Efficient Trade Space Exploration

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esa

concurrent design facility

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Once upon a time…

The purpose of the NASA Pre-Phase A project life cycle phase is,
"To produce a broad spectrum of ideas and alternatives for missions from which new programs/projects can be selected. Determine feasibility of desired system, develop mission concepts, draft system-level requirements, assess performance, cost, and schedule feasibility; identify potential technology needs, and scope."

Two of the principal challenges in efficient trade space exploration are to quickly

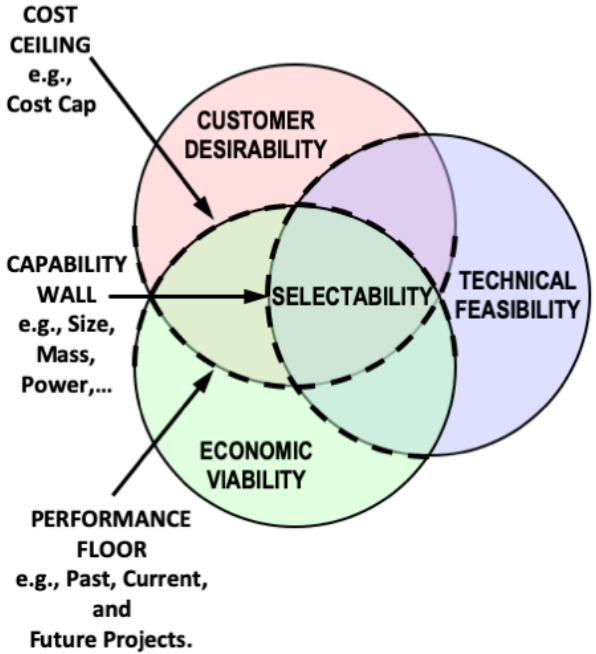
evaluate options

and

obtain stakeholder understanding

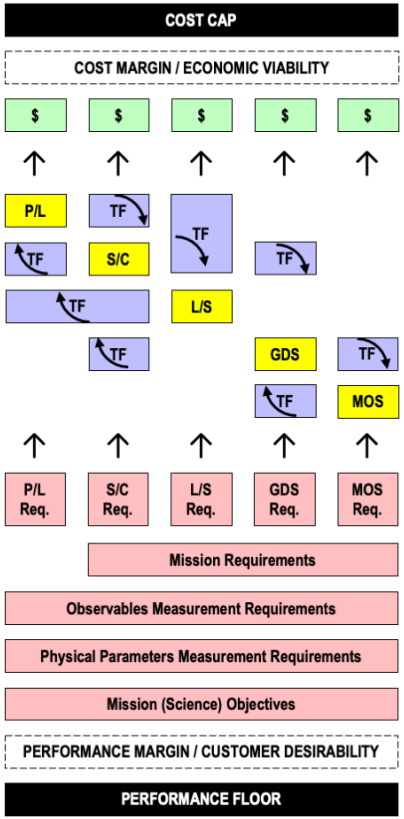
Then, one day…

It was realized that the stakeholders needed to understand the couplings of the *three principal boundary conditions*



Because of that…

the level of
evaluation and information
was simplified to the
element level
using element level
analogy and *parametric*
databases and models



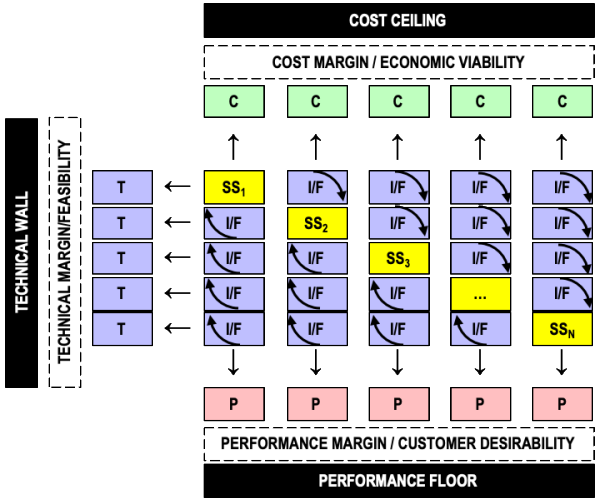
Spacecraft Element Analogy Name	
Unit Cost ($M)	
TECHNICAL RESOURCE SUMMARY	
ACCOMMODATION CAPABILITIES	**ACCOMMODATION REQUIREMENTS**
HxWxL Dimensions (m)	HxWxL Dimensions (m)
P/L Mass (kg)	Mass (kg)
P/L (Peak) Power (W)	
P/L (Average) Power (W)	
P/L Data Rate (Mbps)	
P/L Data Storage (GB)	
PERFORMANCE SUMMARY	
ACS Pointing	Knowledge (deg)
	Control (deg)
	Stability (deg)
Propulsion	Delta V (m/s)
Telecomm	Uplink Band
	Uplink Rate (kbps)
	Downlink Band
	Downlink Rate (Mbps)

Until…

efficiency increased by a factor of nine (9 hours → 1 hour per option)

$$Efficiency = \frac{N_S \times W_S}{N_S \times W_S + N_{NS} \times W_{NS}}$$

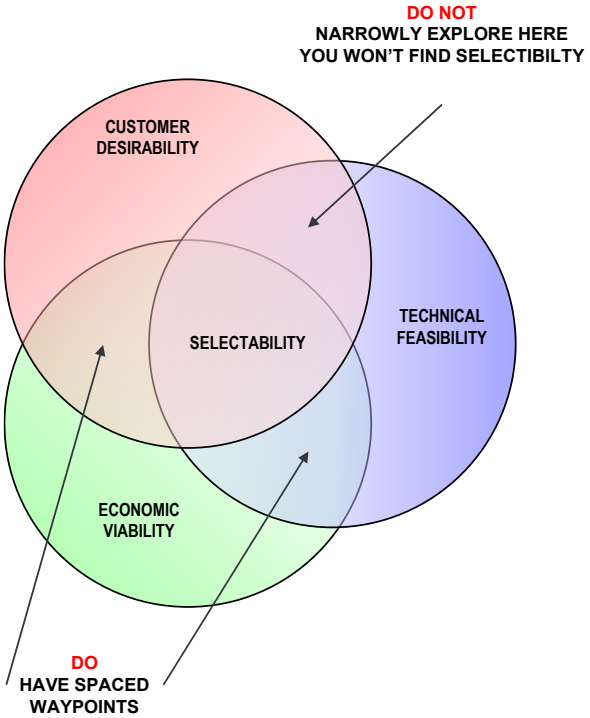
in large part because O(N) boundary conditions are faster to check, especially guided by *allocation rules of thumb*

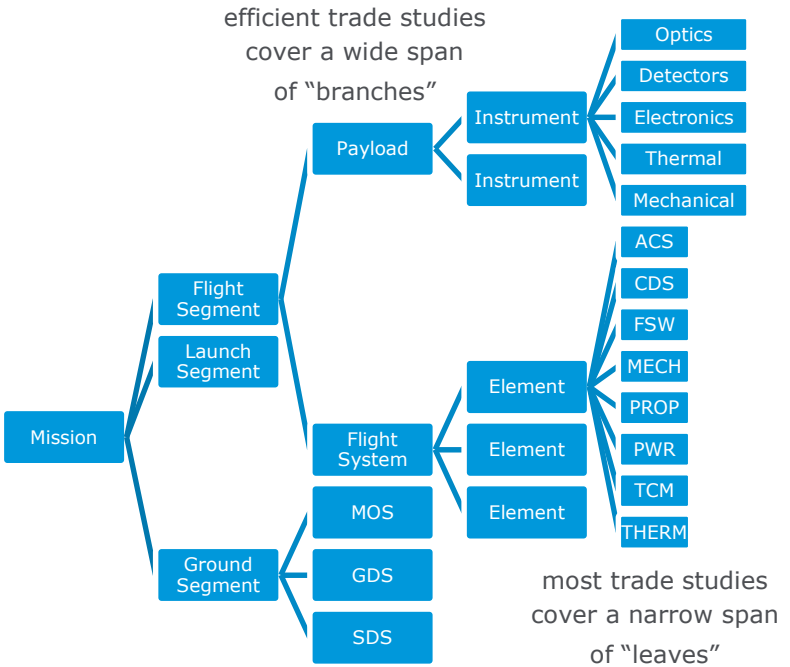


than $O(N^2-N)$ internal self consistencies are to check, *as fun as those are to work on*

Until… *(cont'd)*

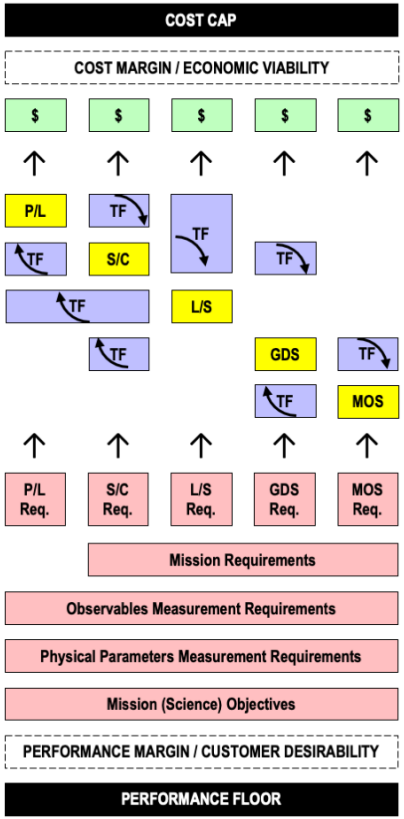
a *broader*, and *more informative*, set of options were being explored





Finally…

Computational and *Cognitive* Efficiencies are Enhanced by *Reduction* in Detail *and* simultaneously tracking against all *Three Principal Boundary Conditions*



Finally… *(cont'd)*

These processes and tools have to date been applied to Astrophysics, Earth Science, and Planetary *Science Mission* and *Instrument* concepts, but the general approach should be applicable to a broad range of system concepts.