Applying PRICE-E, IDtC, & RDD-100 to System Design in a CAIV Environment

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Introduction

- ***Introduction***
  - ***CAIV Definition***
  - ***Elements of CAIV***
  - ***Environment***
- **Proposed Process**
- **Tools**
- **CAIV Trial**
- **Closing**

The CAIV Challenge
(Turning DoD Guidance Into Meaningful Program Results)

CAIV Directive (from DoDD 5000.1)

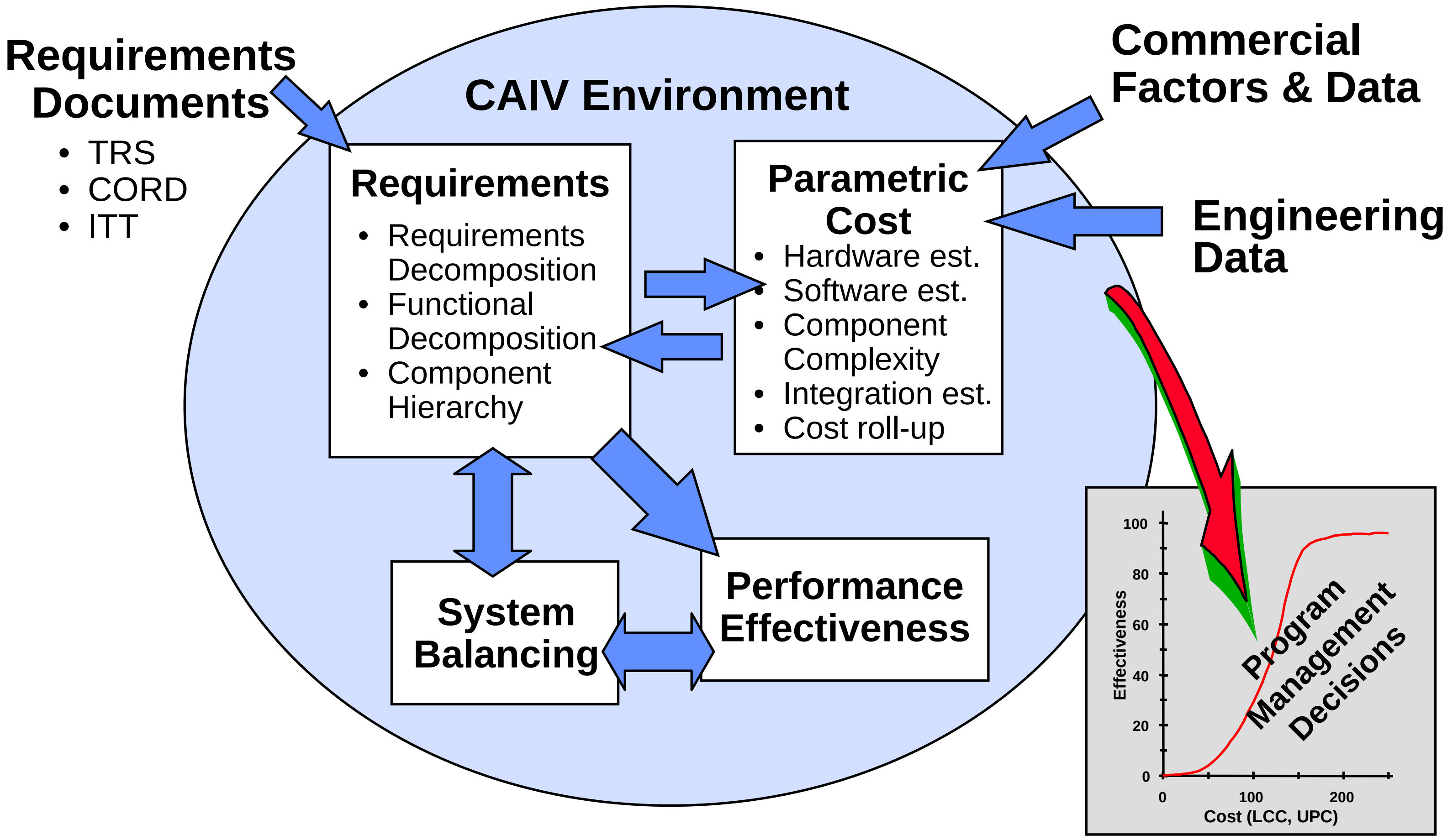
Cost as an Independent Variable (CAIV). Fiscal constraint is a reality that all participants in the defense acquisition process must recognize. Cost must be viewed as an independent variable. Accordingly, acquisition managers shall establish aggressive but realistic objectives for all programs and follow through by trading off performance and schedule, beginning early in the program (when the majority of costs are determined), to achieve a balanced set of goals, based on guidance from the MDA.

Implementing CAIV Activities

- CAIV is a multi-discipline effort:
  - Design engineering
  - Manufacturing engineering
  - Integrated logistics support
  - Specialty engineering
  - Parametric cost estimation
  - System analysis
  - Mission & Operations analysis
- Our approach to CAIV for concept definition phase
  - Automated & integrated process to allow rapid iteration
  - Expanded requirements-to-cost link
  - Configuration selection approach to define & explore trade volume
- Trade performance, schedule, & risk for cost

During the Concept Design Phase, CAIV is Enhanced by a System Engineering Approach

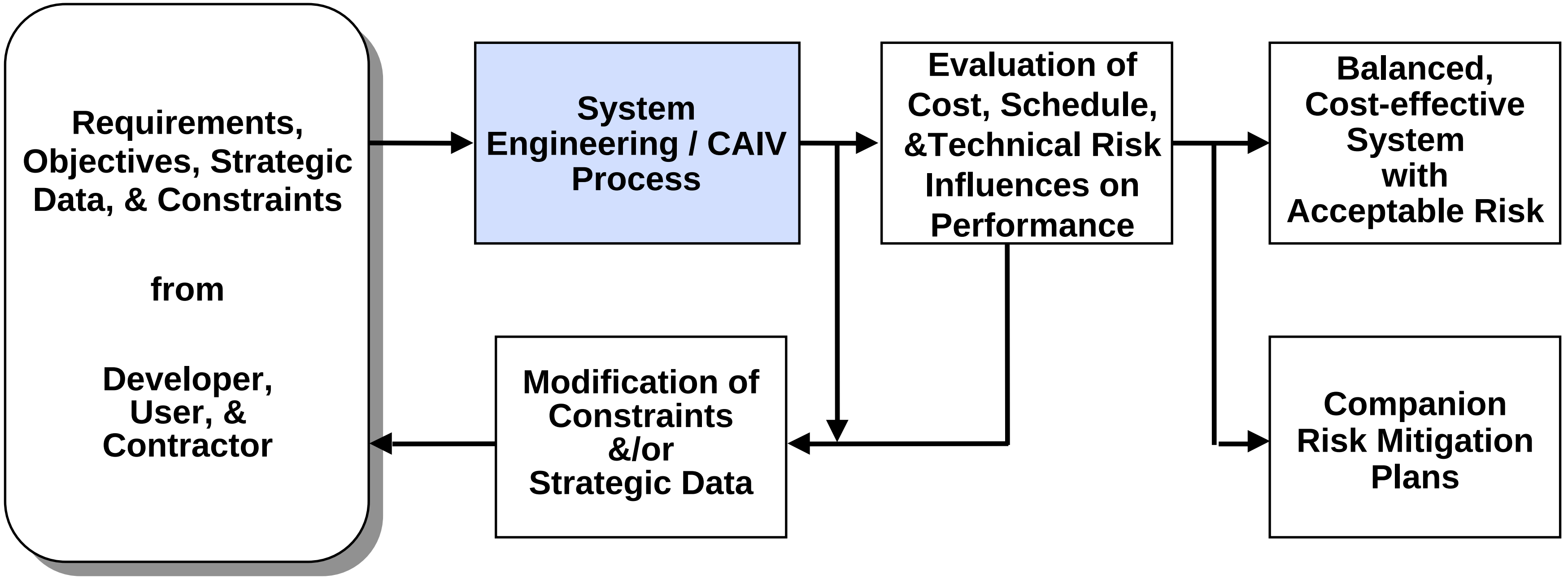
Overview of the CAIV Environment



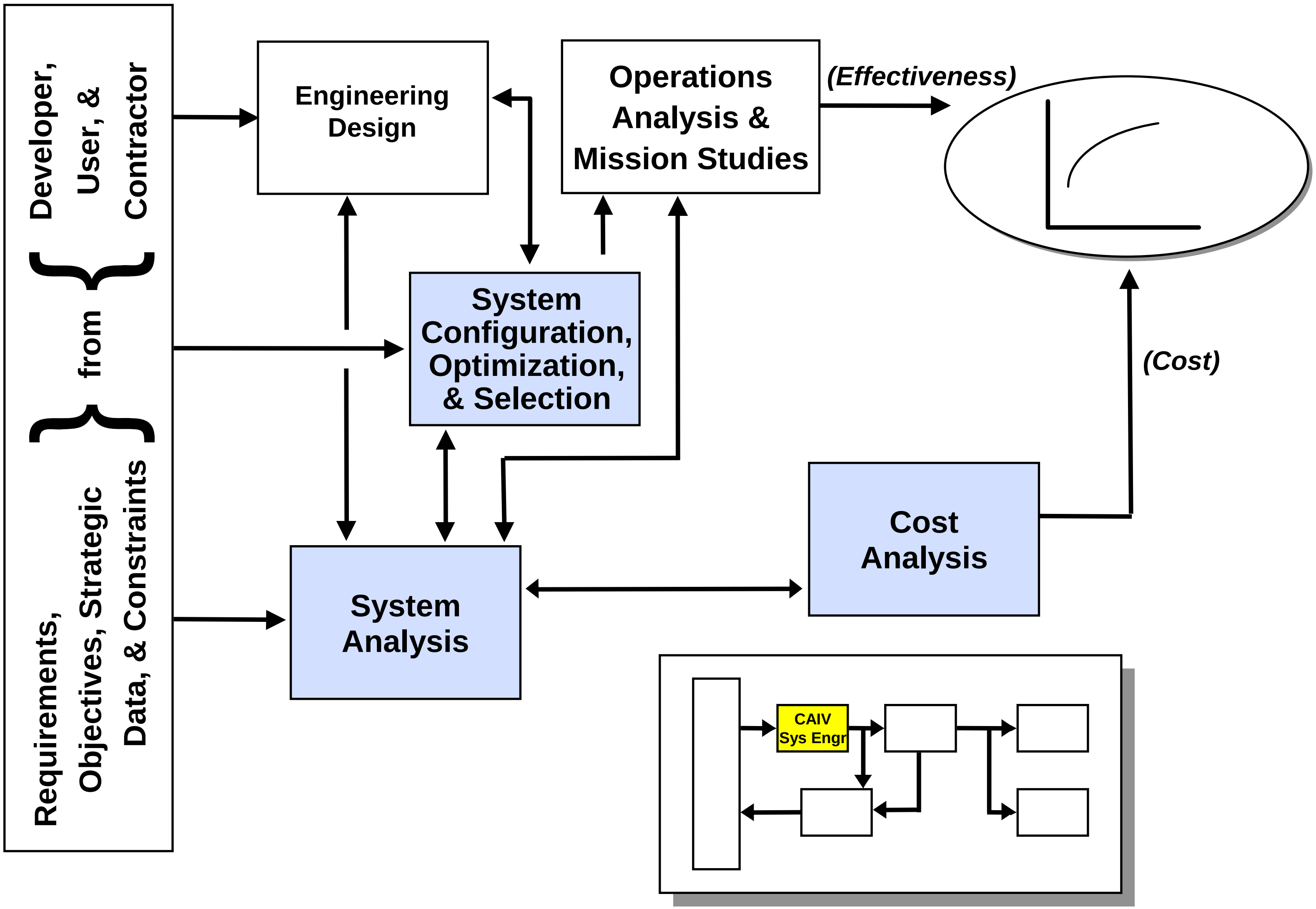
Proposed Process

- **Introduction**
- ***Proposed Process***
  - ***Program Perspective***
  - ***CAIV Process for Concept Definition Phase***
  - ***Decomposition of Selected Functions / Activities***
- **Tools**
- **CAIV Trial**
- **Closing**

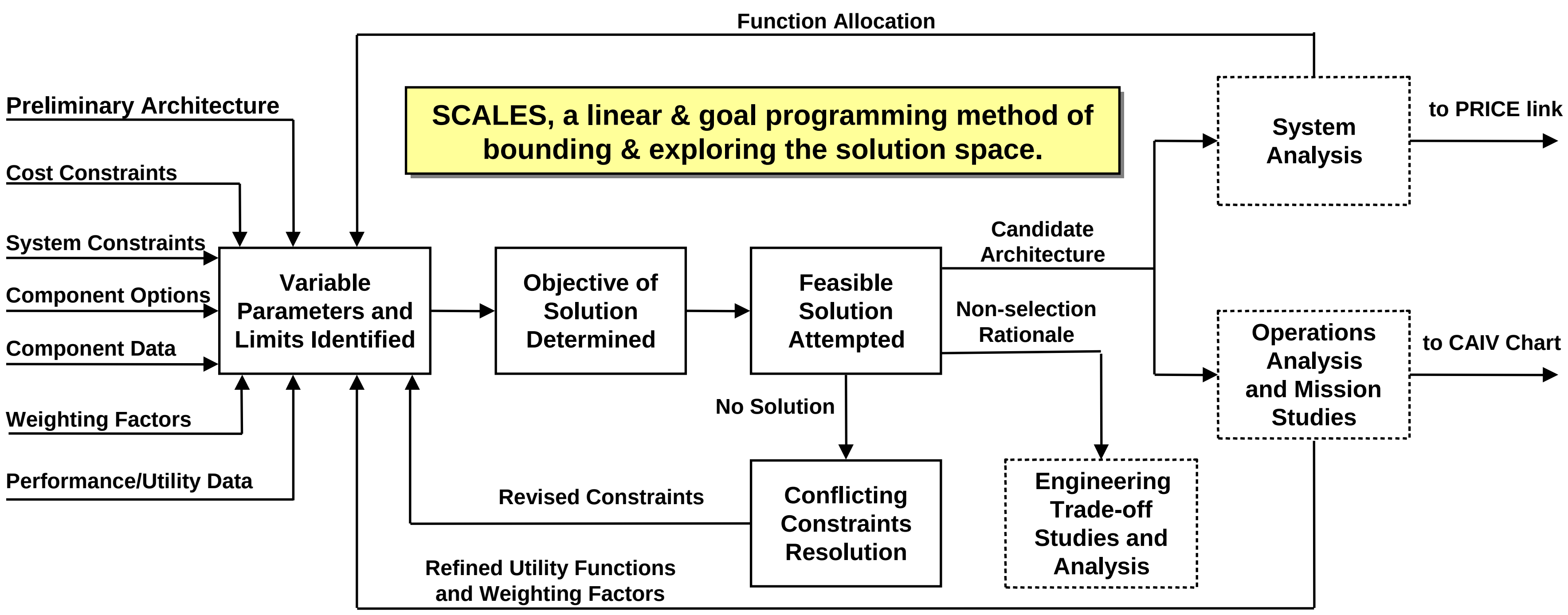
Achieving a Balanced, Cost-effective System

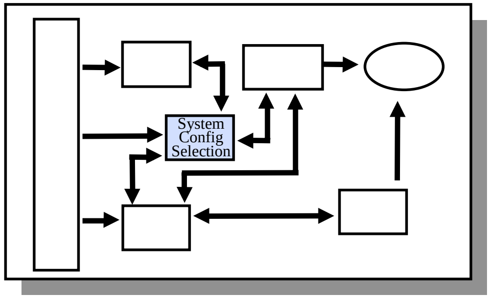


The CAIV Design Process

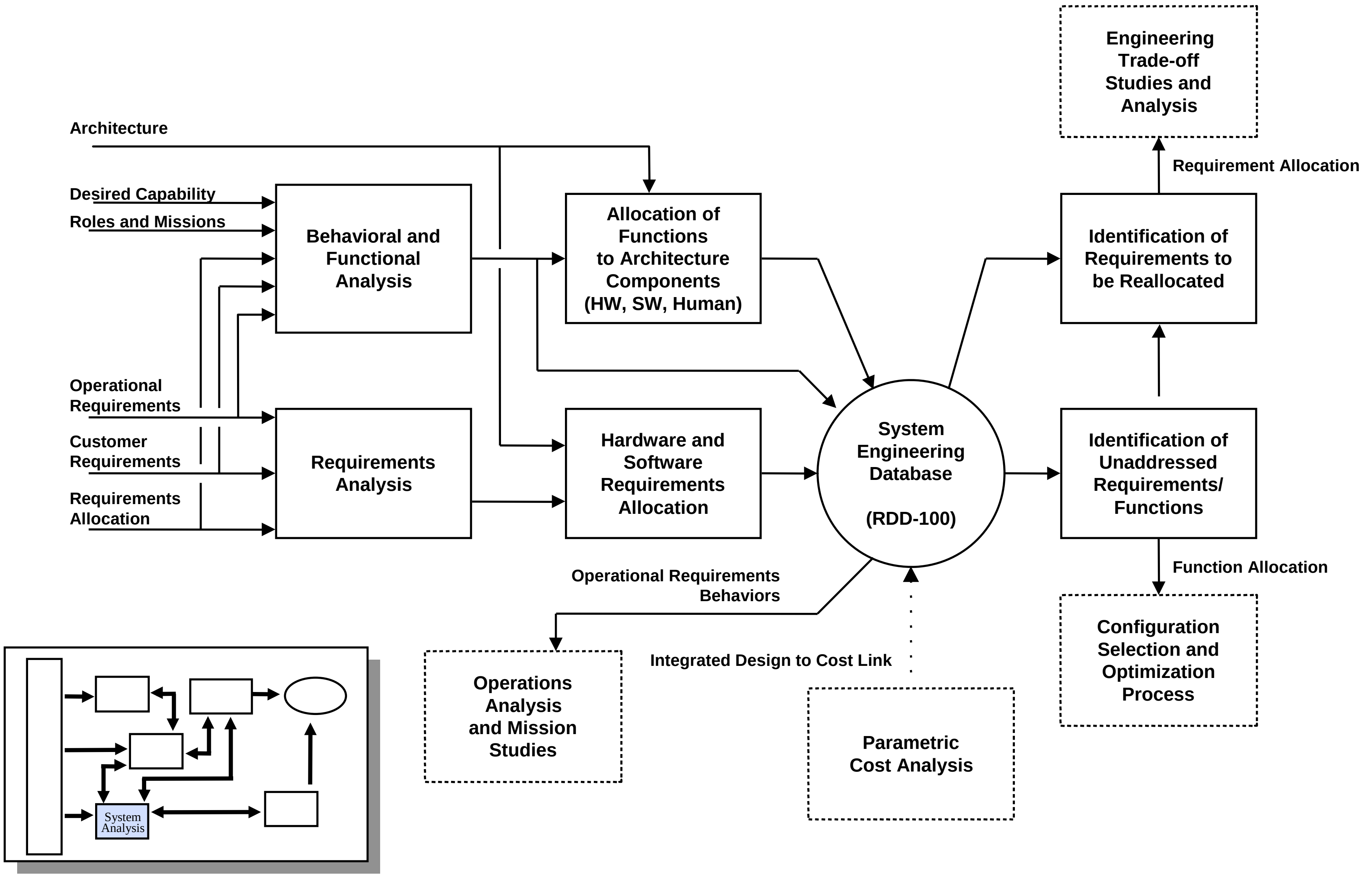


Configuration Selection & Optimization

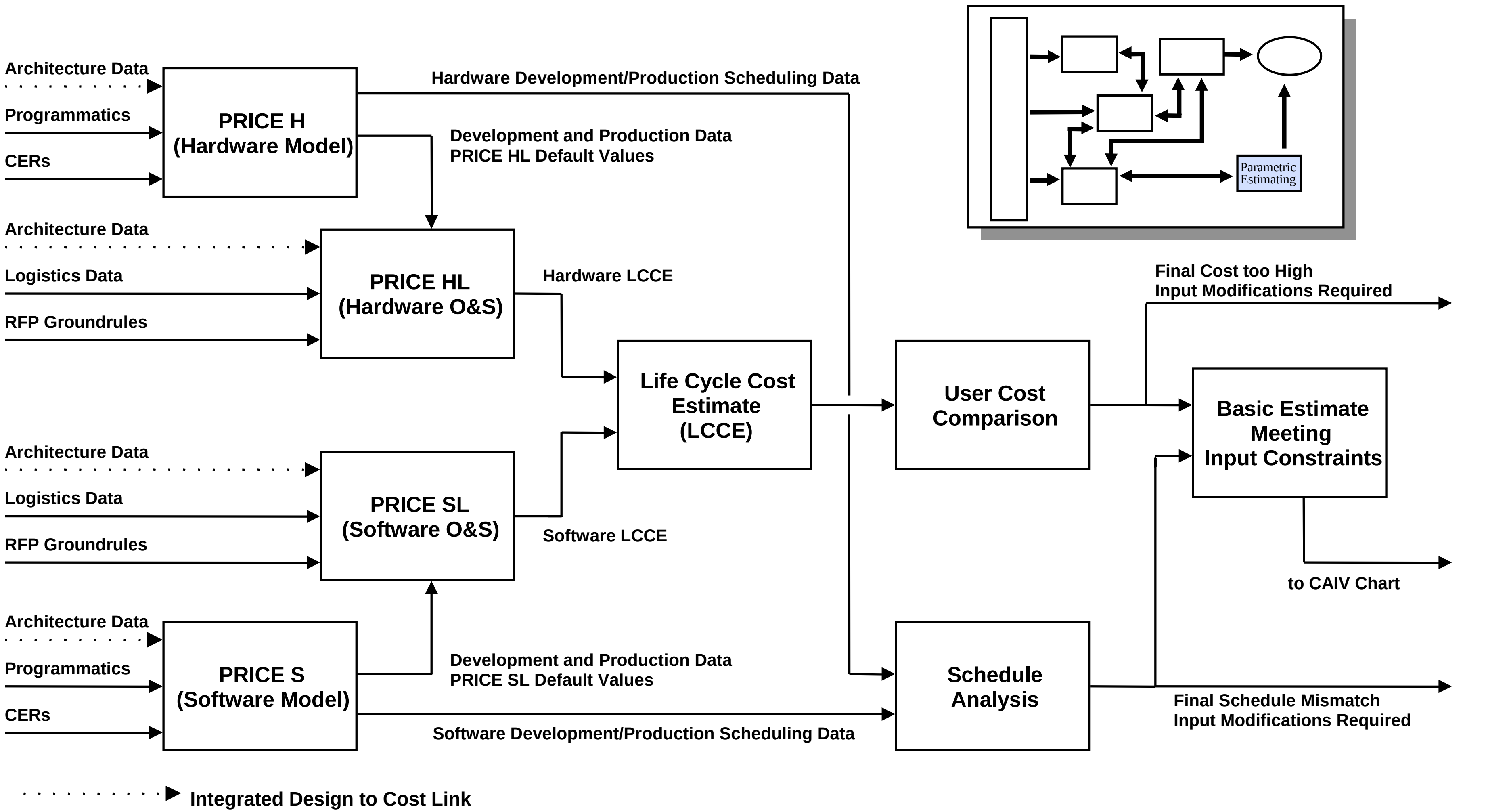




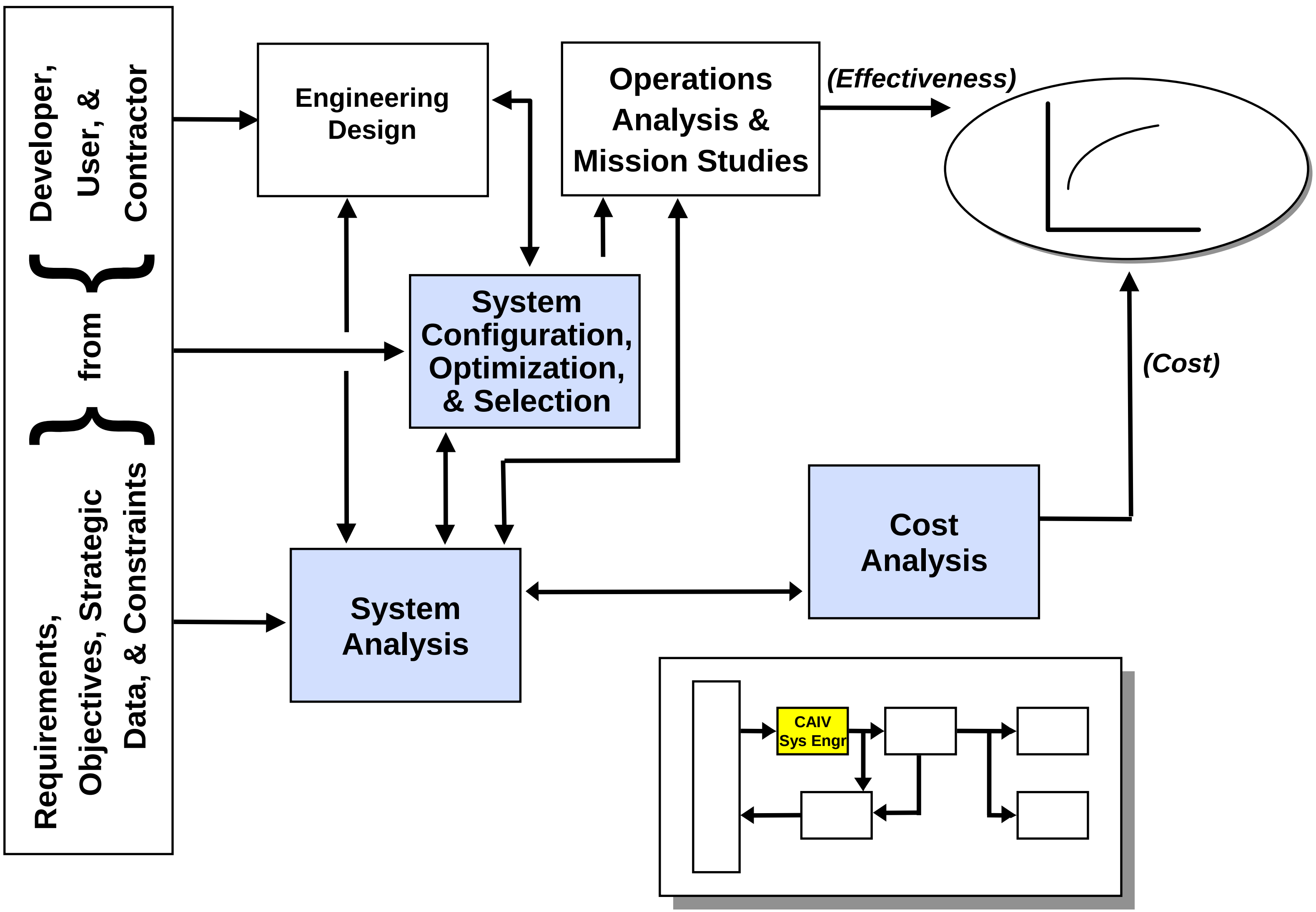
System Analysis



Parametric Cost Estimating



The CAIV Design Process

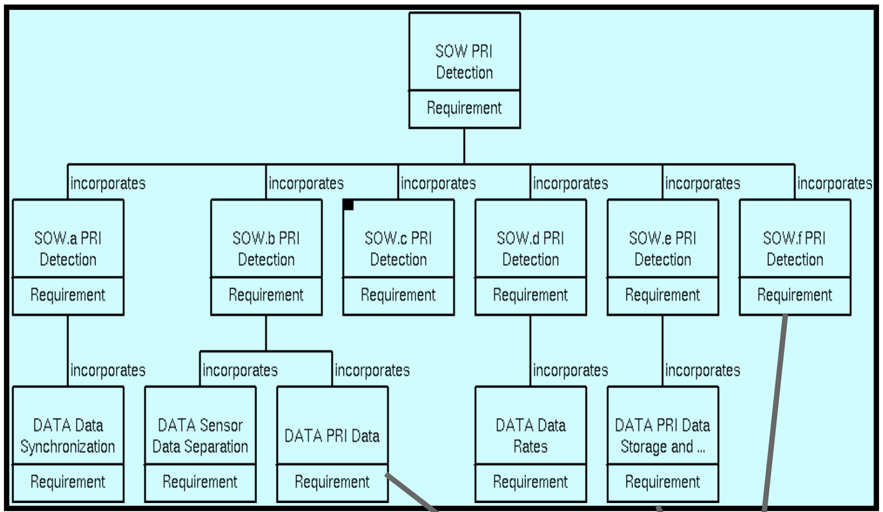


Selected Tools

- Introduction
- Proposed Process
- *Tools*
  - *System Analysis*
  - *Parametric Cost Estimation*
  - *Associating Costs With Requirements*
  - *Configuration Selection & Optimization*
- CAIV Trial
- Closing

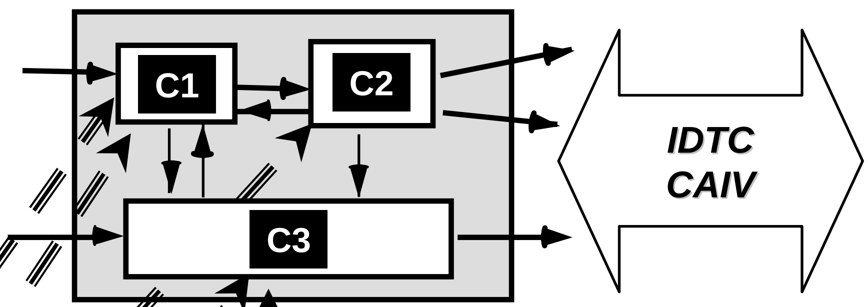
RDD-100 Supports System Engineering

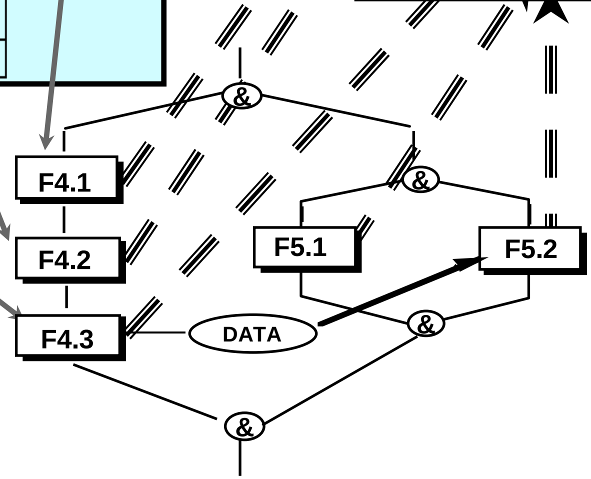
STEP 1: Requirements Analysis



STEP 3: Synthesis

- ➢ Functions and performance are allocated onto the components





STEP 2: Functional Analysis and Requirements Allocation

- ➢ System Functions are defined:
  - requirements allocated to functions
  - data and control flows
  - behavior graphical notation

STEP 4: Costing

- ➢ Component hierarchies are costed using IDtC

PRICE-E Parametric Cost Analysis

- Parametric analyses of development, production, operations, and support costs

- Combines:
  - PRICE H (Hardware model)
  - PRICE HL (Hardware O&S)
  - PRICE S (Software model)
  - PRICE SL (Software O&S)

- Used in conjunction with the IDtC tool to quantify costs associated with:
  - System architectures
  - System behavior
  - Specific requirements

Integrated Design To Cost - IDtC

ASCENT LOGIC'S
RDD-100

SYSTEMS ENGINEER

Enters requirements
Performs requirement analysis, functional decomposition, and generates high level physical architecture

Maintains System Design Database traceable to requirements

Development, Production, Support costs, and Maintenance Concept

Physical architecture
Quantities, size, weight, power, complexity, technologies, design source, and LRU status

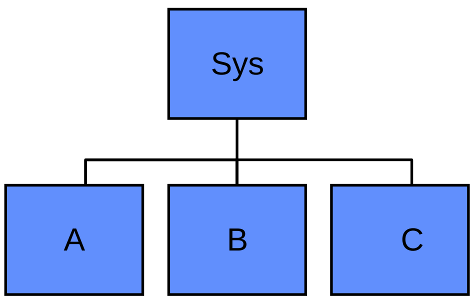
PRICE Systems A Lockheed Martin Company
PRICE E

COST ANALYST

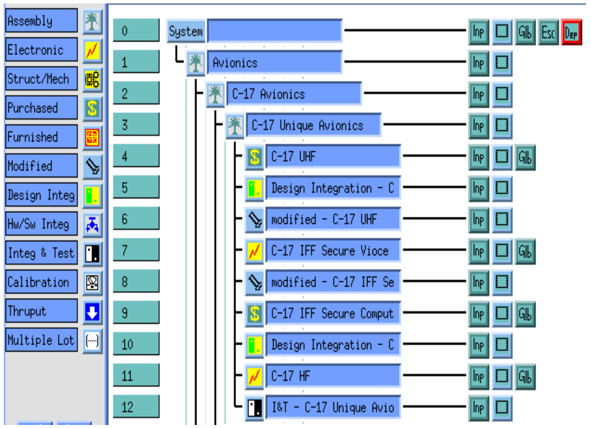
Enters cost history, project specific parameters, and costing details.
Performs cost analysis

EBS Creation from the RDD Architecture

RDD-100 Component Hierarchy



PRICE EBS



- **Automatically creates a hierarchy in PRICE that corresponds to RDD**
- **Maps RDD components onto PRICE “modes”**
- **Automatically adds DI, SI, Hw/Sw Int, and I&T modes where appropriate**

System Configuration & Selection
(SCALES, a goal & linear programming approach)

Provides system options maximizing system performance within given cost and physical constraints

- Uses linear / goal programming to balance system characteristics
- Accounts for component cost, risk, & performance characteristics
- Assists in understanding & exploring the trade volume
- Enables extensive sensitivity analyses
- Repeatable & traceable mathematics relationships provide a reasoned foundation for decision making

CAIV Trial

- **Introduction**
- **Proposed Process**
- **Tools**
- ***CAIV Trial***
  - ***Goals of Trial***
  - ***Ground Rules***
  - ***Overview***
  - ***Methodology***
  - ***Supporting Activities***
  - ***Notional Architecture***
  - ***Analysis***
    - ***Trial Trade Space Defined***
    - ***CAIV Function***
    - ***Feedback to Designers***
    - ***IDtC Review***
  - ***Summary***
- **Closing**

CAIV Trial Goals

- Exercise the CAIV process as defined
- Demonstrate process' usefulness
  - Management decisions
  - Data presentation
- Determine tool suitability
- Refine interfaces and data flow
- Establish basis for estimating required level of effort
- Identify unanticipated problems
- Document the process

Ground Rules

- Use a ground combat system as "test case" of the CAIV process
- Analysis depth limited
  - Time (approximately 8 weeks)
  - Staffing (about 3 to 4 analysts)
  - Relevance (due to surrogate data, etc.)
- System architecture detail limited to two levels for configuration and selection activities
- Use single Measure of Performance (MoP) instead of aggregating multiple measures of merit
- Risk data not considered
- Develop no LCC data

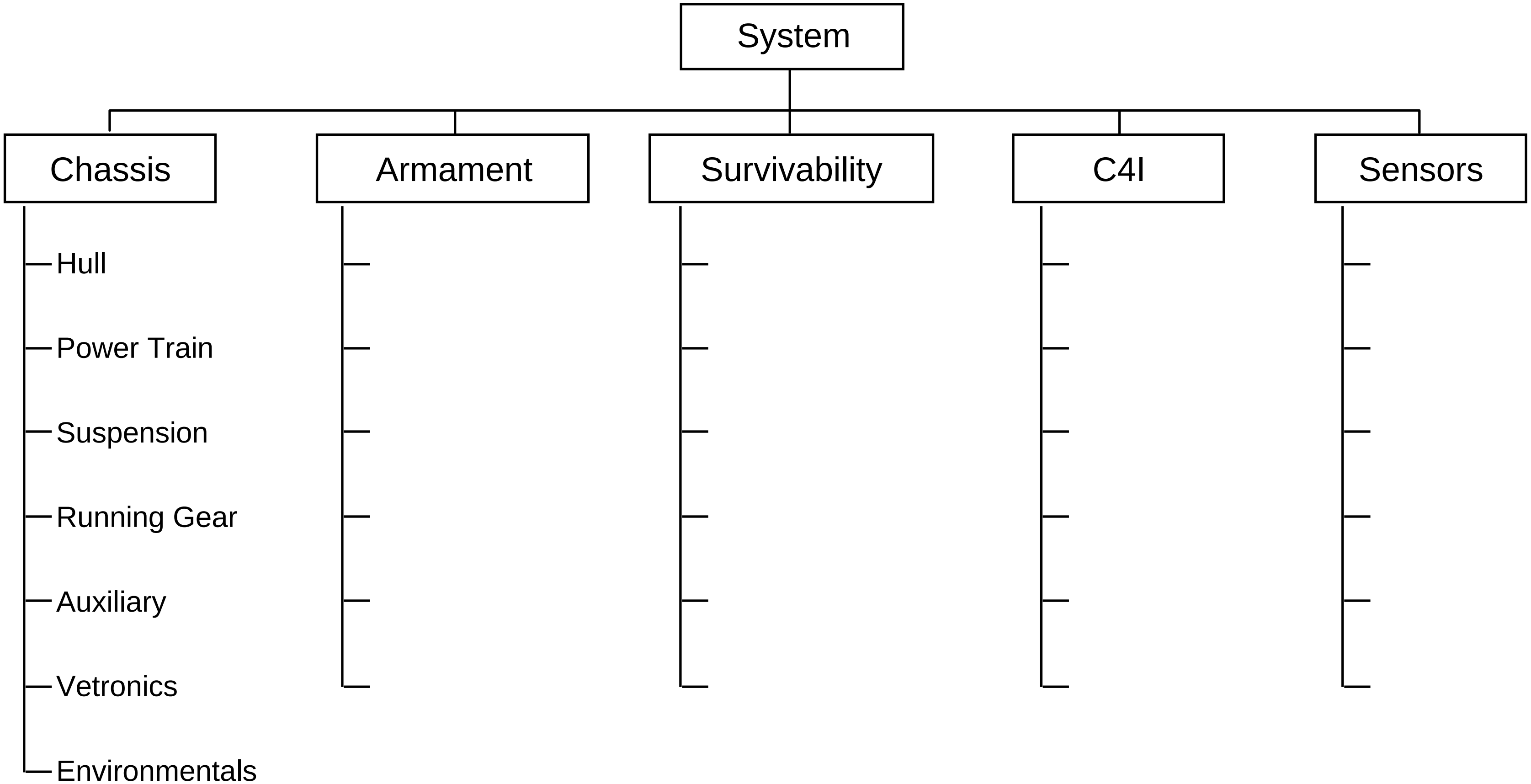
Trial Overview

- **Scope**
  - **5 Major subsystems modeled**
  - **31 sub-subsystems**
  - **Multiple options for each sub-subsystem**
    - **Performance**
    - **Cost**
    - **Physical characteristics**
- **Results**
  - **Developed multiple viable candidate configurations rapidly**
  - **Developed a "CAIV curve" quickly**
  - **Supported sensitivity analyses**
  - **Developed new metrics (component volatility)**
  - **Provided examples of data to support management decisions**
- **Lessons Learned**
  - **Preparation of models most time consuming**
  - **Data availability / collection key**
  - **Rapid iteration is possible**
  - **Data management (configuration control) & suitability**
  - **Effective communication with Program Management crucial**

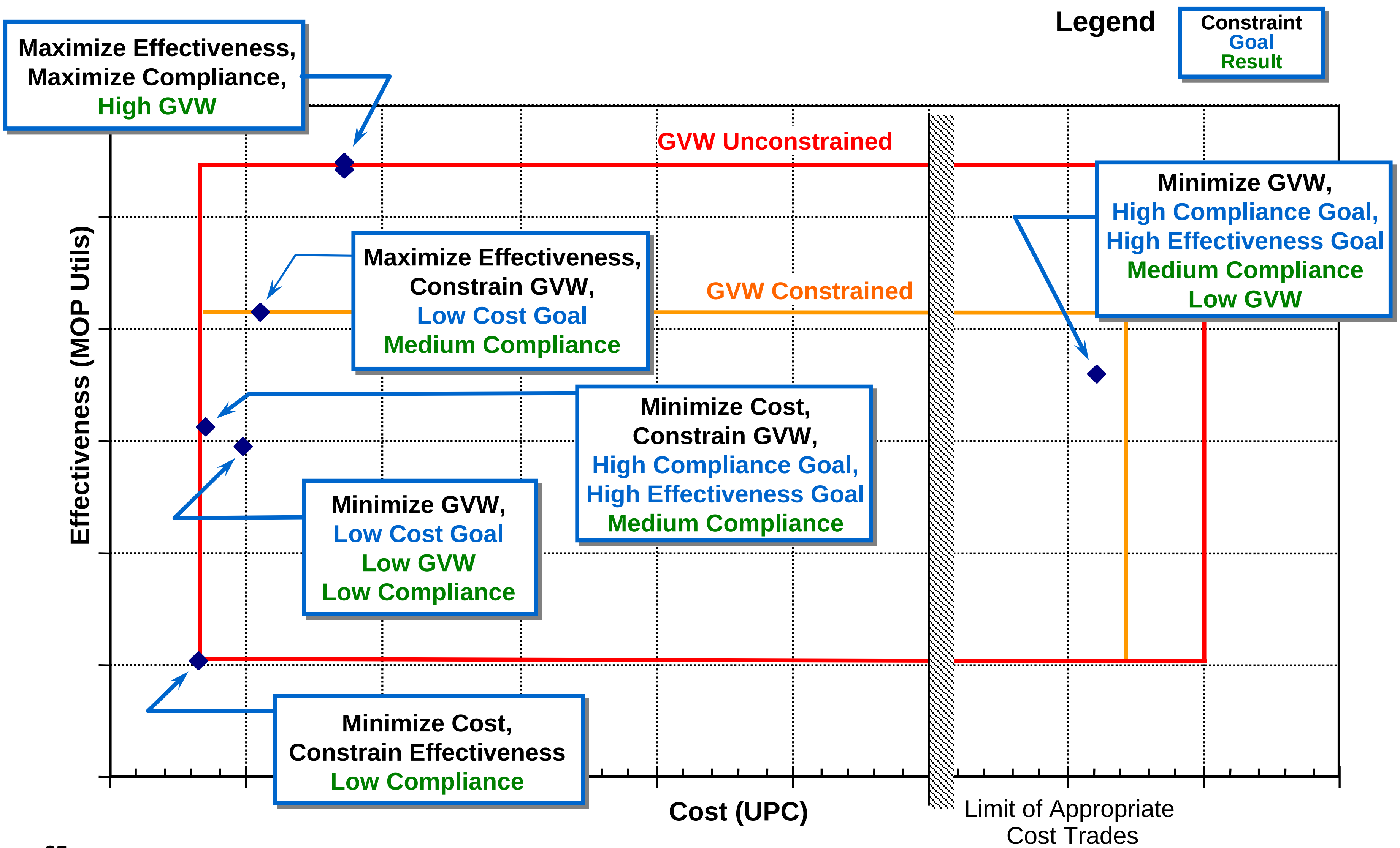
Summary of Supporting Activities

- Strategy to Task (STT) analysis
  - Used to estimate subsystem & component contribution to system
  - Prescribed DoD methodology
  - Decomposition of tasks based on established doctrine
- Physical utility function derivation
  - 380+ defined based on requirements review
  - Many aggregated for trial
  - Allocated to architecture via RDD-100
- Requirements decomposition & allocation
  - Activity to levels normally accomplished by technology areas
  - Selected architectures provided to PRICE-E via IDtC
- Functional analysis of missions
  - Nine missions decomposed
  - One mission functional simulation
- Parametric cost estimation
  - Component & integration costs estimated
  - Selected architectures costs estimated
  - Cost data provided to RDD-100 via IDtC link

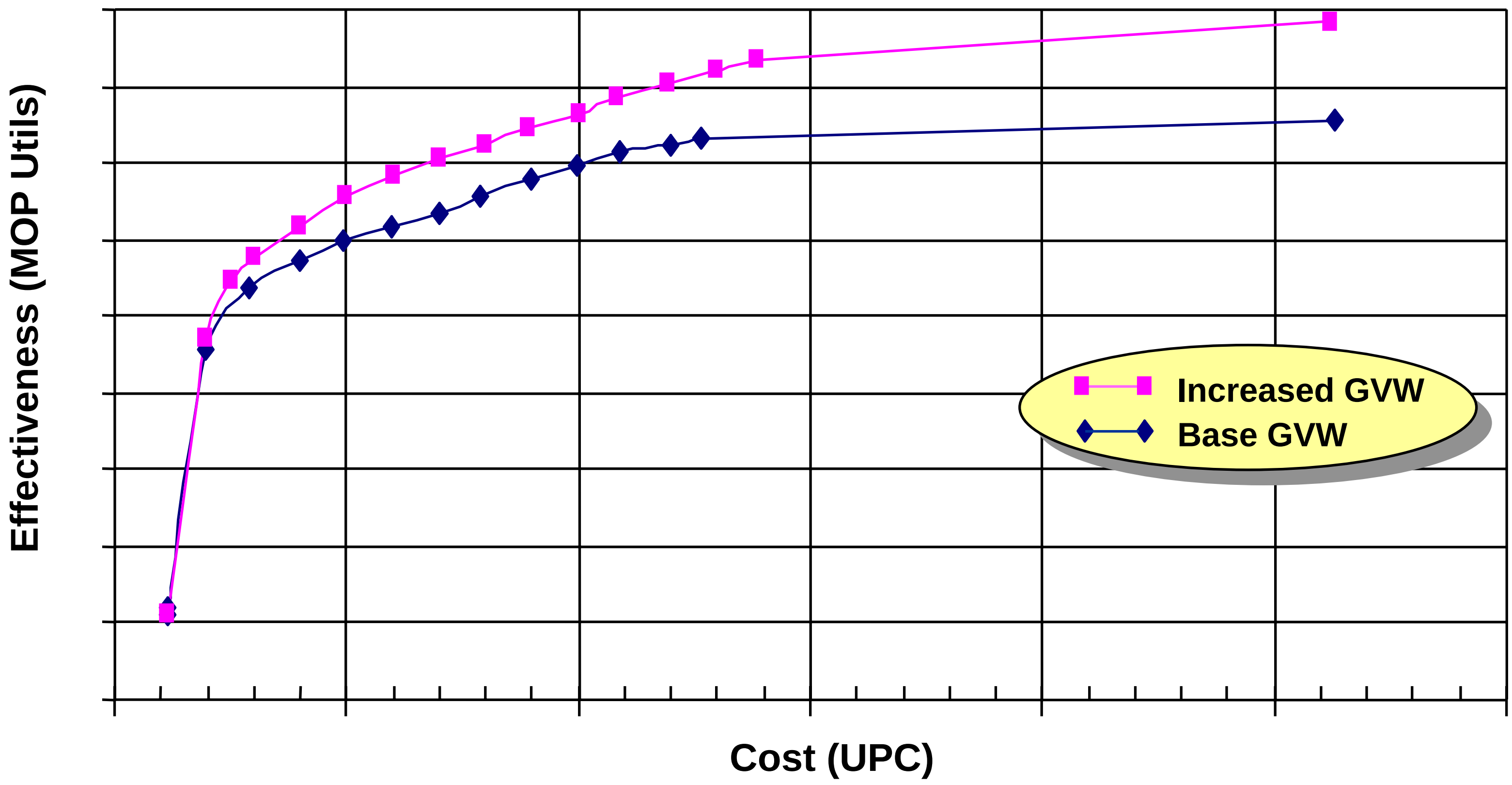
CAIV Trial Notional System Architecture



CAIV Trade Space Identified for Trial



CAIV Function Sensitivity to GVW for Trial



CAIV Feedback To Designers for Trial

SENSOR SUBSYSTEM															
	Total System Cost	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6
	Total System Effectiveness	30.6	47.8	51.2	51.8	53.6	54.9	55.9	56.8	57.8	58.8	59.7	60.6	61.1	61.6
Major Sub-subsystem	**Component**														
Sub-subsystem A	With FLIR 1			1	1	1	1	1	1	1					
	With FLIR 2										1	1	1	1	1
	With No FLIR	1	1												
Sub-subsystem B	Option 1														
	Option 2		1	1	1	1	1	1							
	Option 3								1	1	1	1	1	1	1
Sub-subsystem C	Option 1	1	1												
	Option 2			1	1	1	1	1	1	1	1	1	1	1	1
Sub-subsystem D	Option 1	1	1			1	1			1	1	1			
	Option 2			1	1			1	1				1	1	1
	Contribution to Cost	0.844	0.863	0.878	0.878	0.878	0.878	0.878	1.429	1.429	1.807	1.807	1.937	1.937	1.937
	% Contribution to Cost	26.1%	25.4%	25.1%	24.5%	23.1%	22.0%	20.9%	32.5%	31.2%	37.6%	36.2%	37.4%	35.9%	35.0%
	Contribution to Effectiveness	2.6	5.5	5.8	5.8	5.8	5.8	5.8	8.7	8.7	10.5	10.5	11.0	11.0	11.0
	% Contribution to Effectiveness	8.5%	11.4%	11.3%	11.2%	10.8%	10.6%	10.4%	15.3%	15.0%	17.9%	17.7%	18.2%	18.1%	17.9%
	Contribution to Weight	529	559	554	554	554	554	554	636	636	657	657	685	685	685
	% Contribution to Weight	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.6%	1.6%	1.6%	1.6%	1.7%	1.7%	1.7%

- **Feedback to Engineers & Designers**
  - **High “pay-off” systems identified**
  - **Volatile systems identified**
- **Feedback to Customer**
  - **Identify operationally important subsystems & components**
  - **Subsystem contribution to effectiveness, mission, etc.**
- **Information for Management**
  - **Areas requiring investment**
  - **Candidates for cost, performance, requirement, etc. re-allocation**

Cost / Requirement Link (IDtC Software)

- Small Test Case (Jan 98)
  - Existing software focused on electronics applications
  - Work-around developed for structure components
  - Test results promising
    - Agreement between "independent" cost estimate & estimate via IDtC
    - RDD-100 Schema & PRICE EBS must be coordinated
    - Report helpful
      - Understanding any discrepancies
      - Identifying areas for potential savings (duplicate equipment, etc.)
  - Identified additional development requirements
    - Structure
    - Usability
- CAIV Trial Experience (Aug & Sep 98)
  - Software handles all component categories
  - Very good user interface
  - Some bugs still to be resolved
  - "Style" considerations
    - File naming convention
    - Discrepancy list

CAIV Trial Summary

It Was Successful!

- Demonstrated
  - Process usefulness & capabilities
  - Tools' suitability
- Refined & Validated
  - Interfaces
  - Data flow
  - Procedures
- Developed & Produced
  - CAIV trade space & "curve"
  - Techniques for displaying & interpreting results
  - Level of effort data
- Identified
  - Multiple viable architectures (>65) within identified constraints
  - Areas for further development
  - Staffing and schedule requirements

Closing

- **Introduction**
- **Proposed Process**
- **Tools**
- **CAIV Trial**
- ***Closing***
  - ***Review of Highlights***
  - ***Conclusion***

Review

- **DoD CAIV Environment is a Reality**
  - ***Everything*** **traded with goal of reducing life cycle cost**
  - **Implementation & activities a function of program phase**
- **Integrating a CAIV Process with System Engineering**
  - **Structured but responsive**
  - **Automating where feasible**
  - **Associate cost with requirements, function, task, etc.**
- **Tools**
  - **System Analysis**
  - **Parametric Cost Estimating**
  - **Concept design**
  - **Others not detailed**
- **CAIV Trial**
  - **Successfully demonstrated process & usefulness**
  - **Relevance of analysis**
  - **Lessons learned**

Conclusion

- Approach to Implementing CAIV During Concept Design
  - Process independent of tools selected
  - Viable but requires engineering & management “buy-in”
  - Requires “up-front” investment & System Engineering discipline
- Equally Rigorous Processes Needed for Other Facets of CAIV
  - Program phase sensitive
  - Management decision model
- Processes & Analyses Only Support & Inform Management
  - Allocations still required (cost, performance, requirements, etc.)
  - Tough trades still required