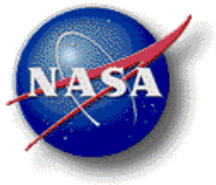

Early Design Choices:
Capture, Model, Integrate, Analyze, Simulate

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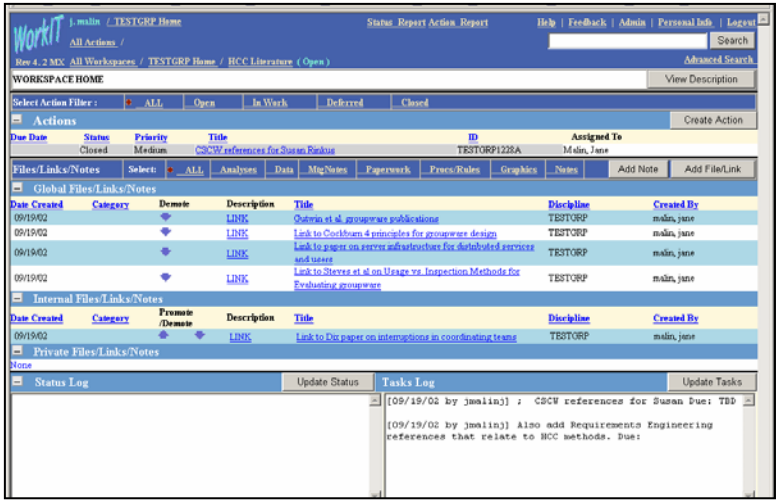
Decision Based Design Structures Workshop
October 7, 2004

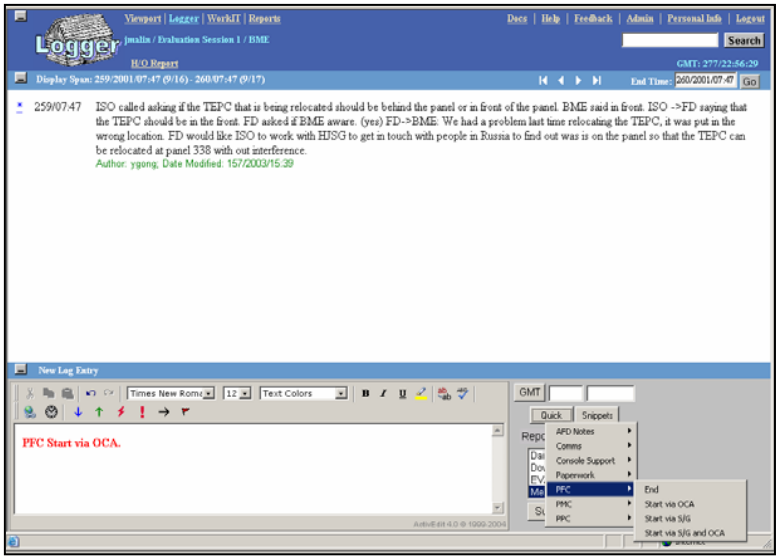
Design: Incremental and Distributed

- 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

[C.1] Telecommunication Subsystem
- [C.1.1] The CDHC sends the TeleSub a compressed picture. [FG.1] [TeleSub C.1.4]
- [C.1.2] The CDHC sends the TeleSub telemetry. [FG.2] [FR.1] [FR.5] [TeleSub C.1.5]
- [C.1.3] The CDHC sends In View of Ground alerts to the TeleSub. [DP.5.6] [TeleSub C.1.6]
- [C.1.4] The CDHC receives plan files from the TeleSub. [FR.3] [TeleSub C.1.3]
- [C.1.5] The CDHC receives ground commands from the TeleSub. [FR.3] [TeleSub C.1.2]
- [C.1.6] The CDHC receives the TeleSub operating state from the TeleSub. [DP.5.5] [TeleSub C.1.1]

…

[C.2] Camera Subsystem
- [C.2.1] The CDHC sends the Camera a "take picture" command. [FG.2] [FR.1] [FR.3]
- [C.2.2] The CDHC sends the Camera x, y and z gimballing coordinates. [FG.2] [FR.1] [FR.3]
- [C.2.3] The CDHC sends a turn on command to the Camera. [DP.5.3] [H Constraint 1.1.4]
- [C.2.4] The CDHC sends a turn off command to the Camera. [DP.5.3]
- [C.2.5] The CDHC receives a compressed picture file from the Camera. [FG.1] [FG.2] [FR.1]

…

[C.4] Attitude Determination Subsystem
- [C.4.1] The CDHC receives an In View of Ground alert from the ADS. [DP.5.6] [ADS]
- [C.4.2] The CDHC receives the ADS operating state from the ADS. [DP.5.5] [ADS]

Reconciler (Parser/Matcher)

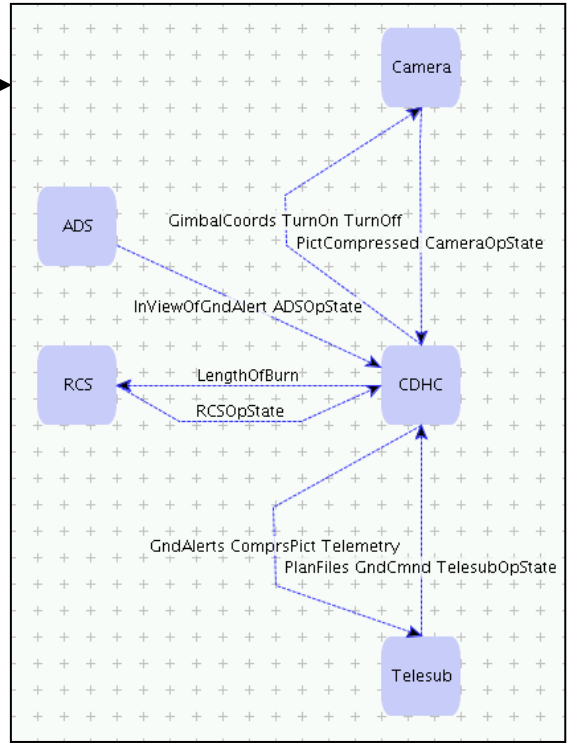
Hazard Identification Tool (HIT) Model Maker (currently manual)

Requirements Model (Shift type)

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

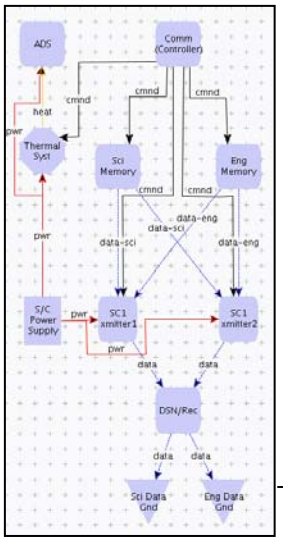
Counteraction Model (Replace type)

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

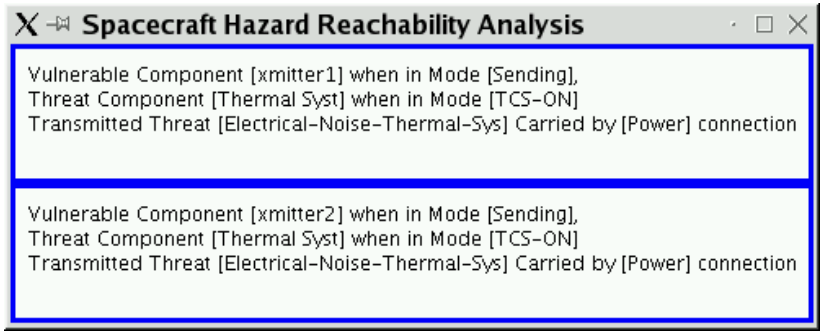


Counteraction leads to next telecomm model version with redundant transmitters

Analyze Repercussions Early

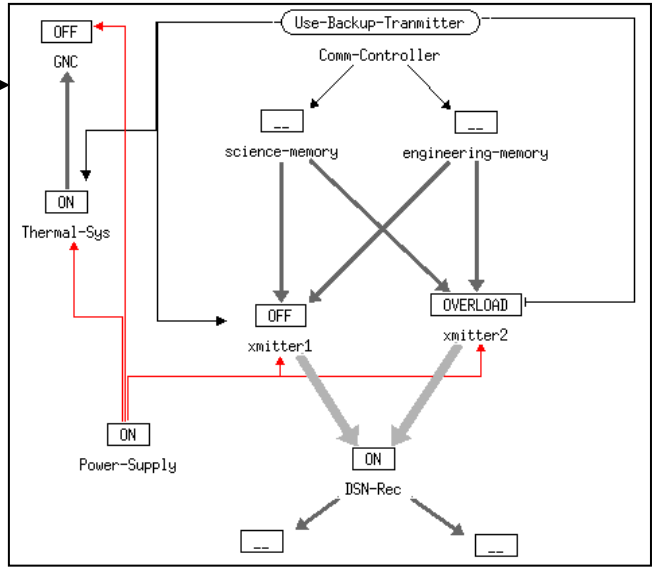


HIT Early Spacecraft Telecom Model
(Redundant Transmitters, Power, Thermal Control)



HIT Spacecraft Model Interaction Analysis

Mapped Model and Scenarios from HIT to CONFIG



CONFIG Abstract Spacecraft Model

Added **TCS** is another **noise** source. This noise can pass to vulnerable **Telesub transmitters** along **Power** distribution lines.

- 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.

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