**Efficient Trade Space Exploration**

A. Nash

*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, United States of America,* [*Alfred.E.Nash@JPL.NASA.Gov*](mailto:Alfred.E.Nash@JPL.NASA.Gov)

Two of the principal challenges in efficient trade space exploration are (1) quickly evaluating options, and (2) quickly obtaining stakeholder understanding of the results of the evaluation. This presentation describes the processes & methodology that have led to a factor of nine improvement in the efficiency of trade space exploration of space systems in Team-X at the Jet Propulsion Laboratory.

The principal method that has enabled this increase in efficiency is the separation of the exploration figures of merit into two distinct types, which are then addressed in an efficient order. The figures of merit in a trade space exploration of N subsystems either scale with the number of interactions between the subsystems and the external constraints, O(N), or with the number of interactions between subsystems, O(N^2-N).

It is more computationally efficient to filter candidate architectures against the O(N) interactions between the external constraints and the subsystems first, and only proceed to filtering against the O(N^2-N) interactions between subsystems if warranted, than the other way around. However, the latter is the typical bottoms up design approach in space systems engineering organizations.

Another methodological change from the typical concurrent design facility approach that has enabled this nearly order of magnitude increase in trade space exploration efficiency is the switch from deterministic, bottoms up estimation methods, to statistical, top down, estimation methods. Through its access to information about actual space missions, and its vast array of space mission studies, now numbering in the thousands, Team-X has produced the analogy-based and parametric performance, technical, and cost information necessary to produce and evaluate system architecture trades.

In addition to the computational efficiencies gained through this pre-filtering of infeasible or non-viable configurations from further work, cognitive efficiencies are also gained by this partitioning of the figures of merit. By partitioning the O(N) external constraints on the system along the border of an N-squared diagram-based dashboard, and the O(N^2-N) of interfaces between subsystems within the dashboard, stakeholders gain several insights: (1) how the external boundary conditions inform the what the optimal internal subsystem choices are, (2) how the internal subsystem choices affect the selectability of the options, and perhaps most importantly, (3) how their own derived requirements are affecting the selectability of the system.