Decision & Risk Based Design Structures: Decision Support Needs for Conceptual, Concurrent Design

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Outline

- Introduction
  - Motivation
  - JPL's Advanced Design Team
  - Workshop on Decision Based Design Structures (DBDS)
- Applications of DBDS
- Decision Support for Conceptual Concurrent Design
- Challenges & Areas for R&D

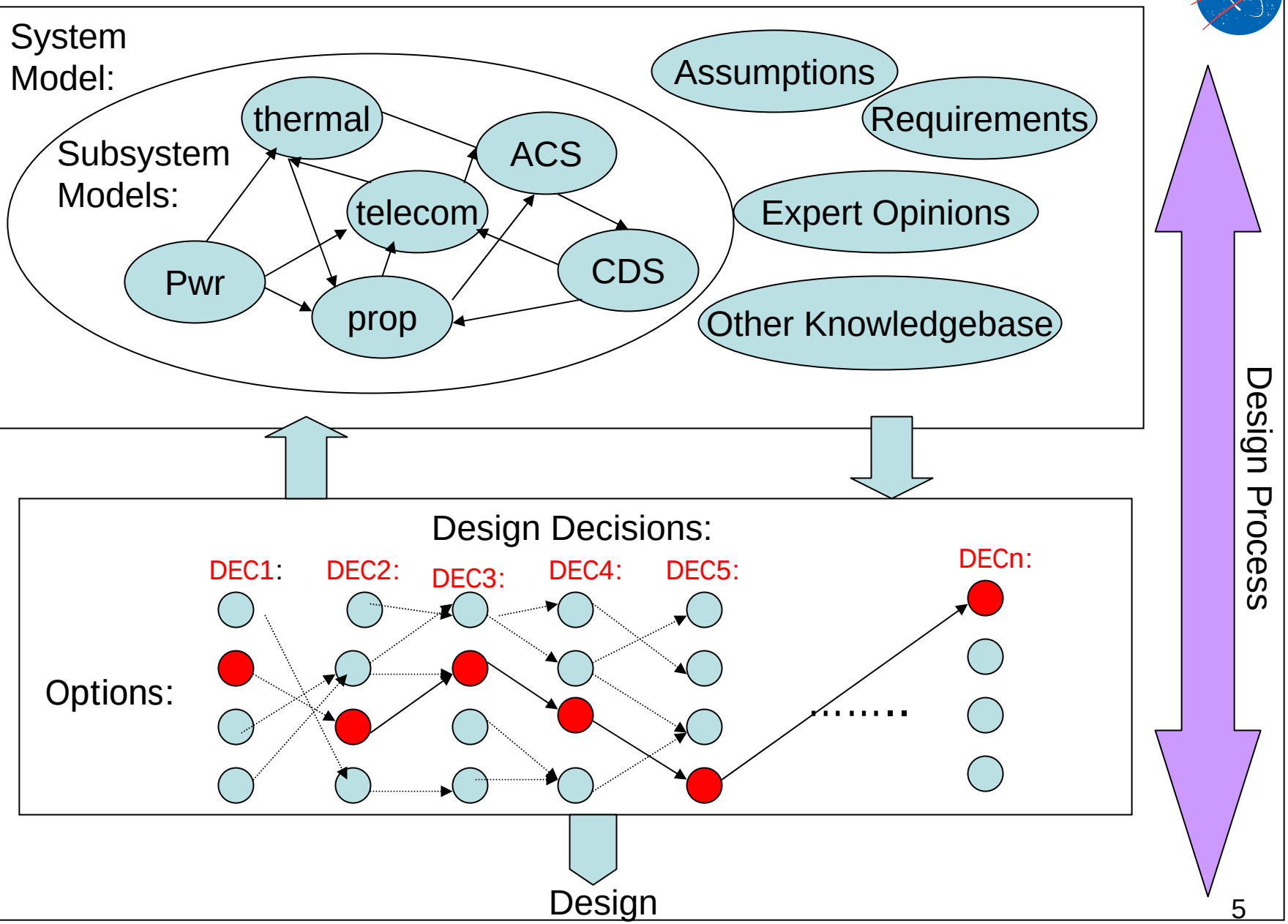
Motivation

- Strategic *Decision Making* at the NASA enterprise, program and project level is partially based on existing body of knowledge about future trends and needs.
- Examples decisions include:
  - Technology selection for avenues of research.
  - Formulating an overall program of missions
- Body of knowledge consists of documentation from existing mission designs.
- This documentation often lacks key design rationale information such as:
  - Options considered for each design decision.
  - How these options were characterized.
  - Why some were dismissed – the paths not taken.

Decision Based Design Structure (DBDS)

- We use the term to span the range of issues that arise in providing the appropriate design decision capture, representation, inference, and optimization to support decision making across NASA.
- DBDS spans the areas of:
  - Engineering Design
  - Design Rationale
  - Decision Analysis

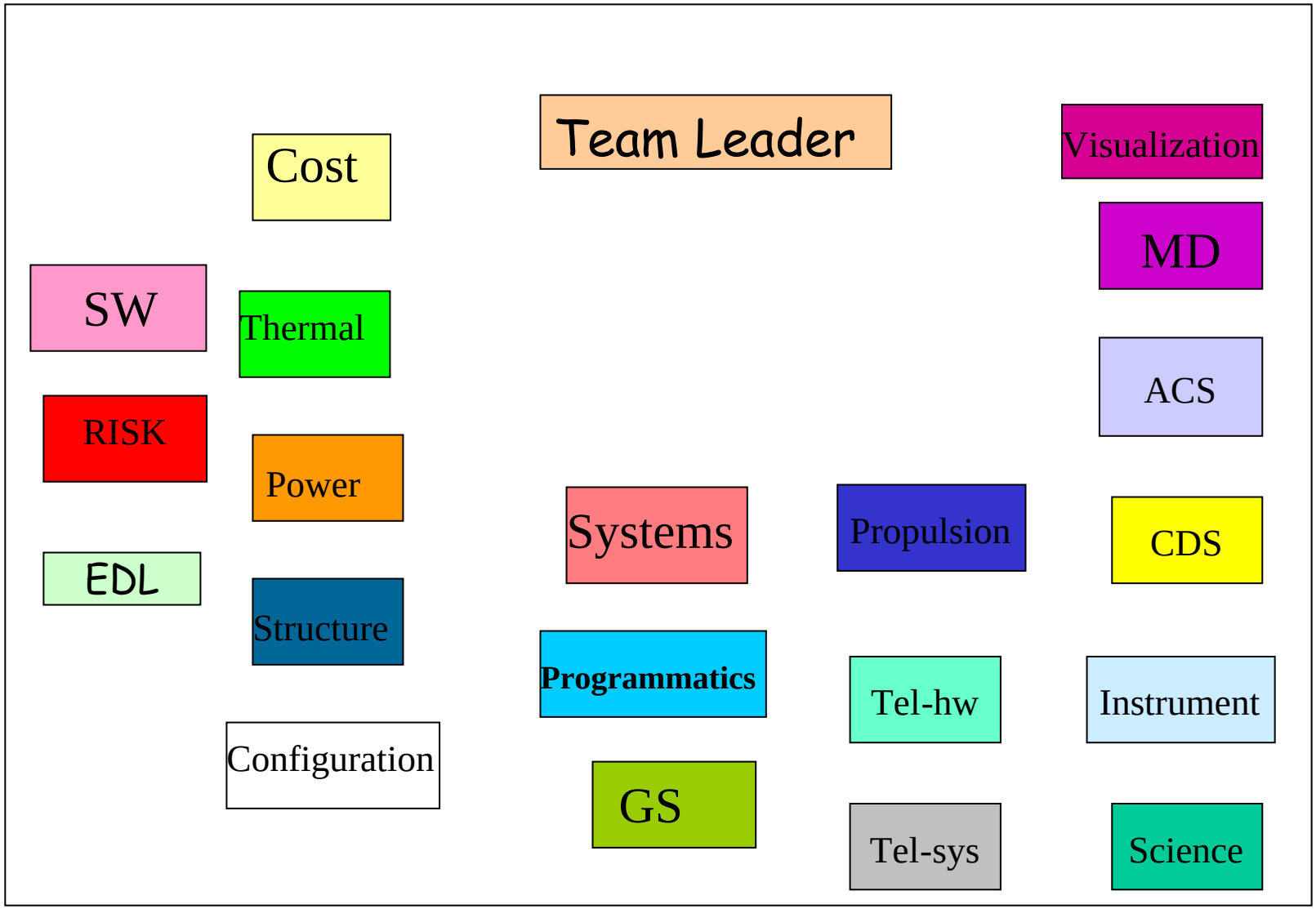
Decision Based Design Structure:

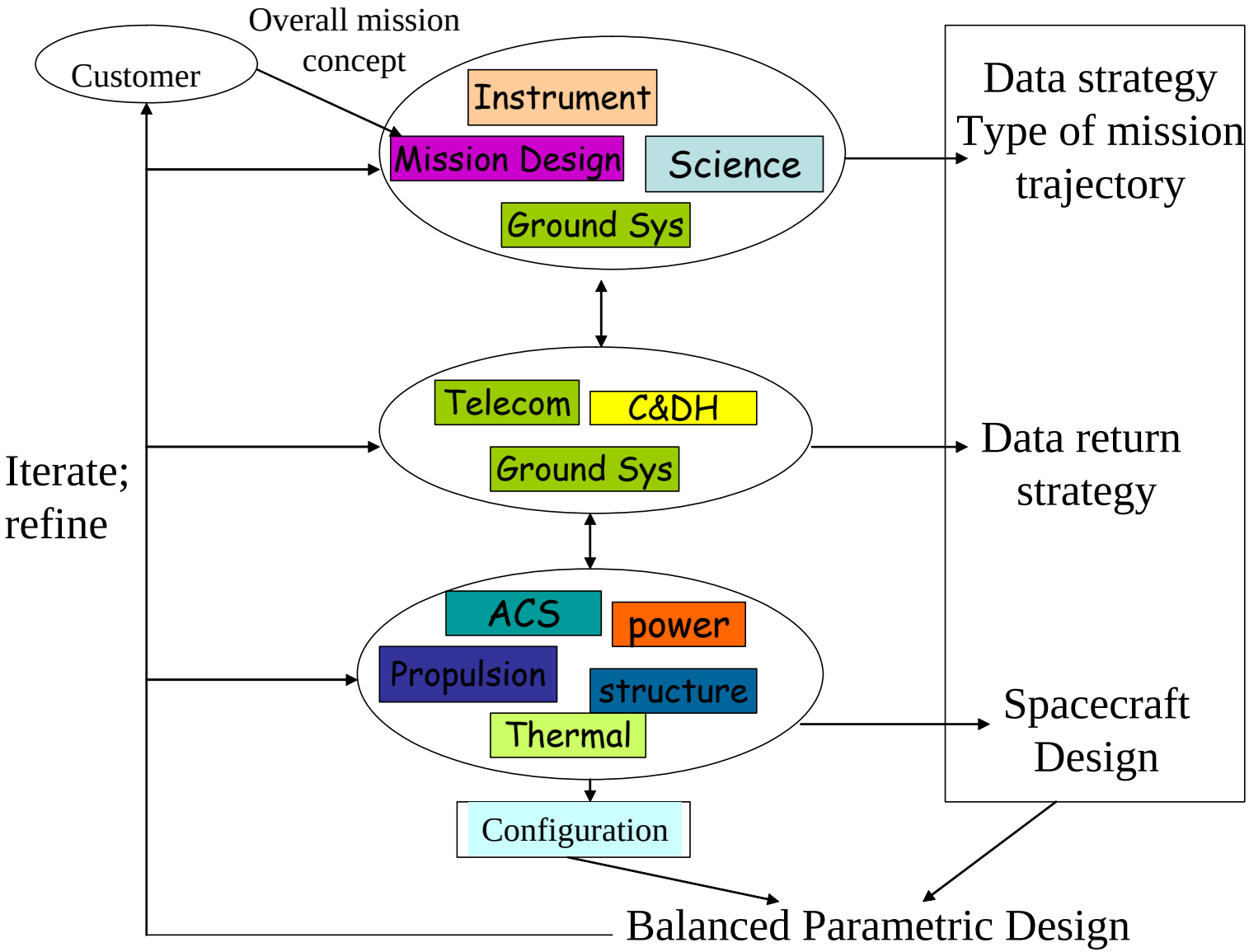


Background

- TeamX
  - Produces Conceptual Space Mission Designs.
  - Mainly for the purpose of Feasibility Studies.
  - Duration of study is typically one to two weeks.
  - Final report includes equipment lists, mass and power budgets, system and subsystem description, and projected mission cost estimate.

Team X
(at the Project Design Center)




Customer
Overall mission concept
Instrument
Mission Design
Science
Ground Sys
Telecom
C&DH
Ground Sys
ACS
power
Propulsion
structure
Thermal
Configuration
Iterate; refine
Data strategy
Type of mission
trajectory
Data return strategy
Spacecraft Design
Balanced Parametric Design

Workshop on DBDS

- Purpose:
  - to plan for the application processes, technologies and tools from the fields of design rationale and decision analysis to assist in solving the design challenges of NASA's space missions.
- Attendees:
  - Key NASA decision makers
  - Key experts and technology providers in the areas of:
    - Risk & Decision Analysis
    - Design Rationale
    - Engineering Design.
- Date: October 6, 7, &8th, 2004
  - Newport Beach, CA

Applications of DBDS

- Risk Assessment & Failure Prevention
  - Risky scenarios occur as a result of combination of events that integrate to cause a failure.
  - These events are related to decisions made by the designers, or the management teams, at various levels.
  - DBDS can serve as a framework for integrating the significant aspect of the interaction between individuals involved as relevant to the final design.
  - Such infrastructure supports the traceability of action items and consideration of requirements, constraints, and the organizational aspect of decision making within a logical framework.

Applications of DBDS

- Mishap Investigation
  - Accumulation and synthesis of various sources of information:
    - Interviews with involved individuals.
    - Design specifications
    - Engineering drawings
    - Material analyses, test data, lab reports, training records, site maps, images, debris, meeting minutes, causal models, review item discrepancies, etc.
  - DBDS benefits for Mishap Investigation
    - Provides traceability from the mishap to it's potential causes.
    - Provides traceability into decisions made during the investigation process and the rationale for taking the specified choices of action.

Applications of DBDS

- Design Reuse & Re-design
  - Clear articulation of the assumptions, constraints, requirements, and performance parameters and traceability into the trades and decisions considered facilitates design reuse.
- Decision Support
  - All techniques using analyses and syntheses of design information to give insight to the designers to better focus their efforts and make better informed decisions.
  - DBDS provides a framework for the appropriate combination of these techniques.

Applications of DBDS

- Technology Road-mapping and Program Planning
  - Program offices make decisions about allocating funding for the R&D of new technologies, and future programs.
  - These decisions are partially based on existing documents from missions designed.
    - Widely disparate sets of missions, with commonalities between them not readily apparent.
    - Information about which technology options were dominant, and which possibly better paths were rejected due to lack of appropriate enabling technologies is often unavailable.
    - DBDS provides a framework for the capture, representation, and execution of the information required for making such assessments.

Decision Support for Conceptual, Concurrent Design

- Decision support tools typically require the decision maker to input all the relevant information before each analysis.
- For practical purposes, tool needs to be pre-seeded with information about the system structure.
- Additional information generated during the design sessions could be automatically captured and mined for relevant knowledge to be incorporated into the decision problem.
- This requires a combination of decision support tools and processes with techniques and technologies for Systems Modeling, Design Rationale Capture and Representation, Data-mining, and Knowledge Management.

Areas for further R&D

- Tools & techniques for integration and representation of heterogeneous models/ideas/information.
- Integration of Design Rationale & Decision Support techniques.
- Integration of Data Capture & Data mining techniques.
- Consideration of the Social System Model in the Design Process.

Effective Implementation & Operation of DBDS

- Defining standard means of communication between various stakeholders.
- Techniques for integrating disparate models, teams, tools and data types.
- Development of techniques that are “invisible” to the process.