Early Design Choices:
Capture, Model, Integrate, Analyze, Simulate

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Decision Based Design Structures Workshop
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Design: Incremental and Distributed

• Designs are constructed incrementally to meet requirements and solve problems
  – Requirements types: objectives, scenarios, constraints,ilities…
  – Problem/issue types: risk/safety, cost/difficulty, interaction, conflict…

• So, capture requirements, problems and solutions
  – Collect design and analysis products and make them accessible for integration and analysis
  – Link changes in design requirements, problems and solutions
  – Harvest design data for design models and choice structures

• System designs are constructed by multiple groups designing interacting subsystems
  – Diverse problems, choice criteria, analysis methods and point solutions

• So, support integration and global analysis of repercussions
  – System implications of point solutions
  – Broad analysis of interactions beyond totals of mass, cost…
Collect and Access Design Products

- Team Work Center Examples
- Workspace Issue Tracking (WorkIT) tool example for diverse products
  - Team workspaces that organize selected relevant products and excerpts for access and reuse
  - Actions, Files, Links, Notes, Logs of status and tasks
  - “Add Item” pages provide easy way to include metadata for search and reports
- Logger tool example of making it easy: effortless metadata collection for use in reports and searches
  - Quick menu attaches metadata while pasting selected text from the menu into a log entry
  - User groups can customize the metadata categories and the Quick menu to capture what’s important
Harvest Design Data for Analysis

• Convert text – Reconciler parser/matcher
  – Requirements and constraints
  – Objectives, risks and mitigations
  – Procedure information and scenarios

• Match and map XML/RDF/OWL models
  – Map requirements to design representations
    • Phase/activity/operation, function, equipment, interaction/interface, constraint
  – Map problems to design structures
  – Map solutions to problem structures

• Collect metadata from process
  – New and changed conceptual design models that are elaborated to address design issues
    • Countermeasures, mitigations, solutions
Hazard Identification Tool Example

Convert requirements and risk text to derive early model

Reconciler (Parser/Matcher) Hazard Identification Tool (HIT) Model Maker (currently manual)

Requirements Model (Shift type)
- Function: Transfer (“Send”)
- Agent: System (“CDHC”)
- Affected Operand: Information (“telemetry”)
- Source: “CDHC”
- Destination/Goal: System (“Telesub”)
- Path Type: Information/Signal
- Resource conditions: ?
- Activation/conditions: ?
- Effect value/measures: ?

Counteraction Model (Replace type)
- Counteract Function: Replace (“Redundancy”)
- Agents/contributors: ?
- Replaced: “Transmitter”
- Replacement: “Transmitter Spare”
- Affected Risk (link to): “Telecom Sub... Failure... Transmitter”

Counteraction leads to next telecomm model version with redundant transmitters

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NASA JSC Automation, Robotics & Simulation –
Analyze Repercussions Early

HIT Spacecraft Model Interaction Analysis

- **Analyze interaction pairs and paths (HIT)**
  - HIT: Hazard-vulnerability pairs and possible paths
- **Simulate abstract operational scenarios (CONFIG)**
  - Transmitter is abstract server with limited service rate (bandwidth) normalized to 1.0 capacity.
  - Science and engineering memory are clients with total load of 0.8.
  - When TCS is turned ON, noise travels from TCS to Xmitters via power connections and takes up 0.3 of capacity.
  - Xmitter 1 is overloaded (total 1.1 “requested”), changing transmitter data rate proportionally to 0.8/1.1 = 0.723 (too slow).
  - Controller unsuccessfully tries to compensate by switching to backup Xmitter2, but transmission rate is unchanged.

**HIT Early Spacecraft Telecom Model**  
(Redundant Transmitters, Power, Thermal Control)

**CONFIG Abstract Spacecraft Model**

Added TCS is another noise source. This noise can pass to vulnerable Telesub transmitters along Power distribution lines.
Capture: Tame the Work Explosion

- **Helpful Capture Tools**
  - Primary goal is to get later long-term benefit when revisit or change the design
    - Reuse of design and analyses
    - Upgrades, repairs, accident analysis
    - Handling changing requirements, systems and environments
  - Provide short-term benefit to balance added short-term effort
    - Help capturing diverse types of design products
    - Help integrating information
    - Help search, access and get reports from diverse perspectives
      - Make metadata collection effortless
    - Help prioritizing decisions and areas for problem solving
    - Provide standard elements: Libraries and ontologies
      - Provide default requirements, problems, issues and solutions
      - Map and match diverse structures and representations
      - Accommodate and highlight special and new data

- In our story, the revised countermeasure for TCS noise has links to supporting analysis and simulation results