U.S. DoD Legacy SE & Implications for Future SE Implementation

Joseph J. Simpson, System Concepts

Mary J. Simpson, System Concepts

Systems Engineering - A Macro Process

□ **Define problem**

✓ What is the problem?

✓ Who needs to have it fixed?

✓ Why does it need to be fixed?

□ **Determine WHAT is needed to fix problem**

✓ What has to be done?

✓ How well does it have to be done?

□ **Decide HOW to fix the problem**

✓ What are various ways to do it?

✓ What way will you use to fix the problem / why?

✓ When done, is the original problem fixed?

✓ Has the best way been used to fix the problem?

□ **Solve problem; provide solution to customer**

INPUT

Constraints - External Environment

WHAT

Functional Analysis, Requirements

HOW

Alternatives, Solution

Verification, Validation

OUTPUT

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Systems Engineering - Notional Format

Problem Statement

INPUT
Constraints from External Environment

WHAT

Functional Analysis

Tradable Derived Requirements

HOW

Alternatives Solution / Architecture

Test Validate /Verify

OUTPUT
Solutions / System Complete

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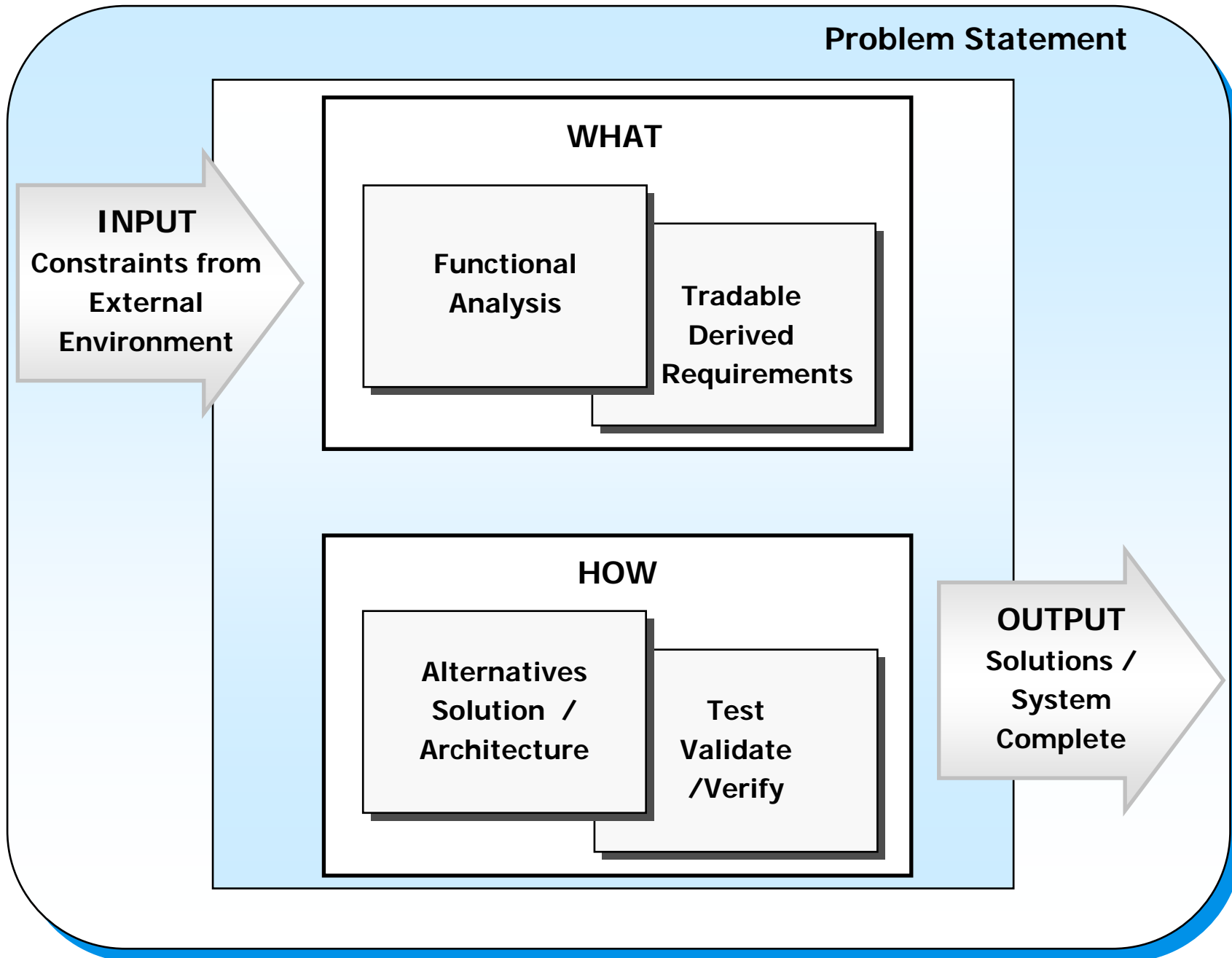
The Nature of a Systems Approach:
Multi-Phased, Hierarchical, Multi-Dimensional
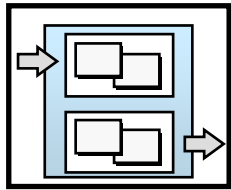
Macro Process

Applies to:

Dimensions
- Technical
- Management
- Programmatic

Phases
- Over time
- Over products
- Over events

Hierarchies
- Abstraction
- Complexity
- Levels of detail

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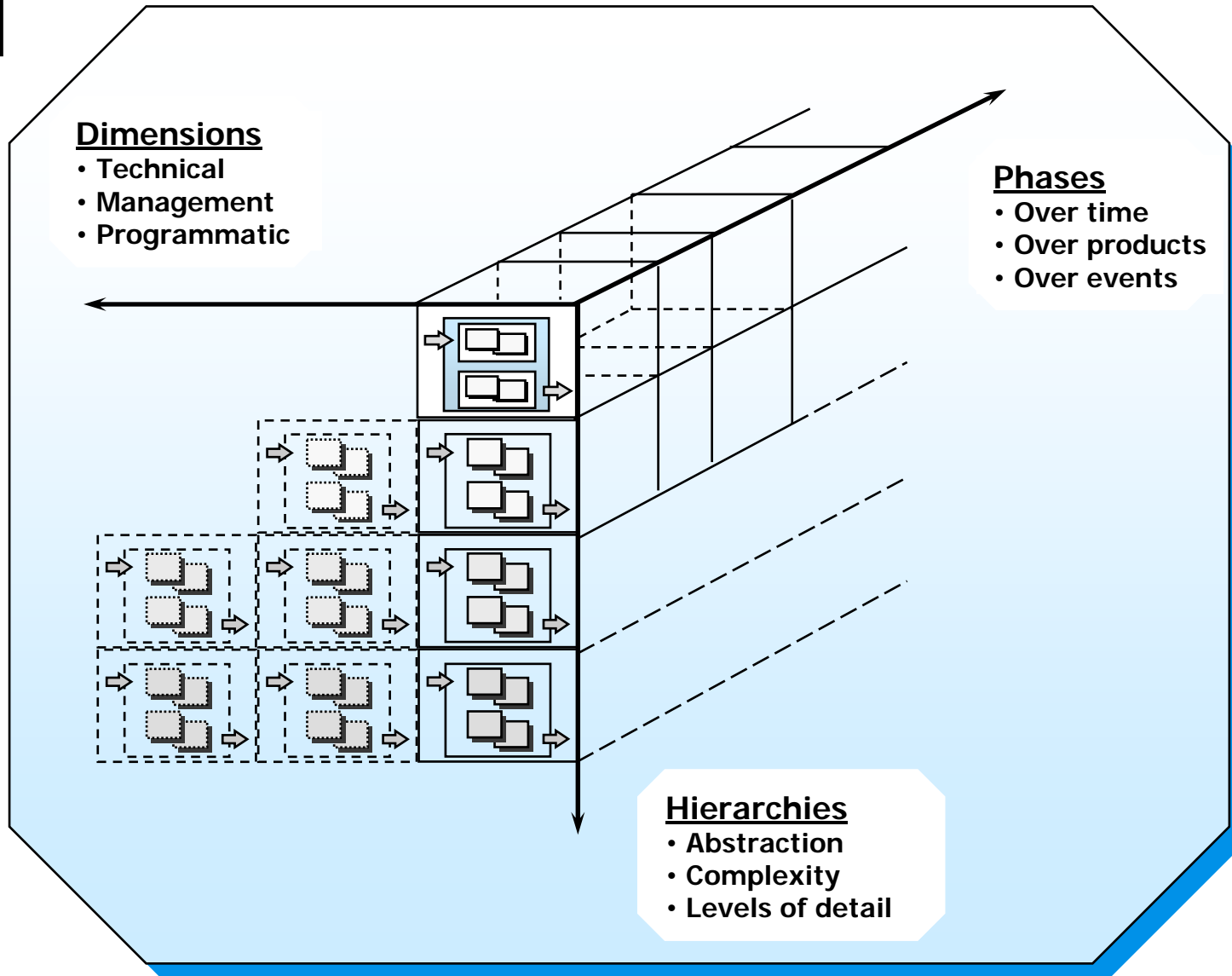
Where in Systems Approach Morphology Does SE Get Applied?

□ **Phases / Time Dimension**

- ✓ Sequenced from birth to death of system
- ✓ Segmented by major decision milestones
- ✓ Populated intervals between milestones called phases and define a coarse structure in life cycle [program & project planning, systems development, production, distribution, operations, retire]*

□ **Hierarchical / Logic Dimension**

- ✓ Defines generalized human group problem solving procedure
- ✓ Logic elements [problem definition, value system design, systems synthesis, systems analysis, optimization of each alternative, decision-making, planning for action]*: (1) may be performed in many time orders, (2) each of which usually must be performed for a phase to be complete, and (3) repeated for subsystems, modules and components at lower levels within a phase
- ✓ Controlled by a multilevel logic

□ **Knowledge / Content Dimension**

- ✓ Bodies of facts, models, and techniques necessary to plan, design, produce and to use a system within a total life cycle: (1) conventional fields [engineering, medicine, law, architecture, ...]* (2) a unique mix of conventional disciplines and some not found among them at all

□ **Cultural / Political / Behavioral (Human) Dimension**

- ✓ Designers and users of systems play characteristic roles and are bound within a culture
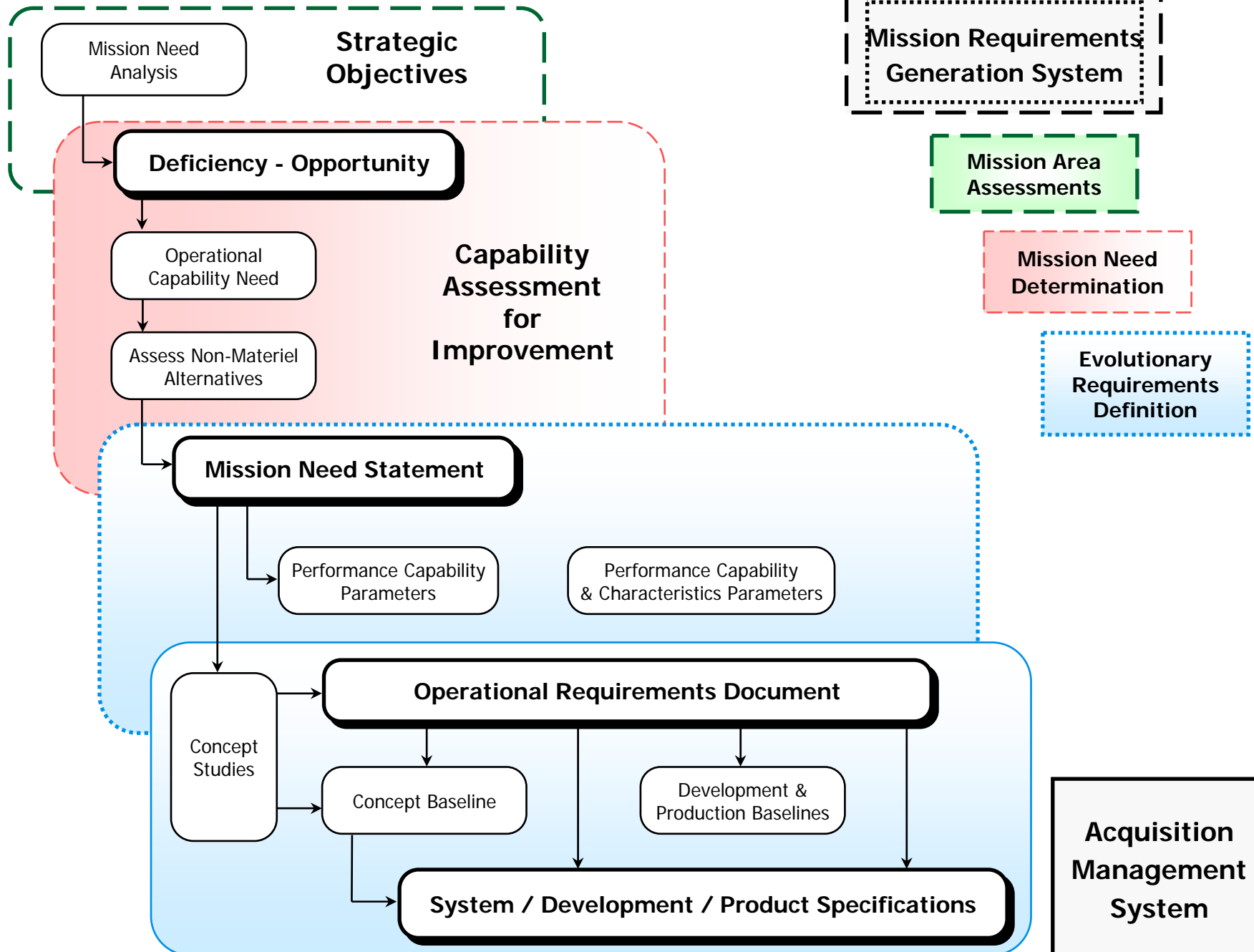- ✓ Culture impacts preferences, attitudes toward risk, management styles, data and models used...

* A.D. Hall, <u>Metasystems Methodology</u>, 1989.

In Framework Consistent with Application Domain

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Major Program Justification: U.S. Military

Strategic Objectives

Mission Need Analysis

Deficiency - Opportunity

Operational Capability Need

Assess Non-Materiel Alternatives

Capability Assessment for Improvement

Mission Need Statement

Performance Capability Parameters

Performance Capability & Characteristics Parameters

Concept Studies

Operational Requirements Document

Concept Baseline

Development & Production Baselines

System / Development / Product Specifications

Mission Requirements Generation System

Mission Area Assessments

Mission Need Determination

Evolutionary Requirements Definition

Acquisition Management System

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Integrated Program Summary (IPS)

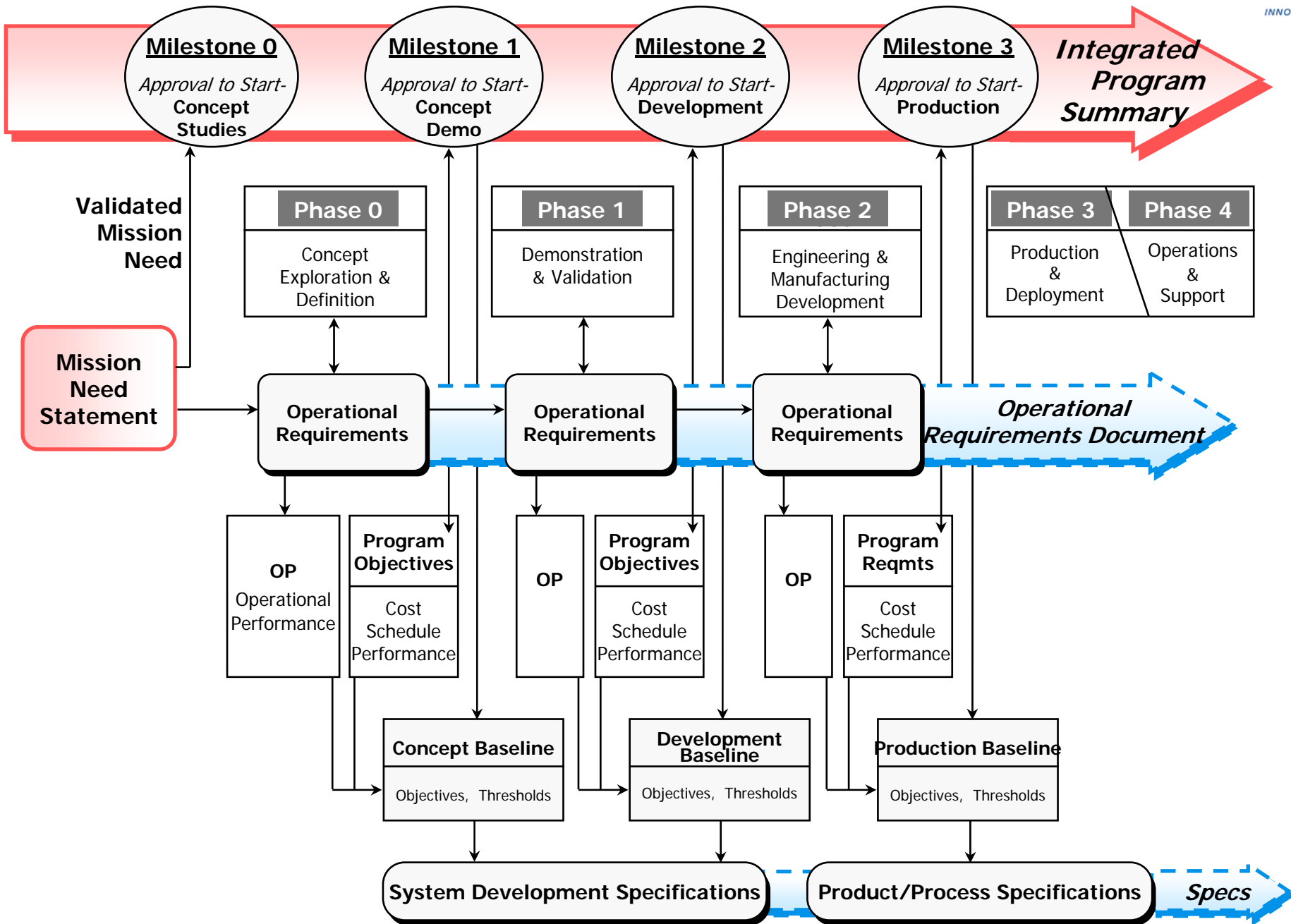**IPS – PRIMARY DECISION DOCUMENT**

- Summarizes where the program is, versus where it should be

- Describes where the program is going, and how it will get there

- Identifies program risk areas and plans for closing risks

- Provides the basis for establishing explicit program cost, schedule and performance objectives and thresholds in the program baseline, and exit criteria for the next phase

A history of all decisions **including value judgments** is kept as part of the IPS record.

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Overall Acquisition Process

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Military Framework - U.S. Dept of Defense Domain

- **Systems engineering:**
  - ✓ Is subordinate to overall project management & control process
  - ✓ Does not normally impact selection of **Program Structure and Schedule**
  - ✓ Does not normally impact **Program Affordability Assessment**
  - ✓ Does not normally impact **Program Acquisition Strategy**

- **Elements of existing U.S. DoD infrastructure that have been historically transparent to systems engineers (and other specialty engineers) include:**
  - ✓ Stated **high-level policies** / values that impact existing system(s)
  - ✓ Articulated **high-level objectives** for new mission
  - ✓ **Defined operational environment** in which system will reside
  - ✓ Application of **well-defined program/project management**
  - ✓ Clear **command and control structure** for management & decision-making
  - ✓ Established **acquisition process** for new/revised system(s)

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Consider Context, Infrastructure & System Environment [1992, U.S. Dept of Energy, Morais, Grygiel]

Considerations	Observations & Conclusions
System Boundaries	"A change in mission resulted in a change from a production system to that of a remediation system."
High-level values, objectives	"... To change from supporting the nuclear weapons production program to one that would eliminate the threats to the environment and hazards to the public that have resulted from this production."
Decision-making structures, processes	"Set up conditions so that the participants have a common understanding of how decisions are made and what is going to be considered."
Acquisition/funding processes,	[Although not documented in this paper, a concurrent effort to evaluate and select appropriate acquisition/funding processes involved in DOE cleanup has been ongoing for the last decade.]
Project and/or program management processes, controls	"Ensure ... change has been communicated down through all ... levels. ...Establish ... milestones to assess progress, risks & problems that will occur while implementing the change."
Operational environment	"The mission change ... resulted in direction ... to stop production, to close waste storage facilities, & to remediate contamination that had occurred."
Existing technical (or other) logic	"This legally binding agreement [TPA] forms a plan that was developed prior to the application of a well thought out systems approach to developing a solution for site remediation."
Additional critical factors (major impacts?)	"Take a systems view of the objectives that require the Culture change. Periodically assess risk."

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Consider Context, Infrastructure & System Environment [1999, Eastman Kodak, Mason, et. al.]

Considerations	Observations & Conclusions
System Boundaries	"... necessary for Kodak to participate effectively in both the design and introduction of the Advanced Photo System"
High-level values, objectives	"Every aspect of the photographic system ... would change. To manage this change ... required Kodak to actively implement system engineering principles."
Decision-making structures, processes	Established "...a framework for managing system level negotiations with our joint development partners and internal organizations."
Acquisition/funding processes,	Not Addressed
Project and/or program management processes, controls	"1) Providing overall process for development, 2) integrating existing development mgmt processes, 3) integrating widely scattered technology..., 4) providing framework for managing negotiations with joint partners..."
Operational environment	"This project required the cooperative effort of five different companies..."
Existing technical (or other) logic	Existing Kodak photographic system and relationship with other four companies - (old way of doing business) required extensive change.
Additional critical factors (major impacts?)	"...integration of existing development management processes by emphasizing the system environment that these processes exist within. ...underlying vulnerability ... was an extreme narrowness of scope ... designed for development of products in which environment (or system) would remain relatively constant."

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Consider Context, Infrastructure & System Environment [1999, Extended Enterprise, Aerospace Sector, Clegg, et. al.]

Considerations	Observations & Conclusions
System Boundaries	EE primarily "internally focused, therefore it neglects the effort necessary to communicate with external supply bases" and other industrial partners."
High-level values, objectives	"...Hopefully produce a process for product introduction that has joint ownership by the extended enterprise companies."
Decision-making structures, processes	"...each companies perceptions of the PIP is different (e.g. when is it unofficially or officially initiated? include new capability acquisition activities? when complete? include derivations from in-service data?"
Acquisition/funding processes,	"[Some] are in a privileged position... have *risk and revenue sharing contracts'*... other suppliers ... still have to work within confines of traditional contractual arrangements"
Project and/or program management processes, controls	"...stage and review gates are defined differently in each company"
Operational environment	"...staggered effect is apparent within the supply chain, which makes it very difficult to practice concurrent engineering principles"
Existing technical (or other) logic	"Proliferation of late customer engr/design changes -> suppliers should be involved as soon as there is a possibility of change so...adjust their own manufacturing & risk mitigation plans"
Additional critical factors (major impacts?)	"...the difficulty in finding links (either in a 'liaison' or 'collaborative' capacity) between the companies"

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Consider Context, Infrastructure & System Environment [In Framework Consistent with Your Application Domain!]

	1992, U.S. DOE (Morais, Grygiel)	1999, Kodak (Mason, et. al.)	1999, EE in Aerospace (Clegg, et. al.)
System Boundaries	✔	✔	✔
High-level values, objectives	✔	✔	✔
Decision-making structures, processes	✔	✔	✔
Acquisition/funding processes,	✔		✔
Project and/or program management processes, controls	✔	✔	✔
Operational environment	✔	✔	✔
Existing technical (or other) logic	✔	✔	✔
Additional critical factors (major impacts?)	✔	✔	✔

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Consider Context, Infrastructure & System Environment [2001, GAO...Better (Weapon) System Outcomes]

Considerations	Observations & Conclusions
System Boundaries	Change DoD Acquisition Process to apply systems engineering before requirements are formalized
High-level values, objectives	"...execute a program more predictably within cost and schedule"
Decision-making structures, processes	"...require that system engineering... evaluate the sufficiency of available resources... before weapon system requirements are formalized.."
Acquisition/funding processes,	"...require... that sufficient evidence exists to show there is a match between a weapon system's requirements and the resources..."
Project and/or program management processes, controls	"...reduce the pressures that encourage setting high and inflexible requirements to win the competition for program approval..."
Operational environment	"DoD's process for setting requirements and justifying programs creates incentives for setting requirements that exceed available resources."
Existing technical (or other) logic	"...the policy changes do not materially alter the mechanics or incentives that shape the process for setting requirements and justifying programs."
Additional critical factors (major impacts?)	"...requirements setters... aim for the most capability possible, given that... DoD may not be able to fund future more capable versions of a weapon..."

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