A PROGRAM PLAN FOR THE DEVELOPMENT OF FAULT TOLERANT LARGE SPACE SYSTEMS

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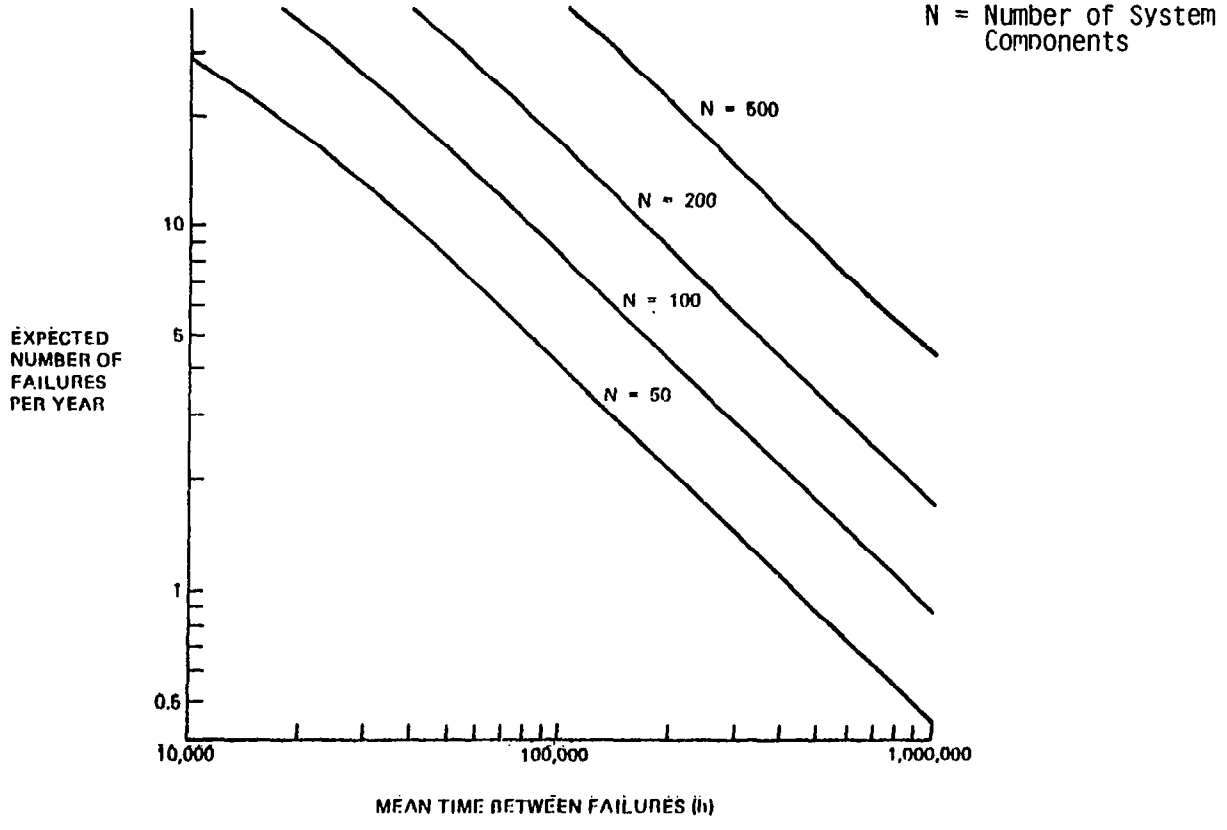
Objectives

- Establish the need for fault tolerance in LSS
- Discuss the unique characteristics of LSS which affect fault tolerance
- Summarize the status of fault tolerant systems for LSS
- Discuss a program plan to validate and demonstrate the concept of fault tolerance for LSS

Establishment of the Need for Fault Tolerant LSS



Characteristics of LSS That Affect Fault Tolerance

- Dimensionality
  - Will have to consider a much larger number of components than in any previous application
  - May affect the achievement of real time operation and computational accuracy
- Precise accuracy and stability requirements
  - Small failures will have to be detected and isolated quickly
- Structural mode and physical displacement effects on sensors
  - May be comparable in magnitude to the failures which must be detected
- Environmental effects
  - Dynamic effects such as large angle slewing maneuvers
  - Thermal effects may produce changes in modal characteristics
- Spillover (Model Order Reduction) effects
  - May introduce uncertainties which can be falsely interpreted as failures
- Many diverse types of sensors present
  - Must be collectively accounted for if system wide fault tolerant capability is to be achieved
- Multiple experiments operating on a single LSS
  - Interactions among experiments may result in false alarms
  - A robust fault tolerant system may be required to tolerate changes in modal characteristics with experiments
- The modal frequencies may be in the controller bandwidth
  - Filtering to reduce modal effects and improve fault tolerant capability may not be possible

Status of Fault-Tolerant Technology for LSS

- Little work has been done in this area
- A large body of knowledge concerning fault tolerant systems has evolved in spacecraft and avionics applications
- This material forms a solid foundation for the development of fault tolerant technology for LSS

Elements of a Program Plan to Validate the Concept of Fault Tolerance for LSS

- System modeling
  - Generate an analytic model of the LSS
- Environment modeling
  - Define LSS tasks, maneuvers and disturbances
- Requirements definition
  - Define LSS accuracy, stability and reliability requirements
- Component modeling
  - Define analytic models, error effects, noise, flexibility effects, etc.
  - Uncertainties establish the fault tolerant capability of LSS
- Fault tolerant techniques development
  - Develop algorithms to detect and isolate faults and reconfigure LSS
- Simulation development
  - Both nonreal time and real time capabilities will be needed
- Development of a fault tolerant data processing capability
  - Needed to carry out computations associated with the LSS
  - A firm basis for this technology exists

Elements of a Program Plan to Validate the Concept of Fault Tolerance for LSS (concluded)

- Conceptual design
  - Preliminary definition of algorithms, components, architectures, etc. and assessment of design alternatives
- System design
  - Detailed and specific determination of parameters, components, architectures and algorithms for selected LSS
- Preliminary implementation
  - Definition of system software and hardware
  - Partitioning of functions among subsystems
- Validation of fault tolerance concept and demonstration of capability
  - Use simulation of complete LSS
- Requirements evaluation
  - Use simulation to assess ability of fault tolerant LSS to meet accuracy and stability requirements
  - Analytic techniques must be employed to evaluate the reliability of the LSS

Conclusions

- There is a definite need for fault tolerance in LSS
- LSS have unique characteristics which impact fault tolerance
- Very little work has been done regarding fault tolerance for LSS although a solid base exists from spacecraft and avionics applications
- A program plan for the validation and demonstration of the concept of fault tolerance for LSS has been developed