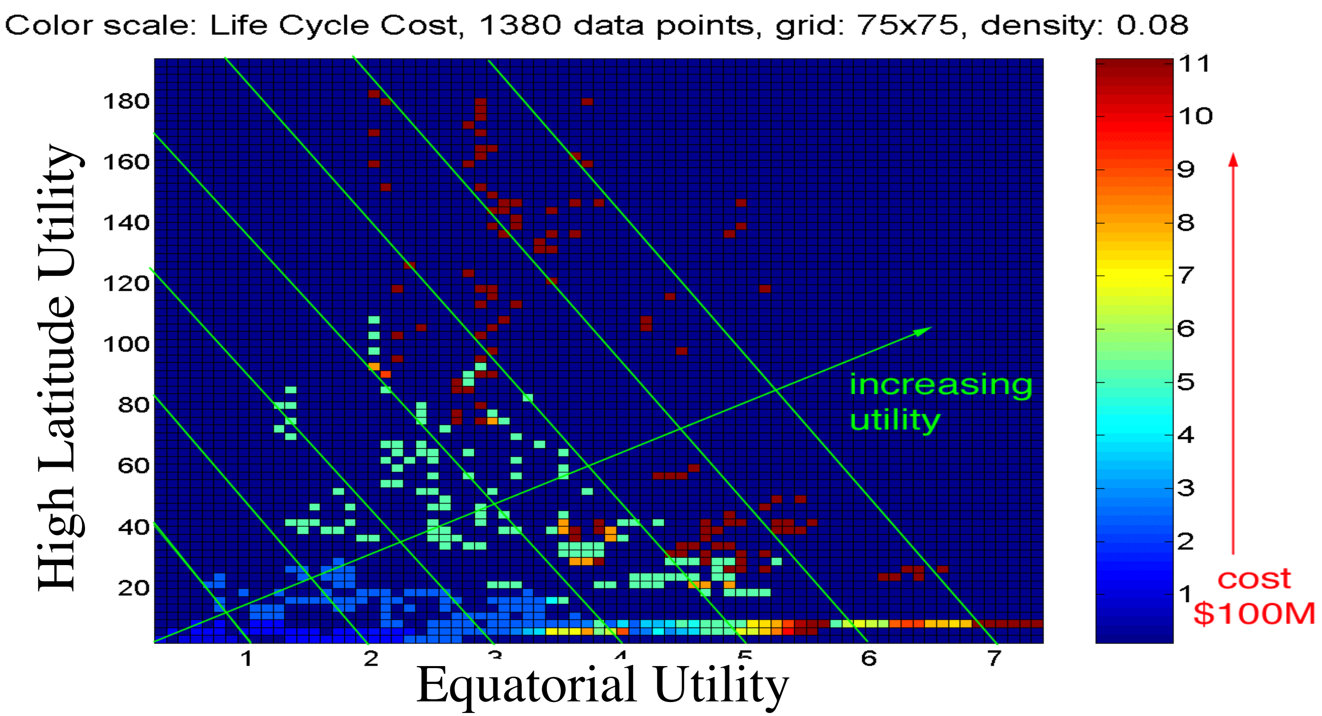


Questioning User Desires

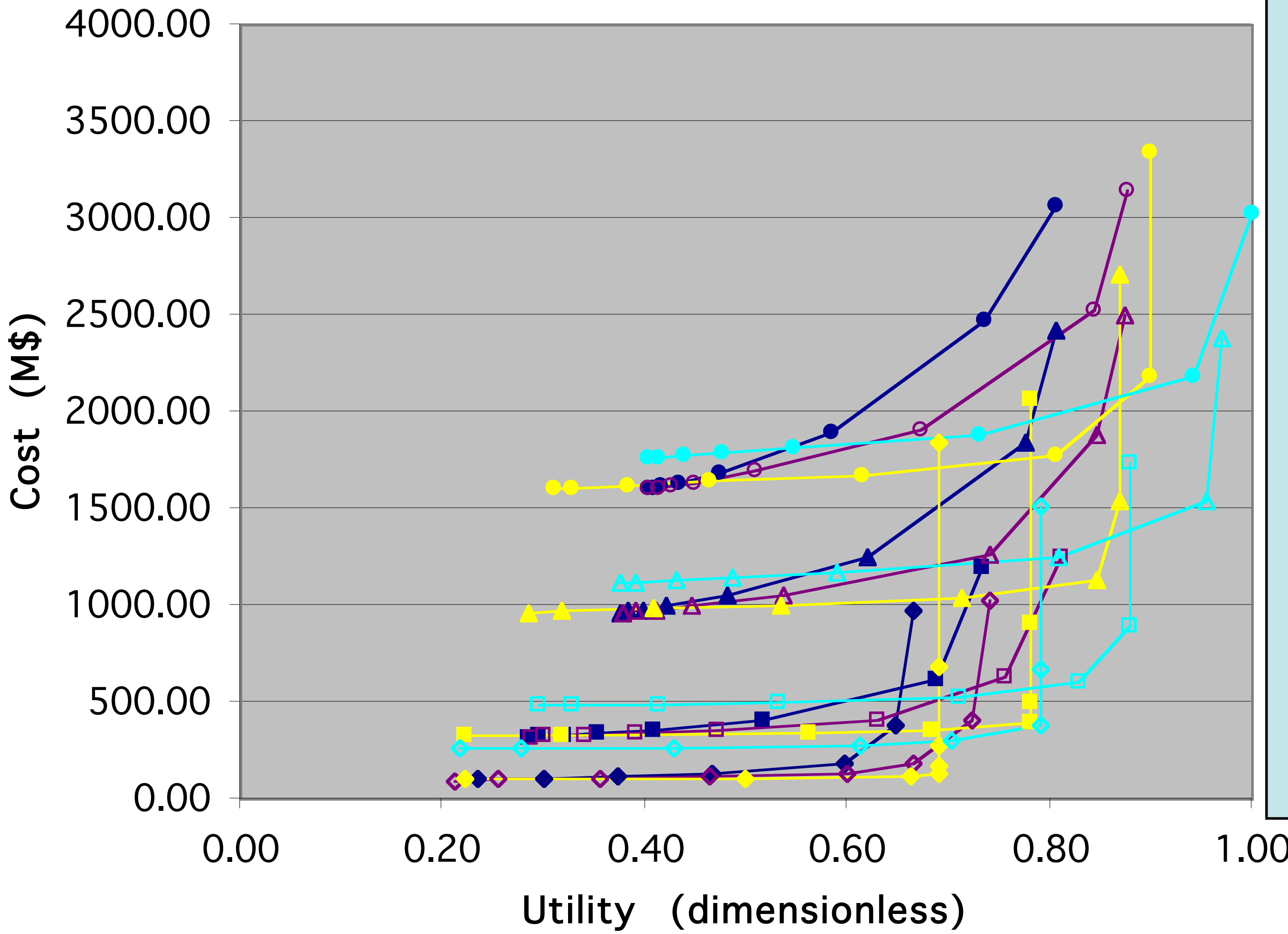
- Best low-cost mission do only one job well
- More expensive, higher performance missions require more vehicles
- Higher-cost systems can do multiple missions
- Is the multiple mission idea a good one?

A-TOS

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



Understanding Limiting Physical or Mission constraints



SPACETUG

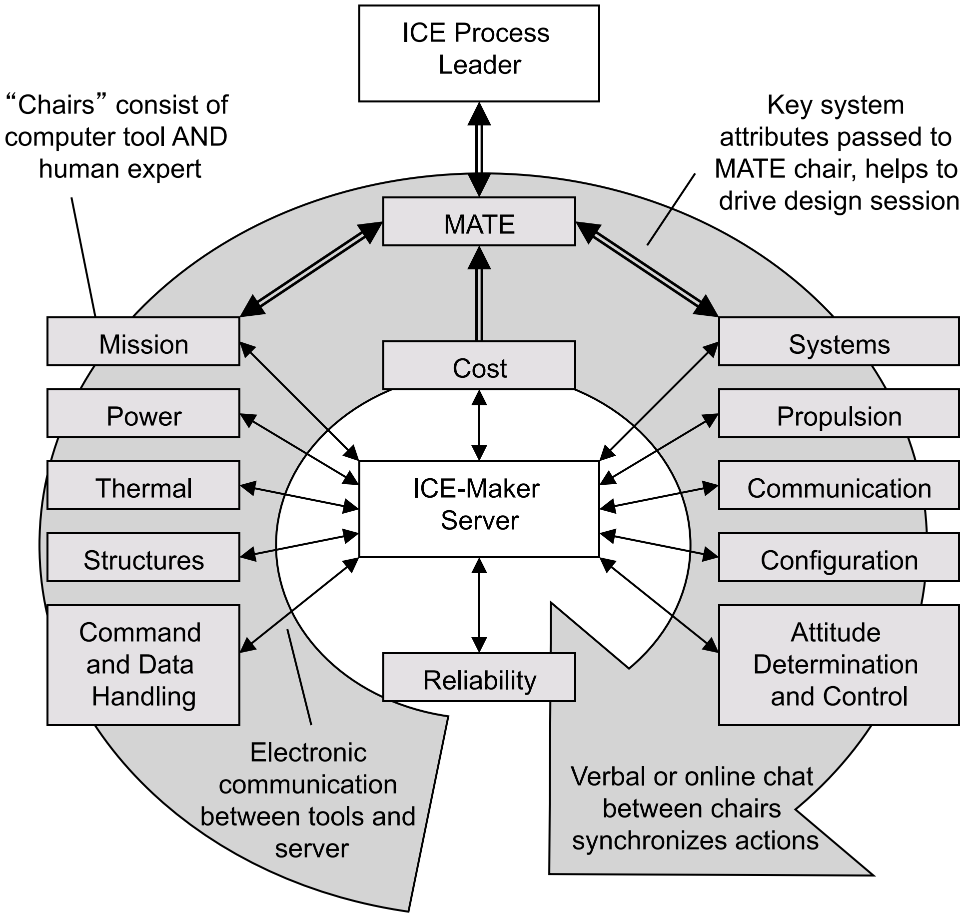
- General purpose orbit transfer vehicles
- Different propulsion systems and grappling/ observation capabilities
- Lines show increasing fuel mass fraction

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

Integrated Concurrent Engineering (ICE)

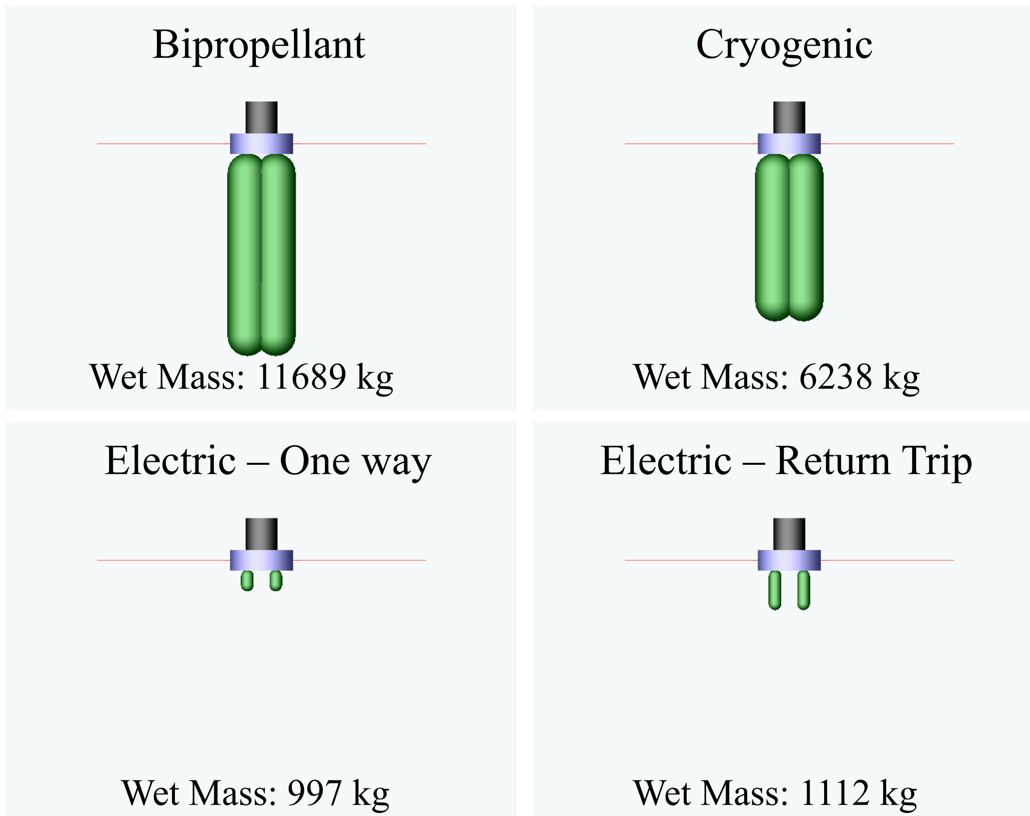
- ICE techniques from Caltech and JPL
- Linked analytical tools with human experts in the loop
- Very rapid design iterations
- Result is conceptual design at more detailed level than seen in architecture studies
- Allows understanding and exploration of design alternatives
- A reality check on the architecture studies - can the vehicles called for be built, on budget, with available technologies?

ICE Process (CON with MATE)

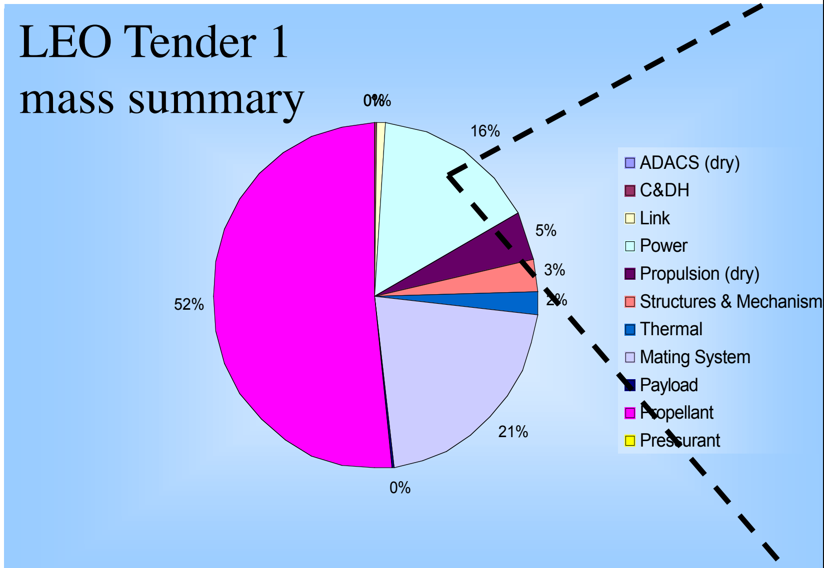


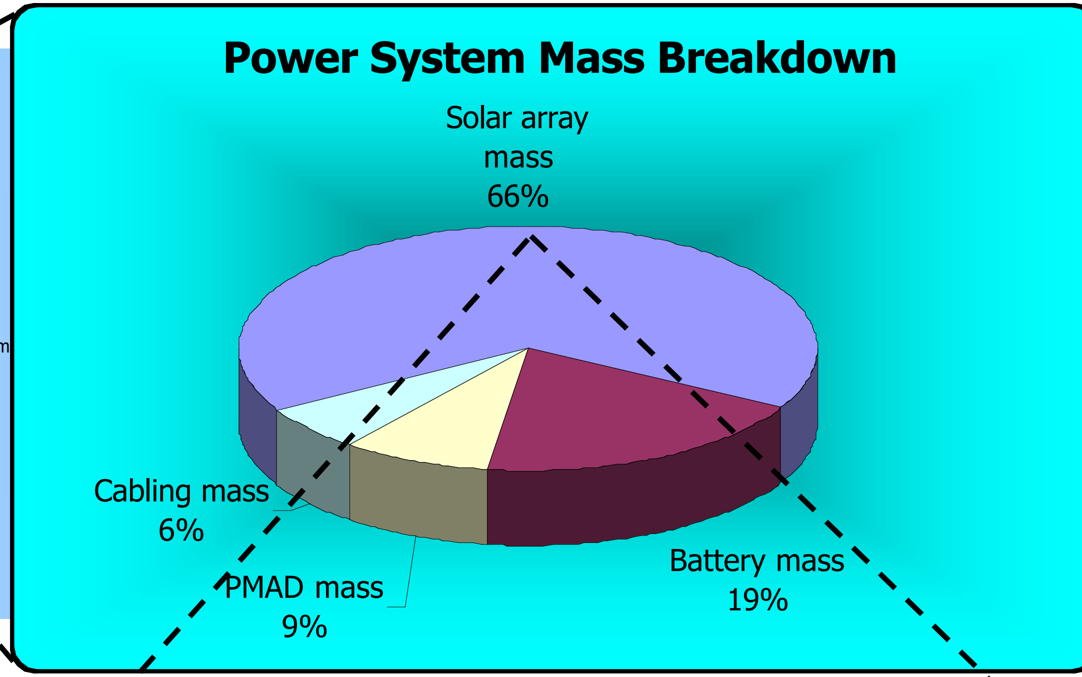
- **Directed Design Sessions allow very fast production of preliminary designs**
- **Traditionally, design to requirements**
- **Integration with MATE allows *utility* of designs to be assessed real time**

SPACETUG Tug Family (designed in a day)



Conceptual design details

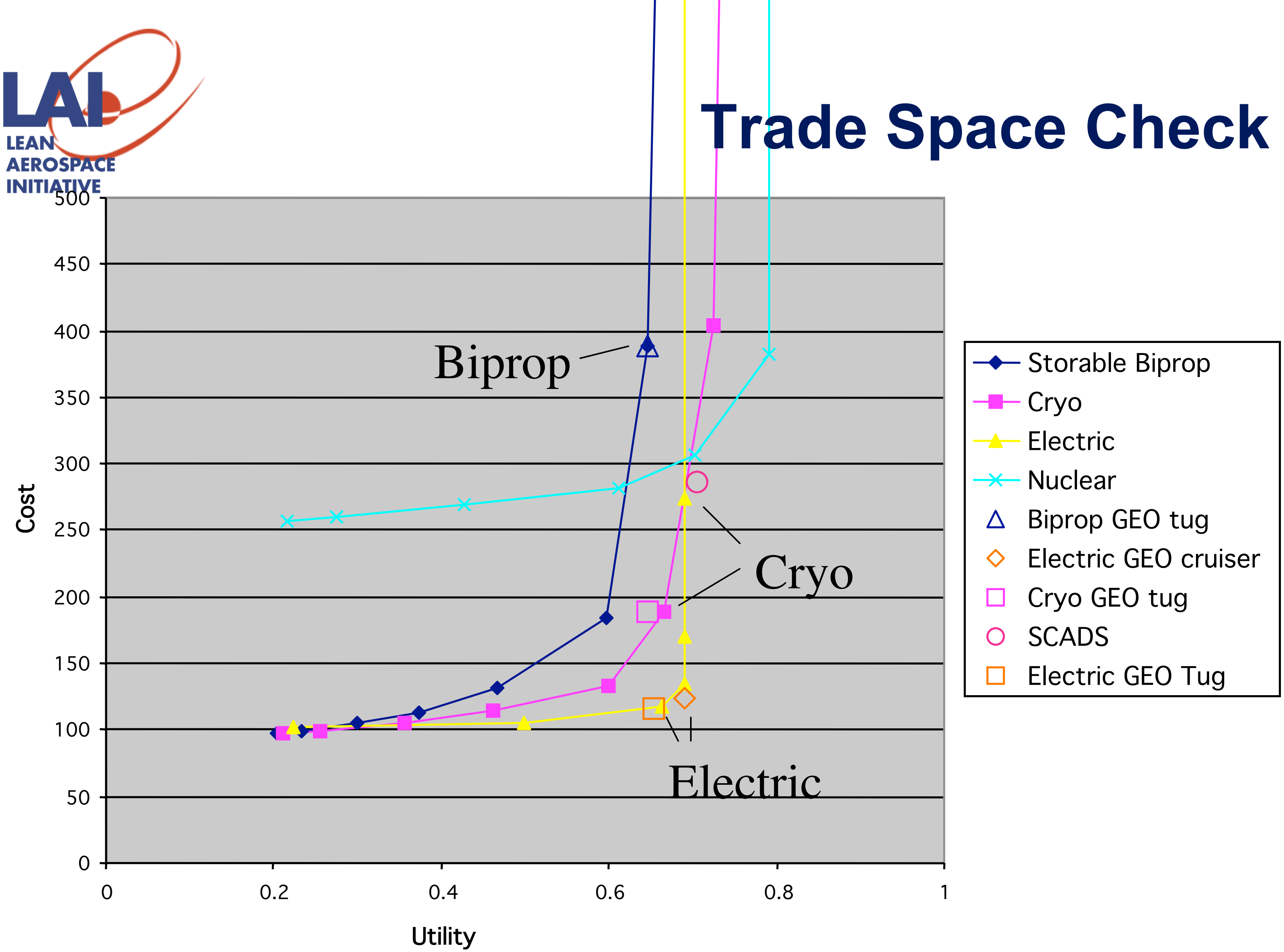




Select solar array material:	Triple Junction (InGaP/GaAs/Ge)	
Minimum efficiency	24.5	%
Maximum efficiency	28.0	%
Nominal temperature	28.0	C
Temperature loss	0.5	%/deg C
Performance degredation	2.6	% / year
Minimum temperature	0.5	C
Maximum temperature	85.0	C
Energy density	25.0	W / kg
Solar array mass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

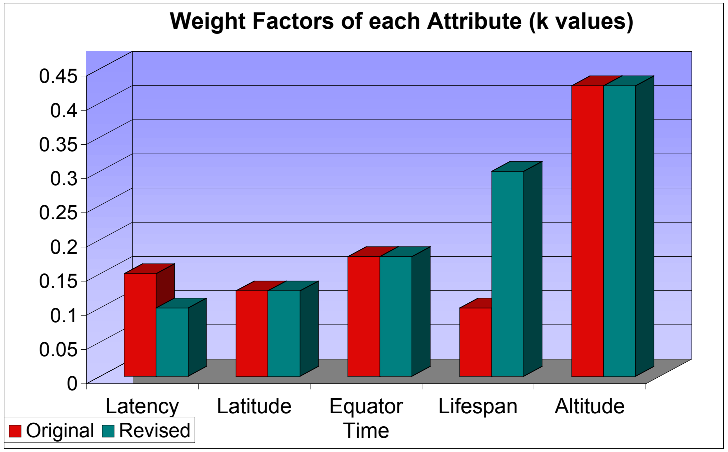
Detailed information can be drawn from subsystem sheets, including efficiencies, degradations temperature tolerances, and areas

Trade Space Check



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

Changes in User Preferences Can be Quickly Understood

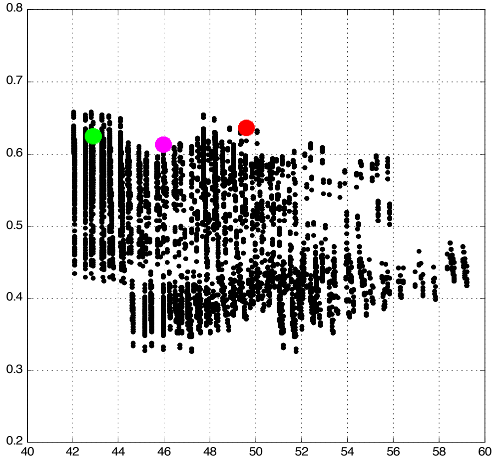


Architecture trade space reevaluated in less than one hour

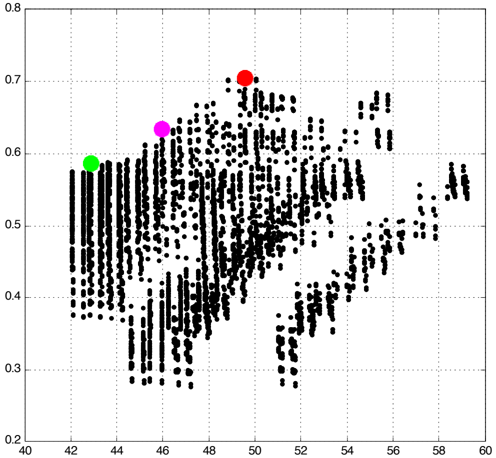
User changed preference weighting for lifespan

X-TOS

Original



Revised



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.