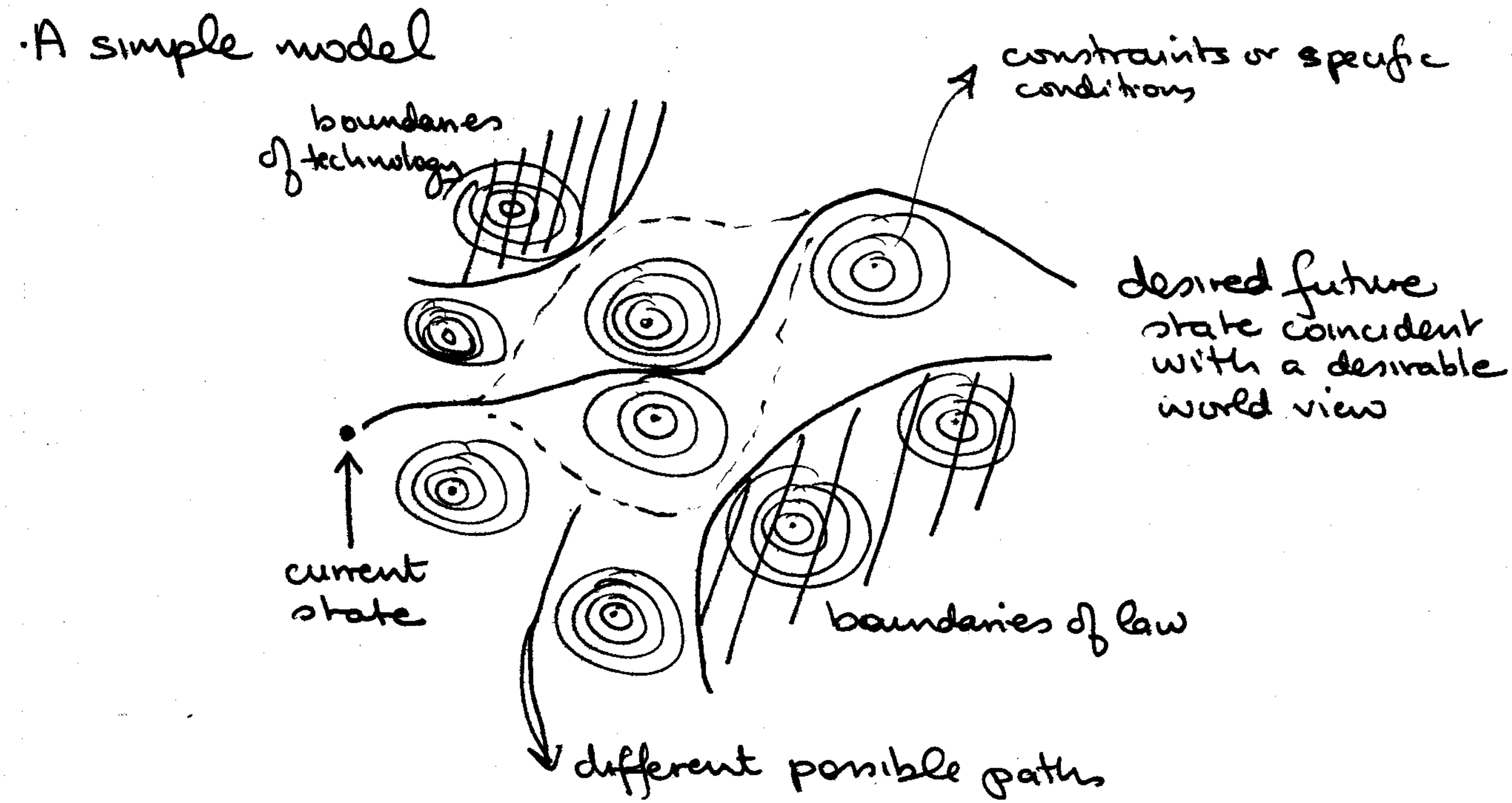
# Policy Choices on Space Systems

# Definition of Policy

- **Policy**
- " A definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future directions."
- Thus policy statements can be parsed in the following way
- Policy statements have several features associated with them:
    - definite course(s)
    - selected from alternatives
    - true in light of specific conditions→ a model of the world
    - to move one in specific (desired) directions→ a model of the world

# Definition of Policy



# Heuristics

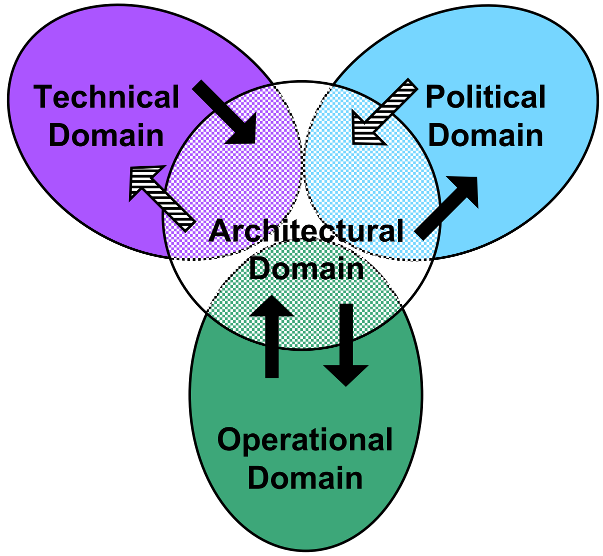
**Forman's Heuristic #1**: *If the politics don't fly, the system never will.*

**Forman's Heuristic #2**: *Politics, not technology, sets the limits of what technology is allowed to achieve.*

**Forman's Heuristic #3**: *A strong, coherent constituency is essential.*

**Forman's Heuristic #4**: *Technical problems become political problems; there is no such thing as a purely technical problem.*

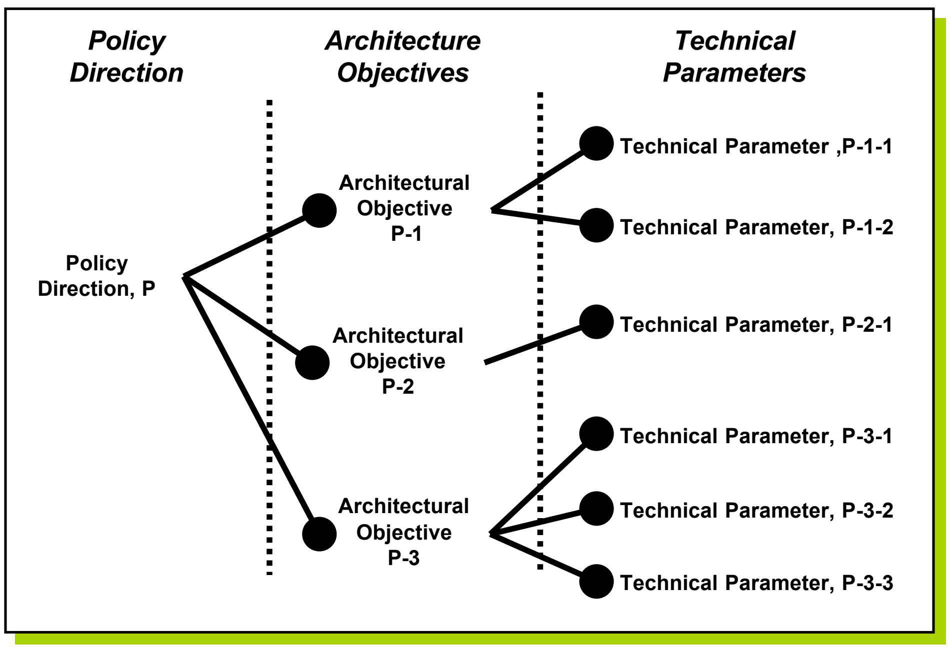
**Forman's Heuristic #5**: *With few exceptions, schedule delays are accepted grudgingly; cost overruns are not.*



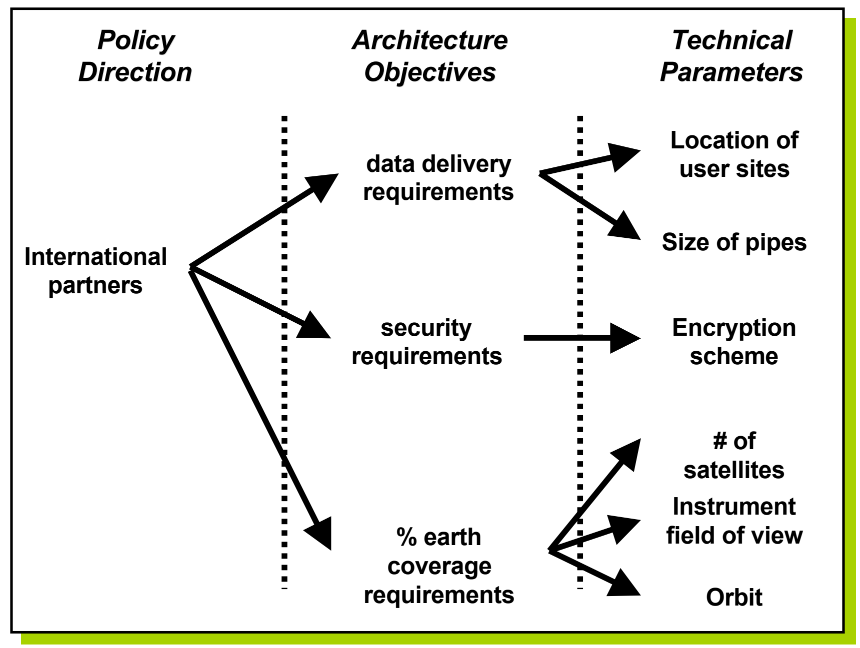
# Policy Impact on System Architecture

- Understand policy impacts at early (architecture) stages
- Framework shows flowdown to technical domain

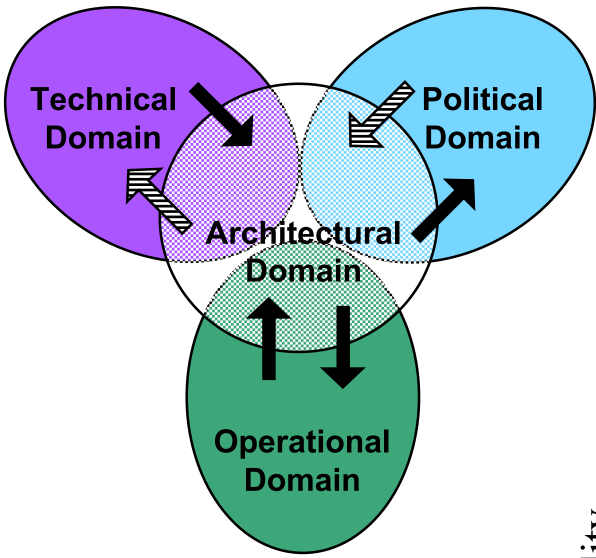
**Generic Flow of Policy Impacts into Technical Domain**



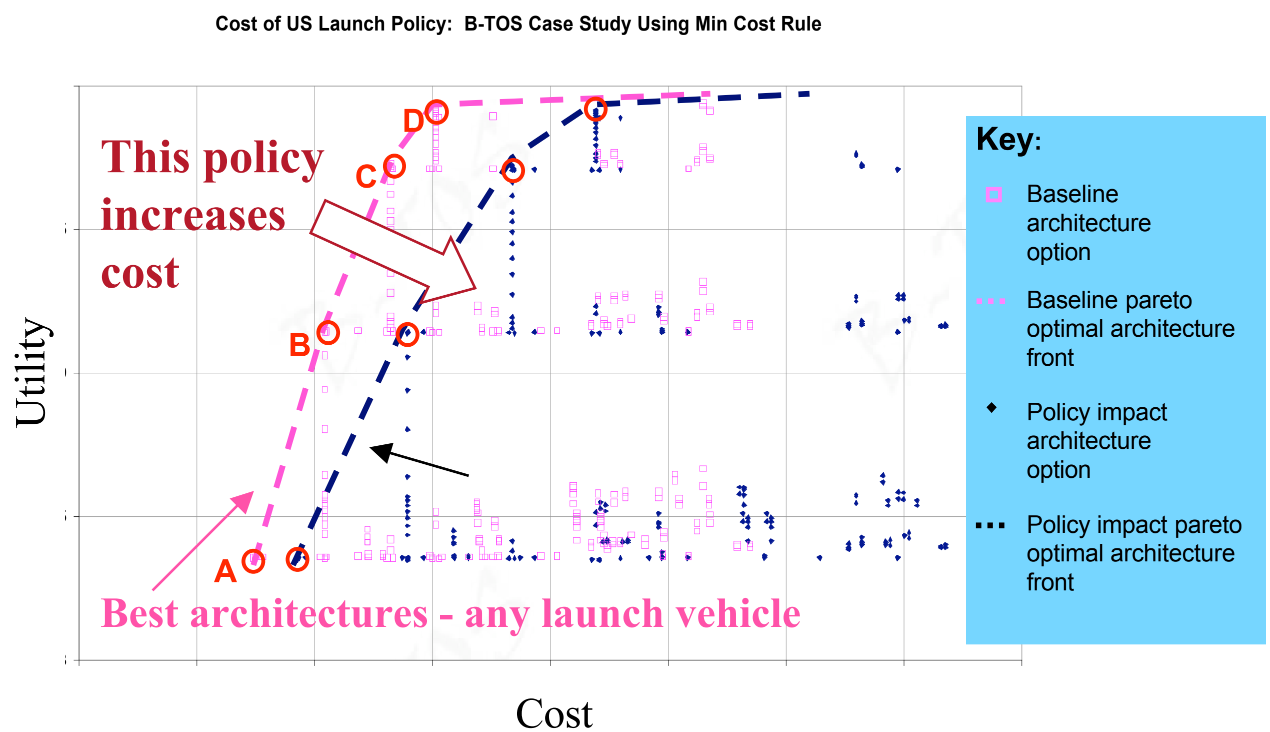

**Discoverer II Example (Space-based GMTI mission)**



# Policy Impact on System Architecture




Space System Architecting
"Domain Framework" Schematic

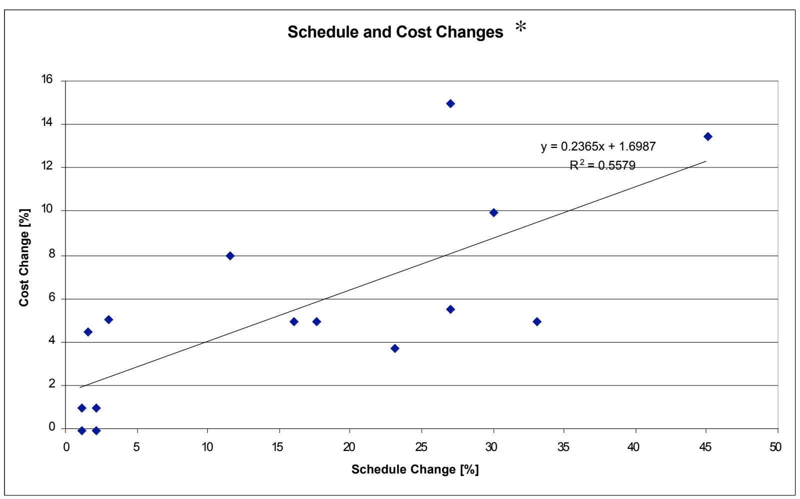



Results from US Launch
Policy Impact Modeling

***Discussions with senior officials indicate most common policy intervention is budget adjustment***

# Cost-capping policy intervention

- Cost-capping government program expenditures is most frequently reported government policy intervention
  - Annual program budget capped by Congress
  - Capping stretches out program duration and increases total program costs as a result
- Historical examples provide basis for relationship between schedule extension and cost growth




***Schedule extension and resulting cost change relationship:***

$c = 0.24s + 1.7$

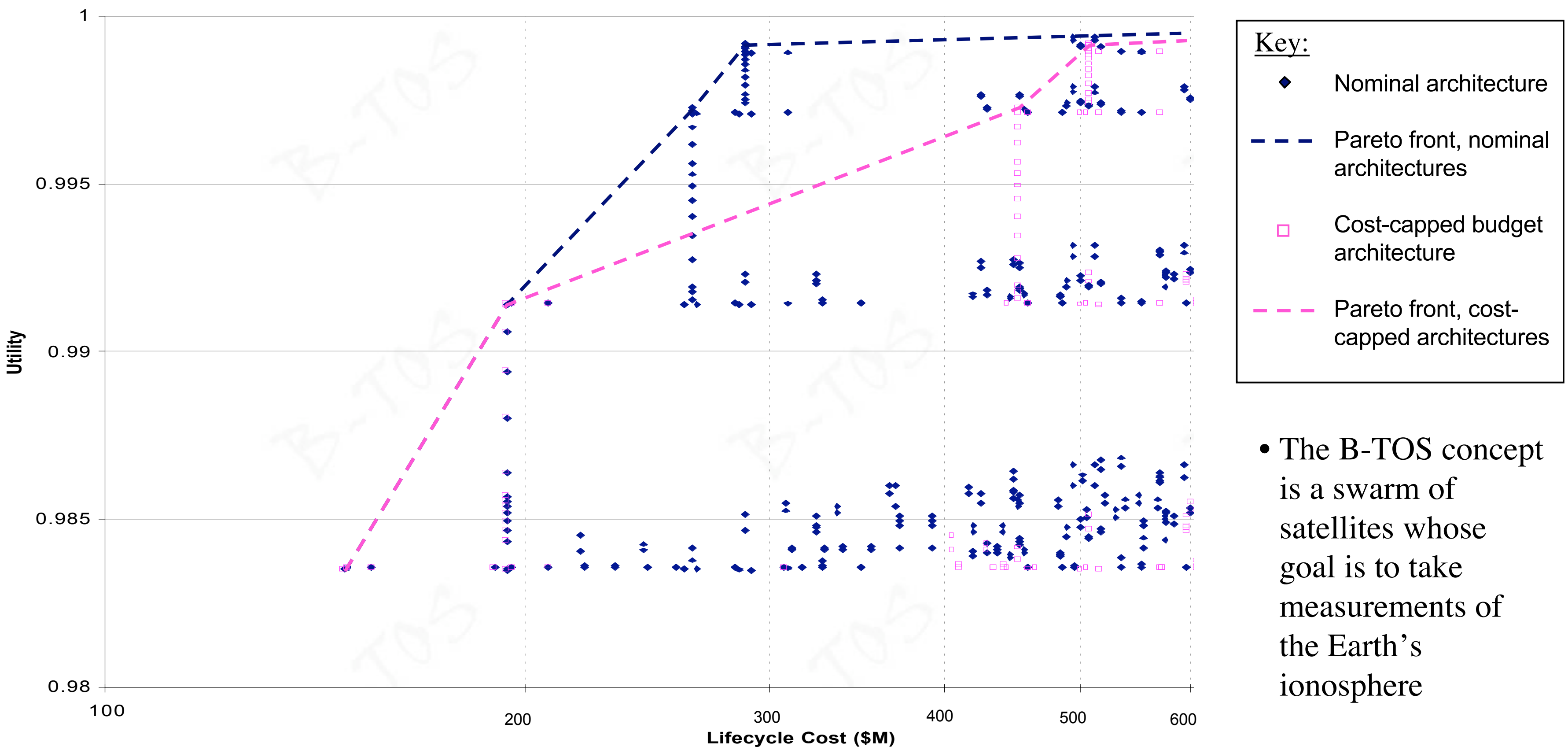
where $c$ = % cost change,

and $s$ = % schedule change

* Data adapted from Augustine, Norman R. *Augustine's Laws*, New York: Viking Penguin Inc., 1986

# Cost-capping on B-TOS architecture study

***Policy Intervention: $35M annual program budget cap imposed by Congress***

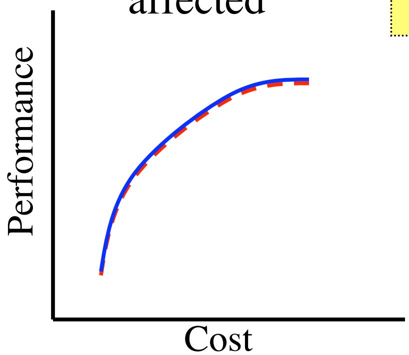



- The B-TOS concept is a swarm of satellites whose goal is to take measurements of the Earth's ionosphere

***Cost-capping policy pushes architecture tradespace pareto front to the right***

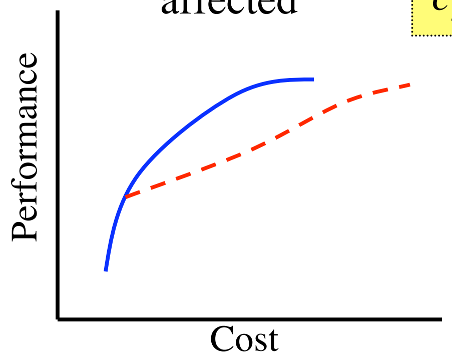
# Boundary of Option Value

**Stage 0**: No Pareto architectures affected



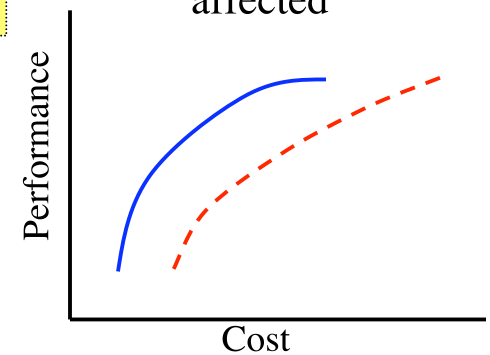

Transition at: $c_{max}/d_{max} > b_i$

**Stage I**: Some Pareto architectures affected




Transition at: $c_{min}/d_{min} > b_i$

**Stage II**: All Pareto architectures affected



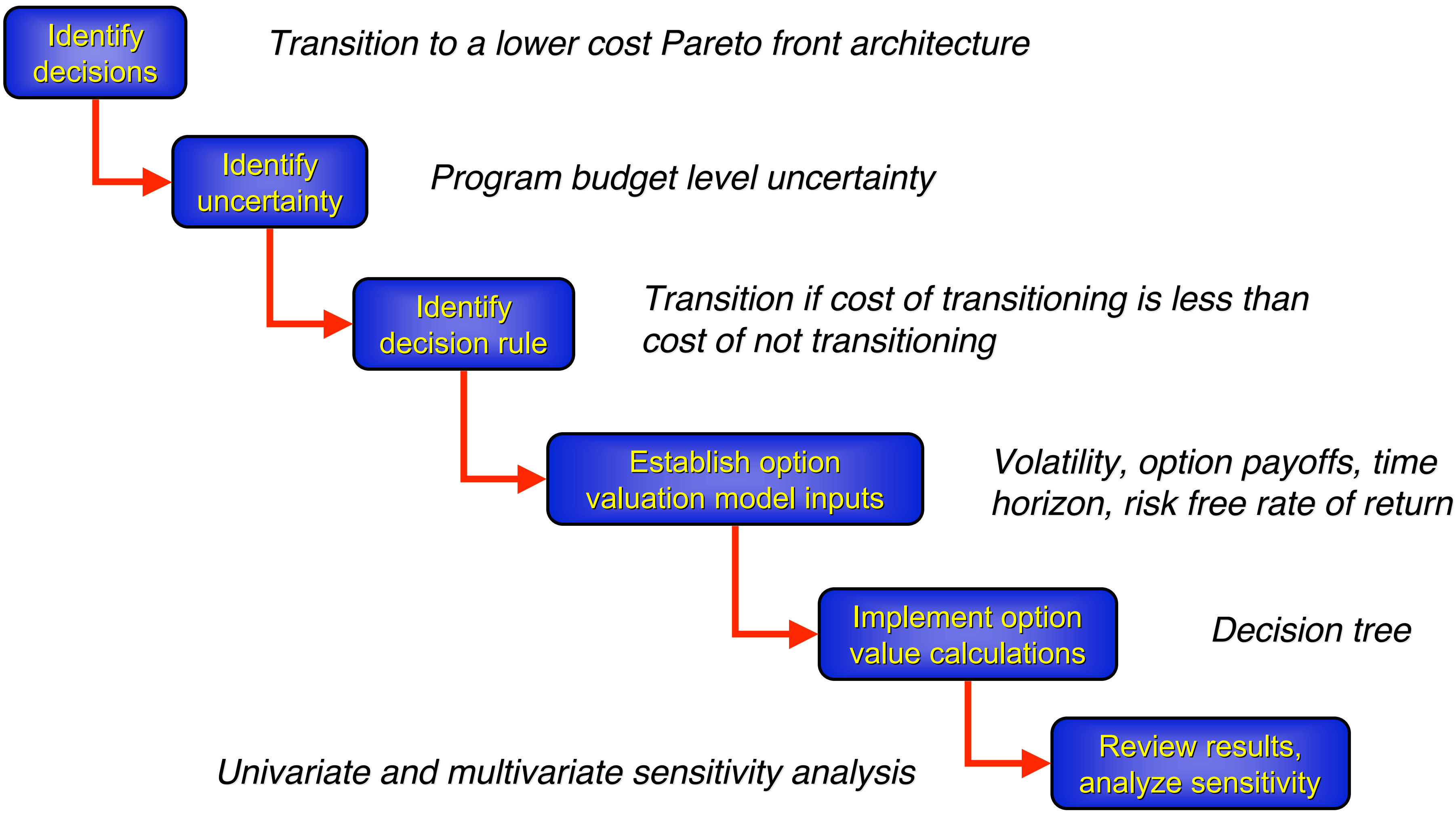

**Transition option has no value in Stage 0, because there is no need to transition.**

**Transition option has value in Stage I**

When $c_{\max}/d_{\max} > b_i$ and $c_{\min}/d_{\min} < b_i$

**Transition option has no value in Stage II, because there is no architecture in the Pareto set to transition to.**

# Steps in Real Options Analysis



# Designing for Budget Policy

***Goal of analysis: Use real options analysis to measure value of designing architecture to accommodate budget policy instability***

- Scenario
  - Future budget levels are uncertain
  - Pursue initial architecture choice
  - When budget is cut, program manager may want to transition to a new, lower budget architecture
- What is the value of a transition architecture option, which provides insurance against budget policy instability and makes a program more policy robust?
- Real options useful for valuing projects under uncertainty

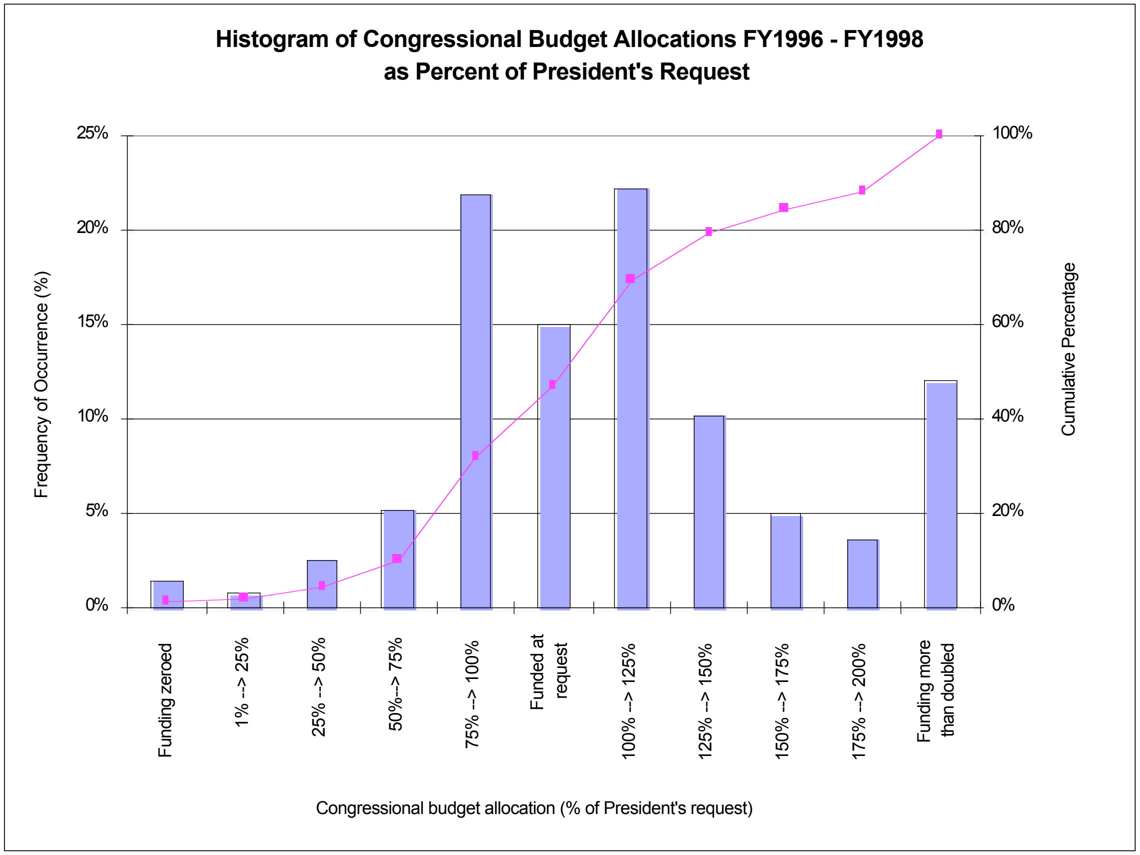
# Measuring Volatility

Use historical DoD budget reduction data for basis of volatility (FY1996-98)

<u>Insights:</u>

- 15% probability get requested budget
- 53% probability get increase
- 32% probability get budget cut

*Degree of budget cut follows exponential distribution with $\lambda = 4.65$*



# B-TOS Transition Option: investing in upfront work on “fallback” system

- Expectation of maximum transition option value calculated with the following assumptions:
  - Five B-TOS Pareto frontier architectures are the architecture set
  - Risk free rate of return, r = 5% Time to exercise option, t = 3 years
  - Volatility of budget cuts follows exponential approximation of historical observed budget cuts with $\lambda = 4.65$, and $1/\lambda = p_c = 0.32$

Expectation of maximum transition option value = $p_c * \Delta c_x / e^{-rt}$
where $\Delta c = c_i[0.24(c_i/b_i d_i - 1) + .017]$

| Expectation of maximum transition option value: | in $M | As % of spacecraft budget |
|---|---|---|
| For Architecture E | 7.4 | 3.1% |
| For Architecture D | 3.9 | 3.1% |
| For Architecture C | 3.4 | 3.1% |
| For Architecture B | 2.6 | 3.1% |
| For Architecture A | 0 | 0% |

**By historical averages, a B-TOS transition option will have an expected value of 3% of total spacecraft budget**