

# **FAULT RECOVERY RECOMMENDATION**

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**and**

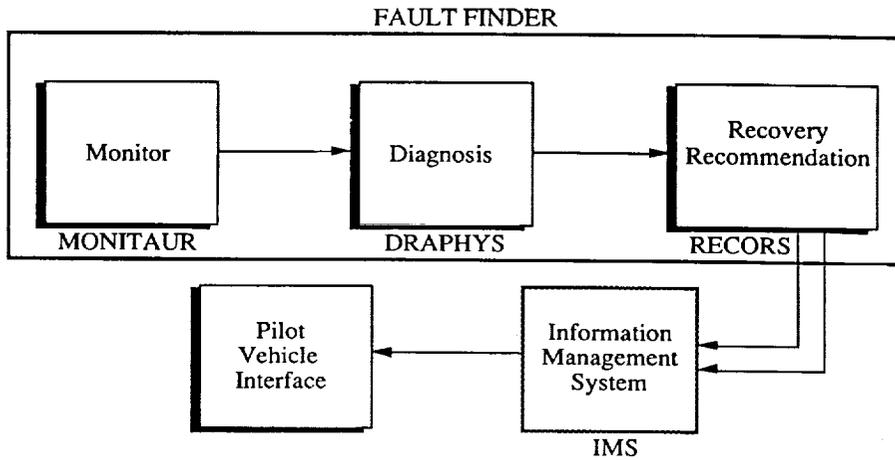
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**BBN Systems and Technologies Corporation**

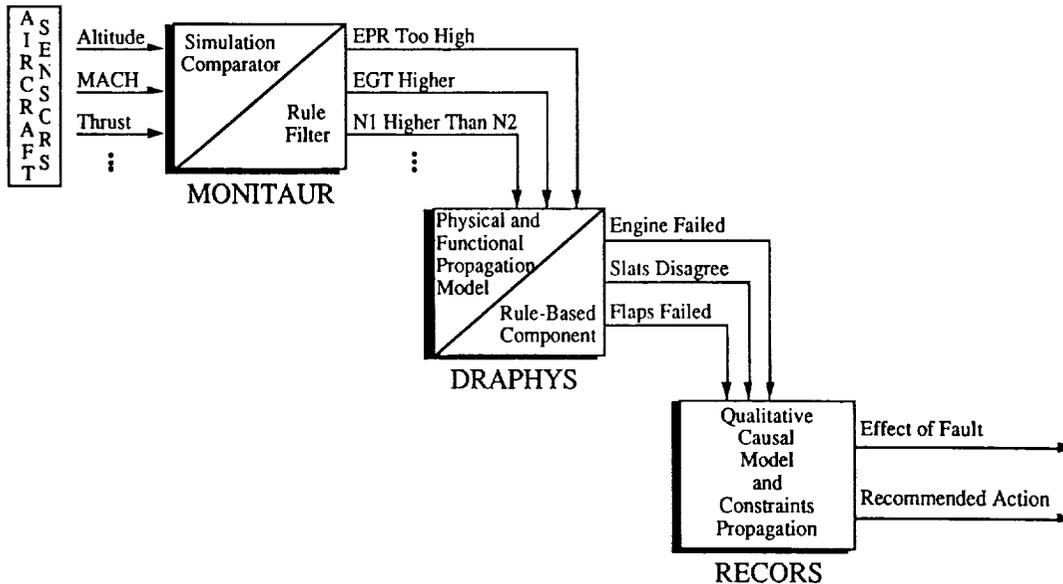


# SYSTEM INTEGRATION CONTEXT FOR THE RECOVERY RECOMMENDATION SYSTEM (RECORS)

**System Goal: To provide intelligent aiding for monitoring, diagnosis and response to aircraft system failures.**



## DATA FLOW CONTEXT FOR RECORS



# **GOALS OF RECOVERY RECOMMENDATION SYSTEM (RECORS) ARE SITUATION ASSESSMENT AND RESPONSE AIDING DURING EMERGENCIES**

## **Method:**

- **Predict effects of faults on future system behavior**
- **Perform reasoning to aid the time-stressed and/or capacity limited flight-crew to suggest response to faults**
- **Predict consequences of recommended actions and advise crew**

## **RECORS: MODEL-BASED SITUATION ASSESSMENT/RESPONSE AIDING**

### **Current Status:**

- **Functions in a help mode, rather than autonomous mode**
  - pilot is in the Loop
  - pilot has Final Authority
  - explanation of Reasoning and Displays are Important
- **Uses a causal model of the aircraft and the flight domain**
- **Reasons at multiple levels of abstraction**
- **Predicts the effects of aircraft system failures on flight profile**
- **Suggests responses in emergencies**

## **. . . RECORS**

### **Planned Development:**

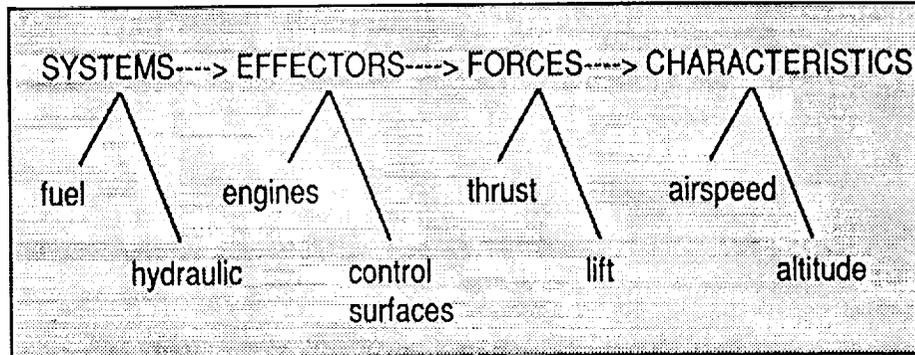
- **Help identify faults based on their effects on the system**
- **Help make up for lack of sensor data by inferencing**
- **Predict long-term effects of actions to help in response selection**

## **RECORS: CAUSAL MODEL**

- **Model implemented within Object-Oriented, Frame-Based representation formalism**
- **Model consists of objects representing:**
  - **aircraft sub-systems**
  - **effectors**
  - **forces acting on the aircraft**
  - **flight characteristics**

## CAUSAL MODEL (cont)

- Represents both the taxonomic and the causal relationships among the objects



### RECORDS: MULTIPLE LEVELS OF ABSTRACTION

- Two orthogonal types of abstraction exist in the model: taxonomic and causal

- Taxonomic ("IS-A" relationship)

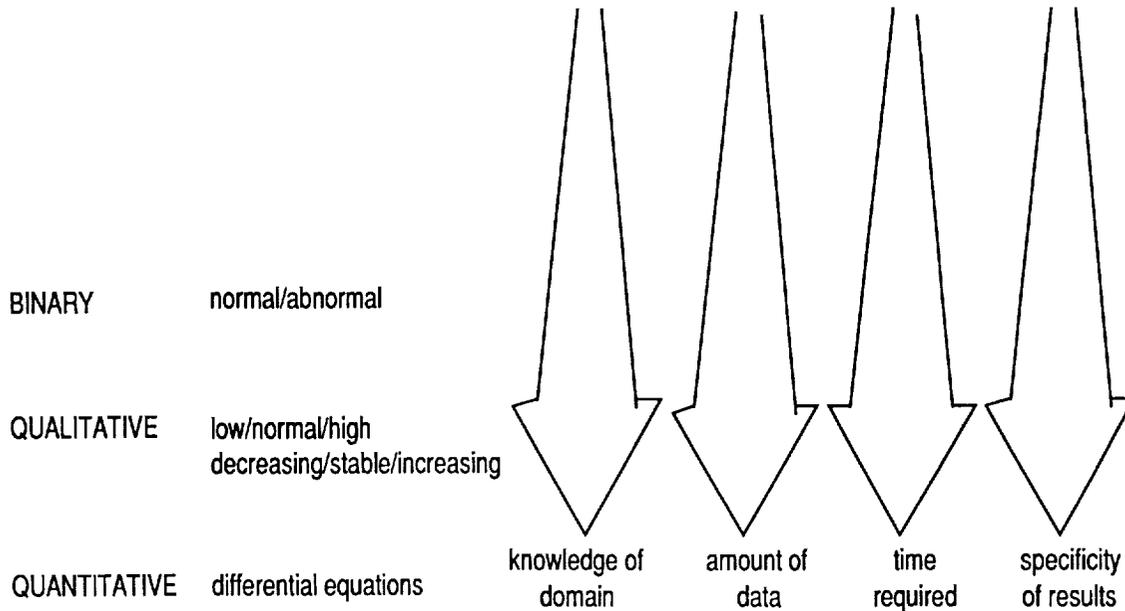
Taxonomic abstraction consist of the different levels of the model hierarchy

- Causal: causal relationships among model objects expressed at binary and qualitative levels (AFFECTS and AFFECTED-BY relationships)

Causal relationships are represented at both binary and qualitative levels at each level in the object taxonomy

- Other planned abstractions include partonomy and physical location relations

## MULTIPLE LEVELS OF ABSTRACTION



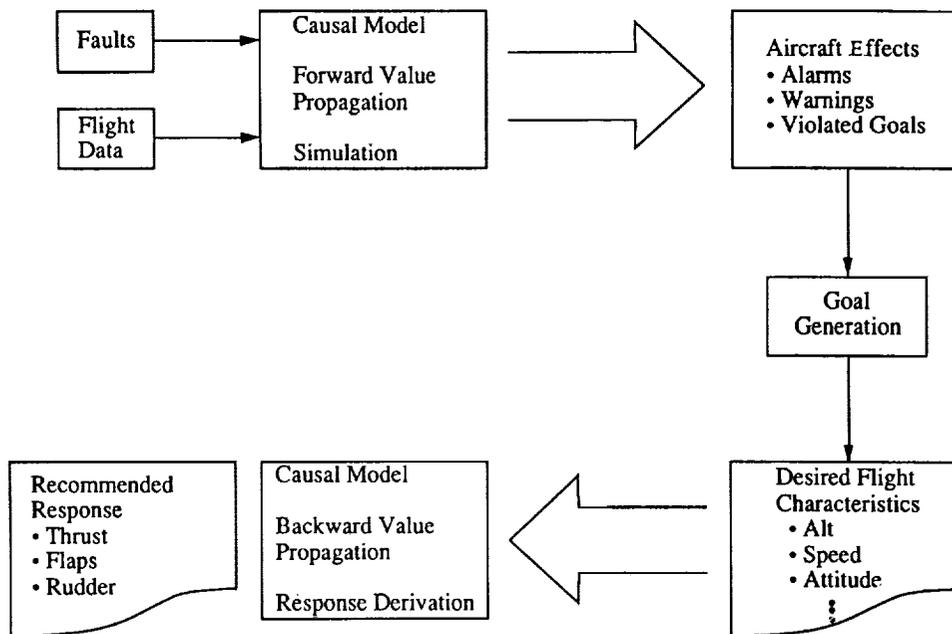
## RECENT DEVELOPMENTS

- Causal Model Editor
- Subsystem Modeling
  - Requires the Representation of various types of Causal Relations
  - Different Temporal Propagation Delays Exist Along the Causal Links
  - Requires Use of Different Causal Contexts
  - Specialized "Device" Models
- Representational Formalism Modified to Reflect these Requirements
- Simulation Algorithm Modified to Reflect These Requirements
- Time Representation Included in terms of Delays Along Causal Links
- Reconfigurable Interface

## FUTURE DIRECTIONS

- **Explanation**
  - **Display Format for Recommendations and Aircraft Effects**
  - **Visual and Textual Explanation of RECORS' Reasoning**
- **Verification and Validation**
  - **Determine How System Effectiveness Varies with**
    - **fault type**
    - **emergency type**
    - **display design**
    - **crew experience**
  - **Verify Model Function**
  - **Validate Against Known Accident Responses**
- **Evaluation**
  - **Test Pilot Acceptance in Cockpit Simulation**

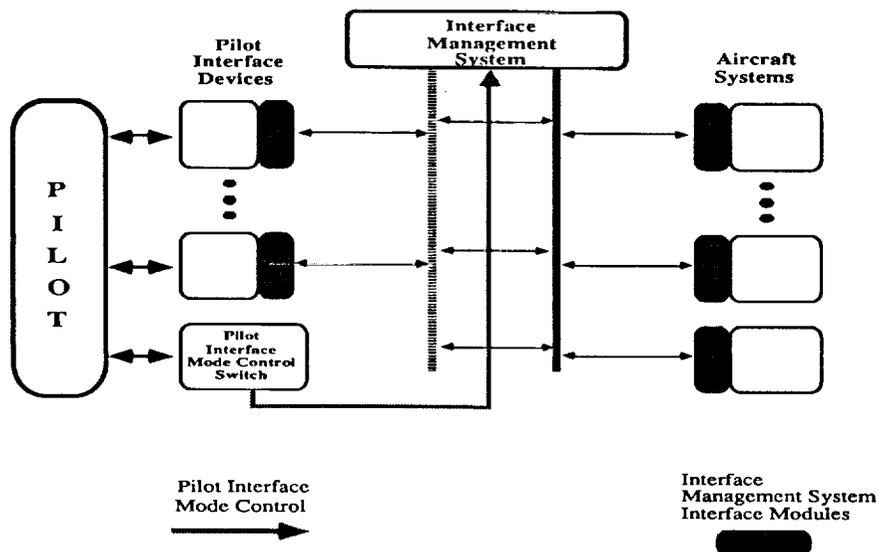
## RECORS INFERENCE CYCLE



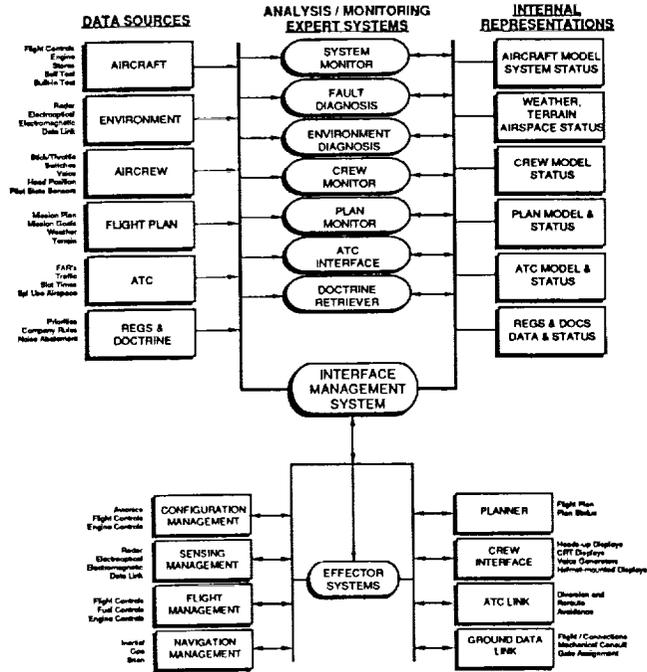
# RECORDS IMPLEMENTATION

- Version I: Implemented in the KEE development environment on a Symbolics 3600
- Version II: Implemented in Zeta LISP Using an Object-Oriented, Frame-Based Language on a Symbolics XL400

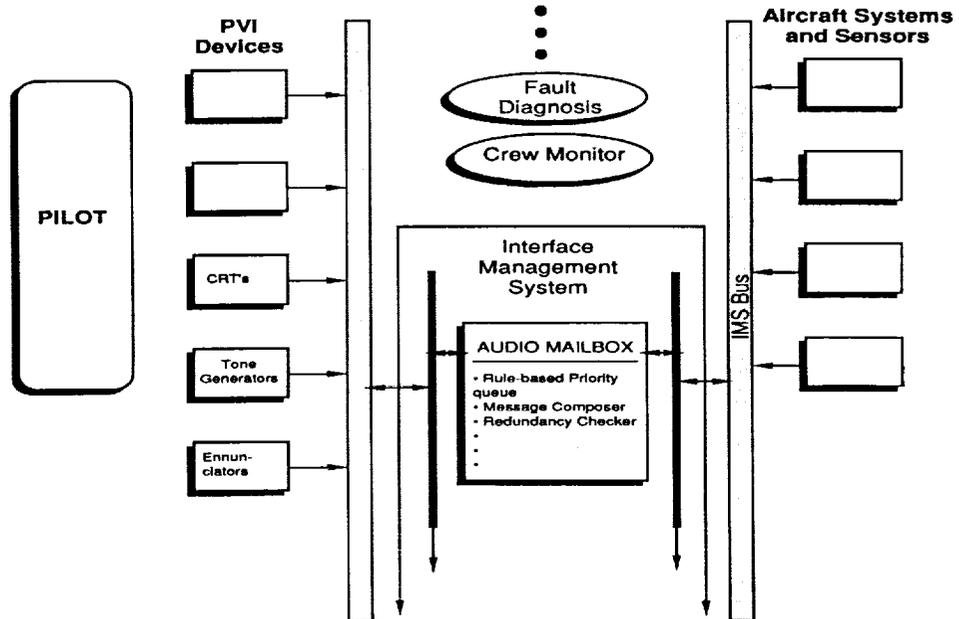
THE INTERFACE MANAGEMENT SYSTEM MANAGES THE FLOW OF INFORMATION AND THE DIALOGS BETWEEN THE SYSTEMS AND THE PILOT

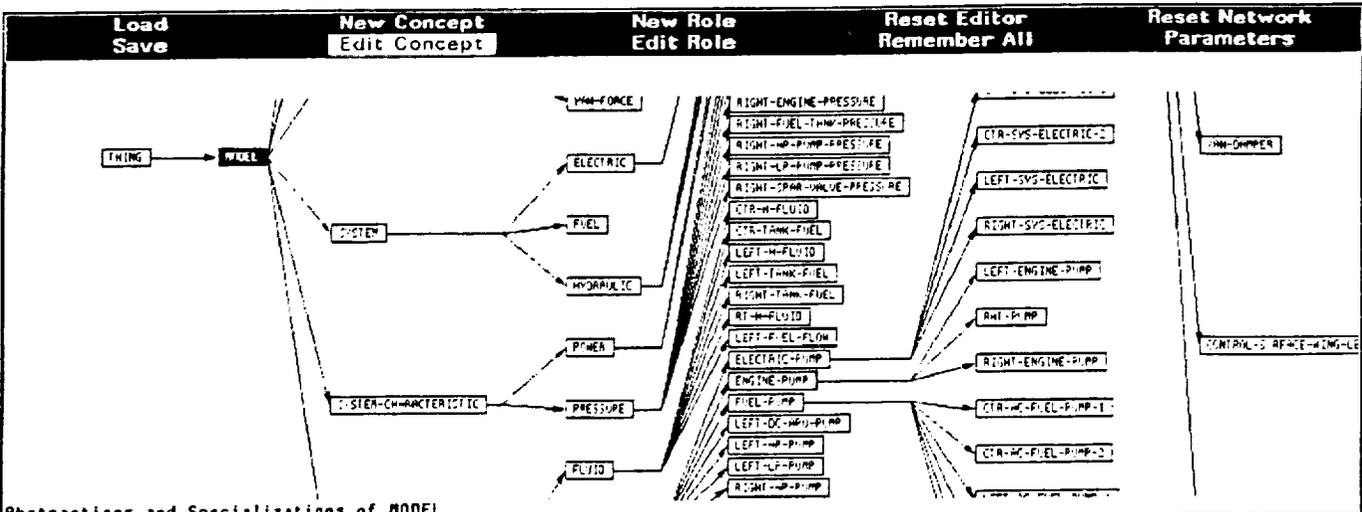


# OVERALL A3 ARCHITECTURE



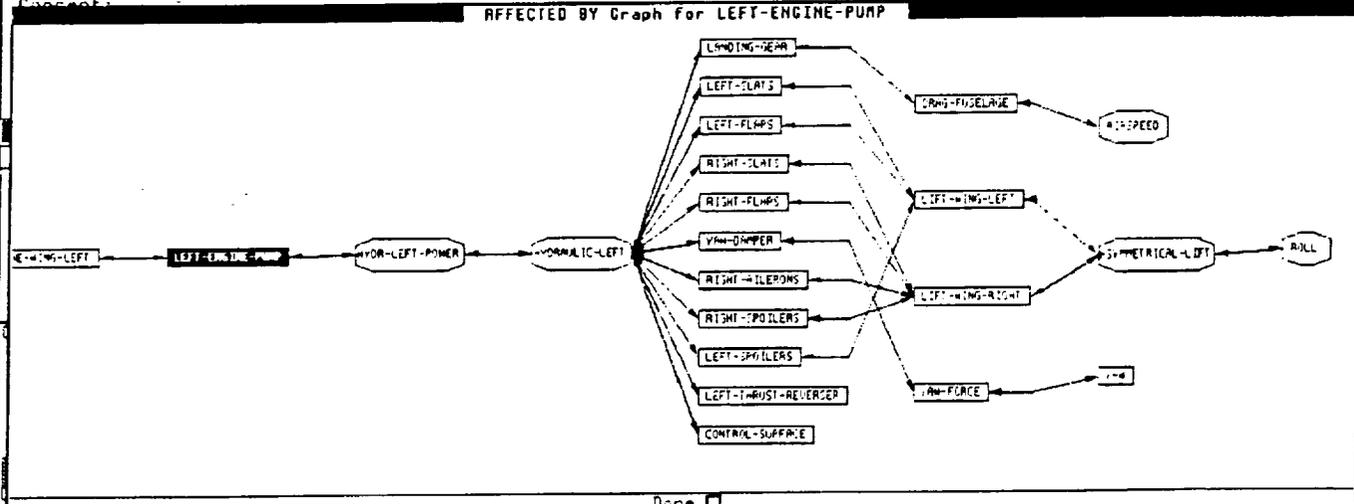
# AUDIO MAILBOX ARCHITECTURE AND INTERACTIONS WITH IMS





Abstractions and Specializations of MODEL

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Left and hold: pan; Middle: speed pan; Right: menu of other graph operations. To see other commands, press Control, Meta or Shift.

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