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Utilization of IT in Space System Design Processes (A Personal View)

Ohkami Yoshiaki

Research Director

National Space Development Agency of Japan (NASDA)

Professor, Keio University

“IT Revolution” in Japan

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- The Government identified a drastic change in social and industrial structures caused by IT Revolution.
- The Advisory Group on IT for NASDA submitted a report in December 2000.
- Science journalists have been warning that delay in IT utilization will be fatal to the competitive power of industries.

Warning by Mr. Baba

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Evaluation by IMD indicates clearly decline of the world ranking on industrial competitiveness of Japan:

- In 1989, No. 1
- In 1996, No. 4
- In 1997, No. 9
- In 1998, No.18
- In 2000, No.17

"IT has changed the industrial structure completely. Speed and service are inevitable. Space technology can be a driving force to restore the industrial power."

Recommendations by Advisory Group

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NASDA should

- Catch up with the rapid progress of IT
- Translate implicit knowledge into explicit information using computerized systems
- Accumulate technical data of the past projects
- Use digital information systems extensively
- Establish effective development environment in connection with industries and related institutes
- Establish centralized information management & support system as top priority

Response of NASDA

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NASDA has established

- IT Promotion Executive Group to monitor the level of achievement
- Dedicated IT Promotion Team to coordinate the related sections with the following tasks:
  - Pilot project execution
  - Integrated and centralized control
  - Provision of infrastructures
  - Security issues

IT Pilot Projects - Scope

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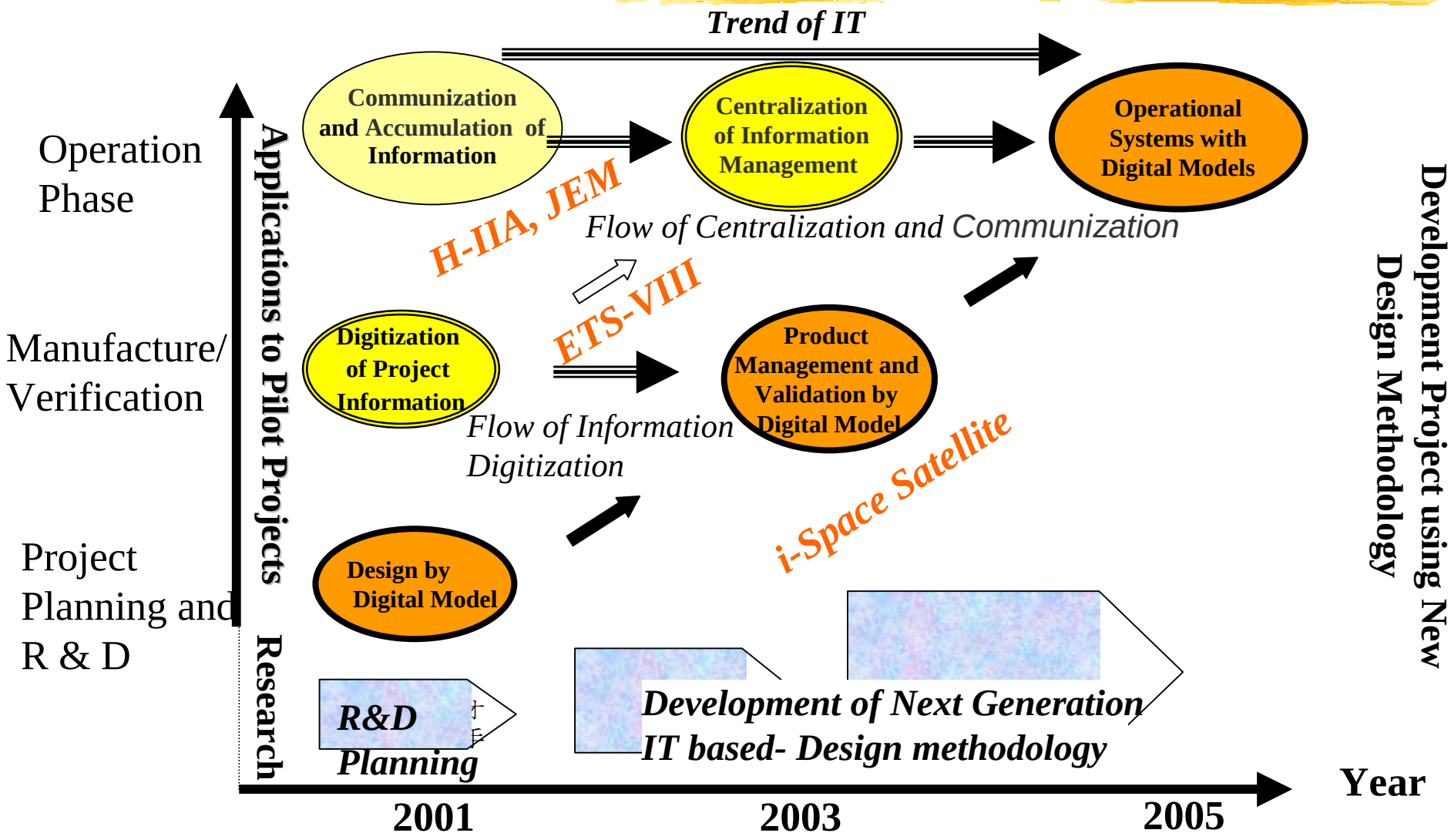

IT Pilot Project
- H-IIA Launch Operations

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Computerized Documents for Launch Operations

1) Reduction of Procedure Manuals (8000 Pages by 120 Copies)

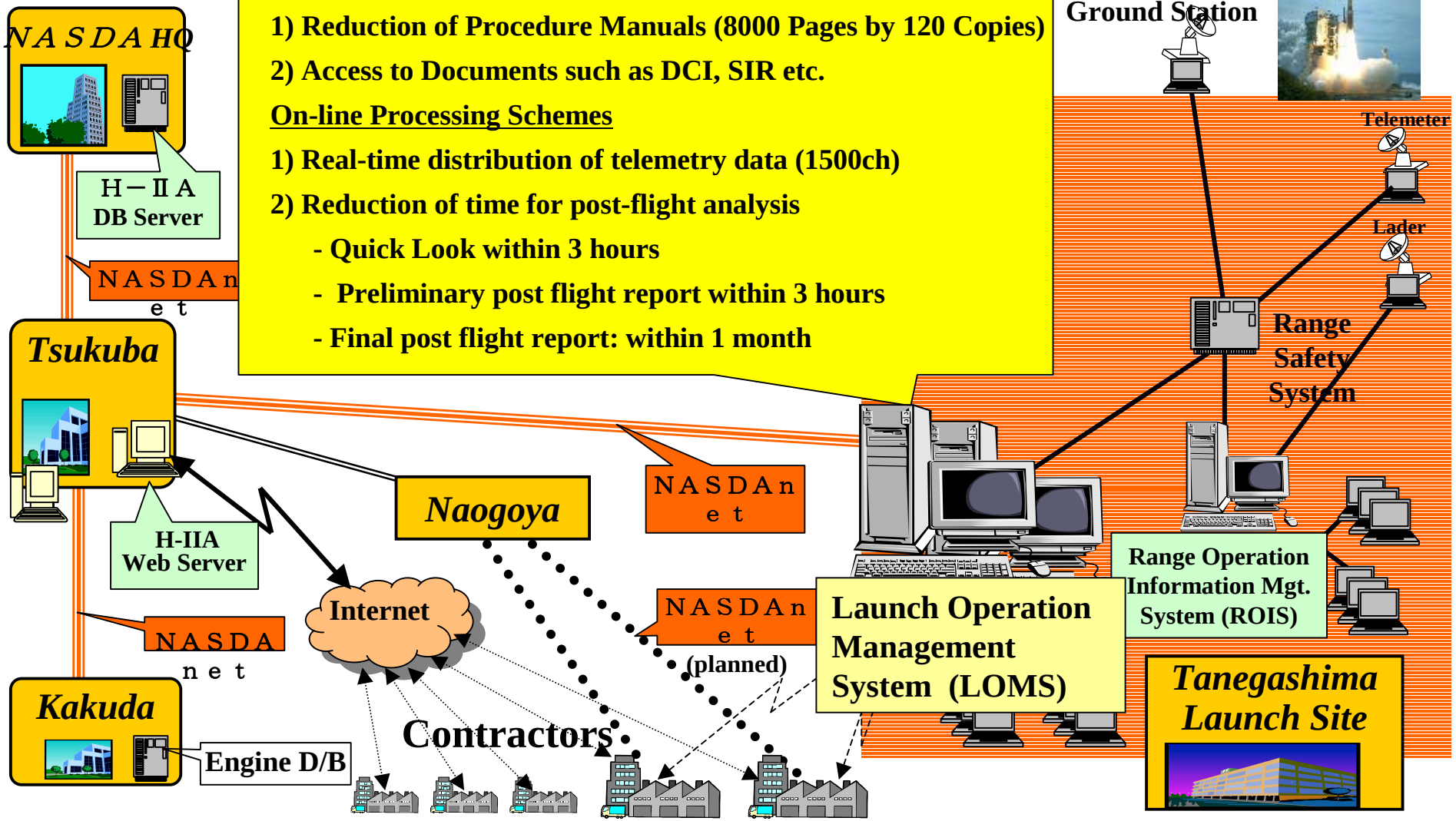
2) Access to Documents such as DCI, SIR etc.

On-line Processing Schemes

1) Real-time distribution of telemetry data (1500ch)

2) Reduction of time for post-flight analysis

- Quick Look within 3 hours
- Preliminary post flight report within 3 hours
- Final post flight report: within 1 month



IT Pilot Projects
- H-IIA Launch Operations

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- **Computerized Documentation for Launch Operation**
  1) Reduction of Procedure Manuals (8000 Pages by 120 Copies)
  2) Access to Documents such as DCI, SIR etc.
- **On-line Processing of Data**
  1) Real-time distribution of telemetry data (1500ch)
  2) Reduction of time for post-flight analysis
     - Quick Look within 3 hours
     - Preliminary post flight report within 3 hours
     - Final post flight report: within 1 month (previously 3 months)
- **Development of Information Subsystems**
     - Launch Operation Management System (LOMS)
     - Range Operation Information Management System (ROIS)
     - Flight Date Real-time Monitoring System (FORMS)

IT Pilot Project: H-IIA Flight Data Real-time Monitoring System

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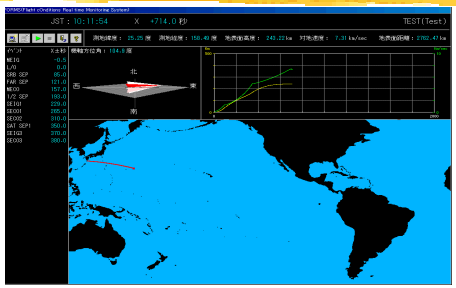
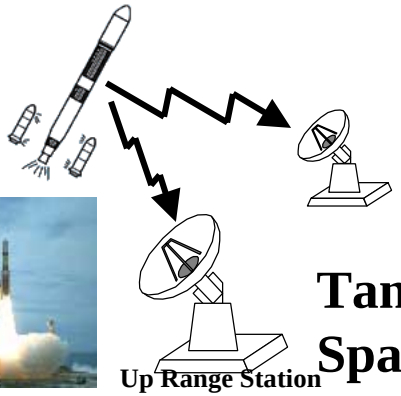
- Flight Data Evaluation
- Data Distribution
- Minimized Documentation





Tanegashima Space Center

Tokyo HQ's

Executives

Tsukuba Space Center
Office of R&D

Up Range Station

Telemeter Data

Telemeter Data

Takesaki Range Comand Center (RCC)

Range Safty System

Telemeter data

NASDA net

Support of Flight Data Evaluation

Evaluation System

Servers

Server

Servers

Flight Status Monitor

Flight Status Monitor

Launch Operation Team

Tracking and Control Team

IT Pilot Project - ETS-VIII

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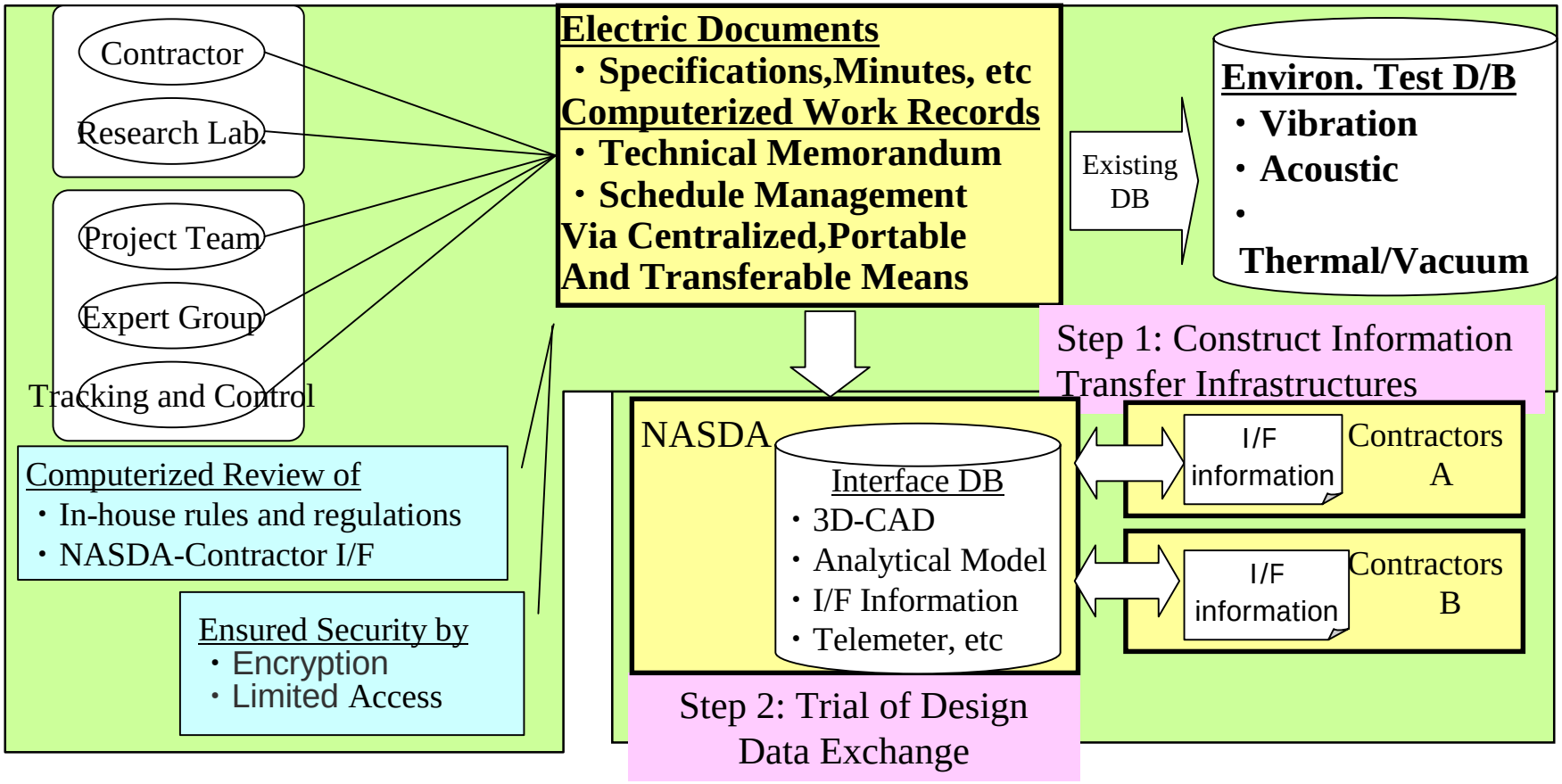
- **Collaboration of NASDA and Contractors**
- **System Design Using 3D-CAD**
- **Mutual Exchange Design Information**



IT Pilot Project - i-Space Satellite

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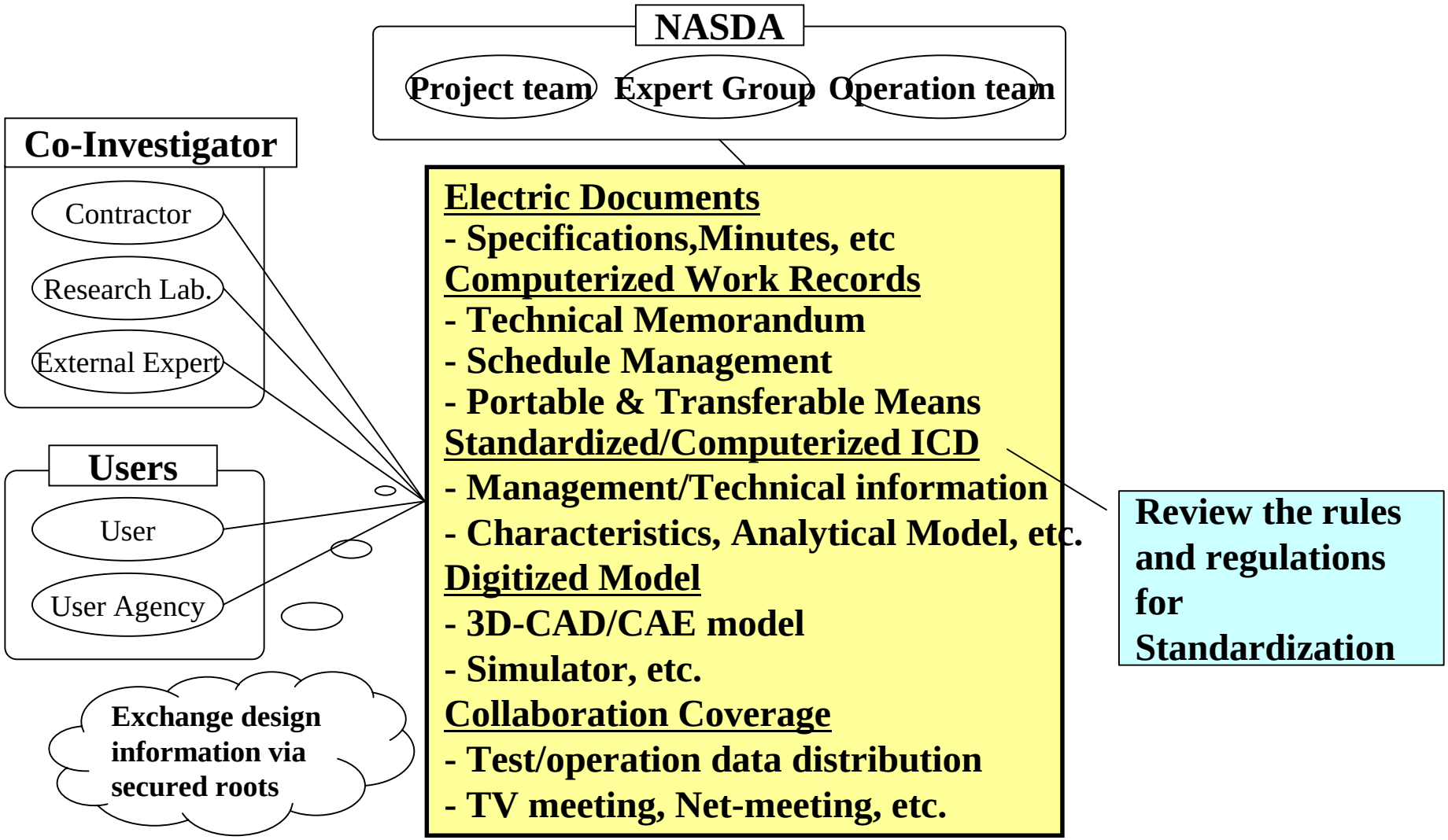

IT Pilot Project - i-Space Satellite

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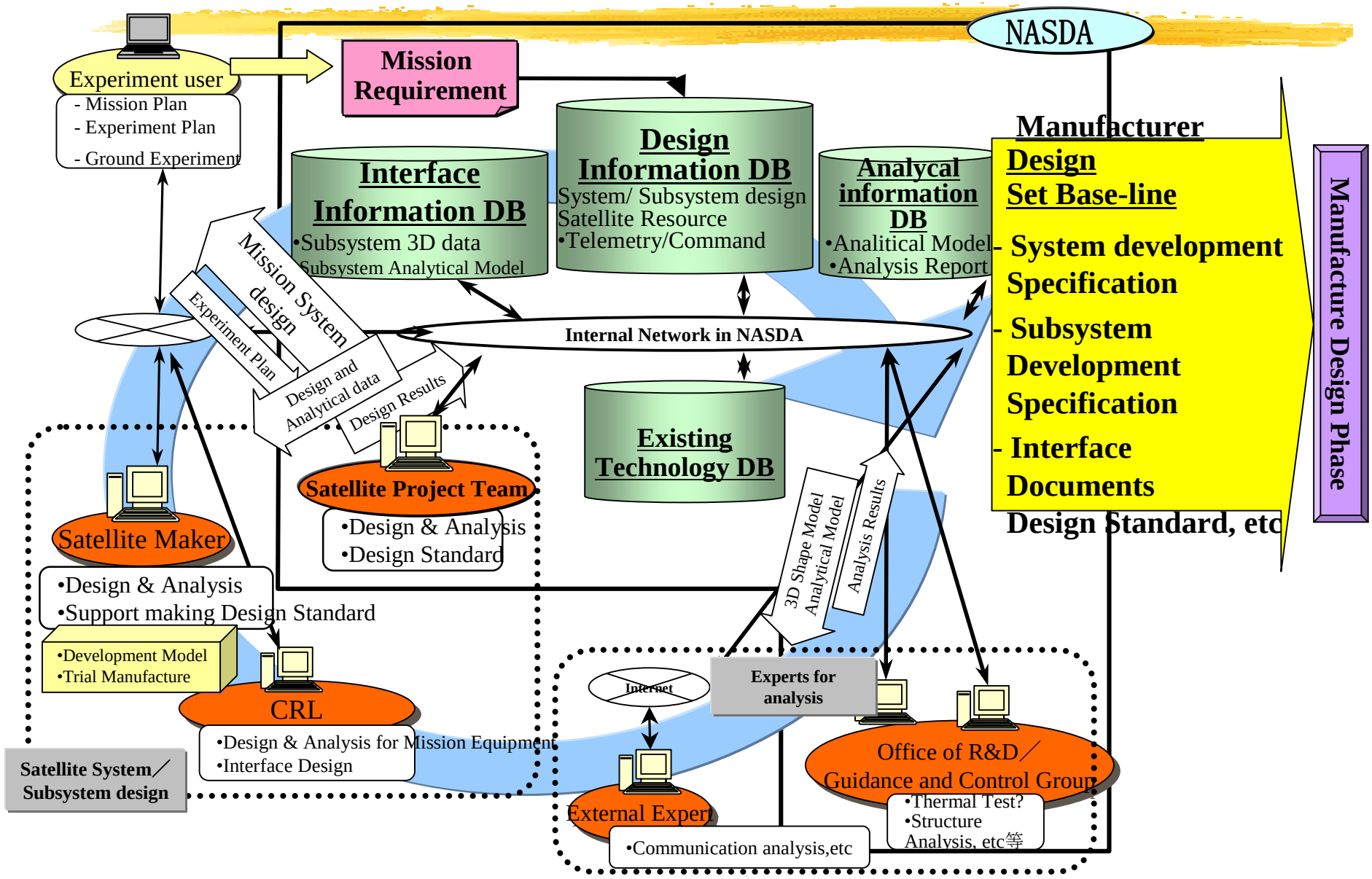

IT based Space Systems Design

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- Intelligent Data Management System
- Conceptual Design Support Tools
- Virtual Design Center
- Validation System using Artificial Intelligent
- Object Oriented Spacecraft Design
- Virtual Flying Testbed

Intelligent Data Management System

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- Sharing of project information
  - Various information such as design parameters, products lists, analytical model, test data, etc.
  - Access to the data by all team members via their own PC's
  - Data updates controlled by the Manager after approval of the design review board
  - Intelligent retrieval system enabling team members to find the desired information from huge amount of data to save working hours

Conceptual Design Support Tools

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- **Conceptual Design – a key to creation of advanced missions.**
- **Feasibility study through system analysis and simulation**
- **Conceptual Design Support Tools (CDST) – innevitable**
- **User Friendliness of CDST without requiring details**
- **Example: HOPE Team**

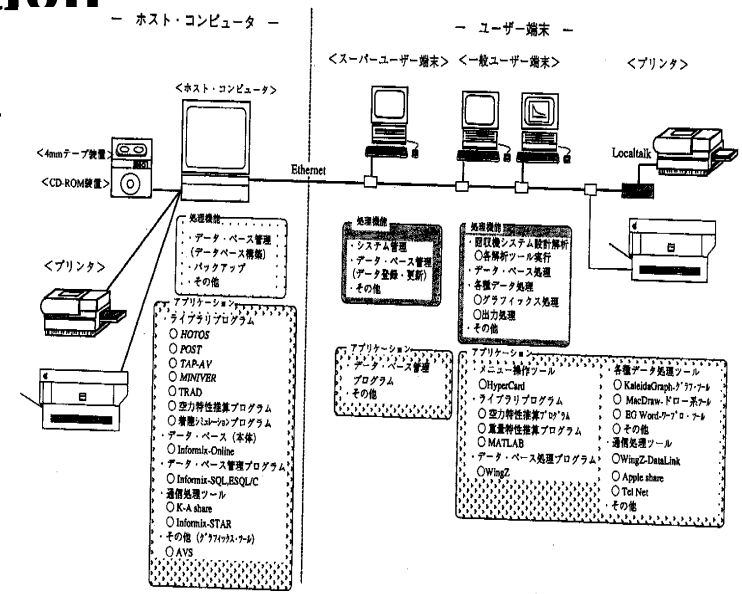

図2-1 HOPE設計解析システム構成

Virtual Design Center

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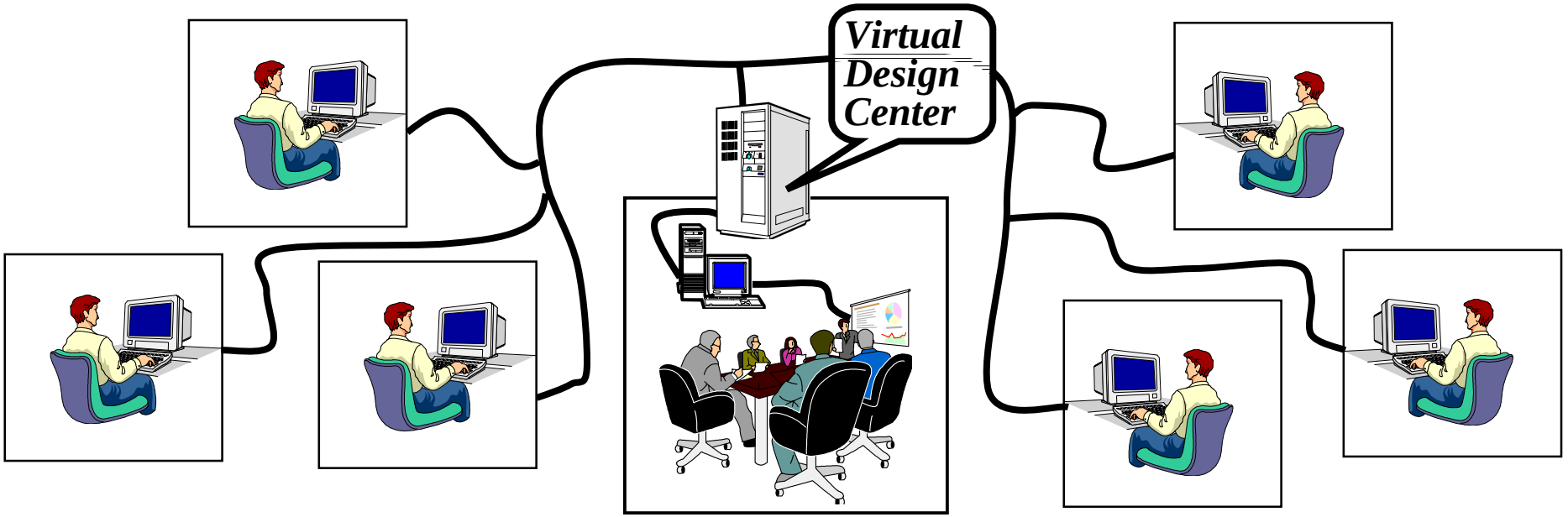
- **Space Systems Design requiring collaborative works and interface management throughout all phases**
- **Current procedures of NASDA – Face-to-face design meetings held weekly, biweekly or monthly**
- ***Virtual Design Center* in cyber-space connecting design team members for timely design meeting for trouble shooting**



Artificial Intelligence Applied to Design Validation System

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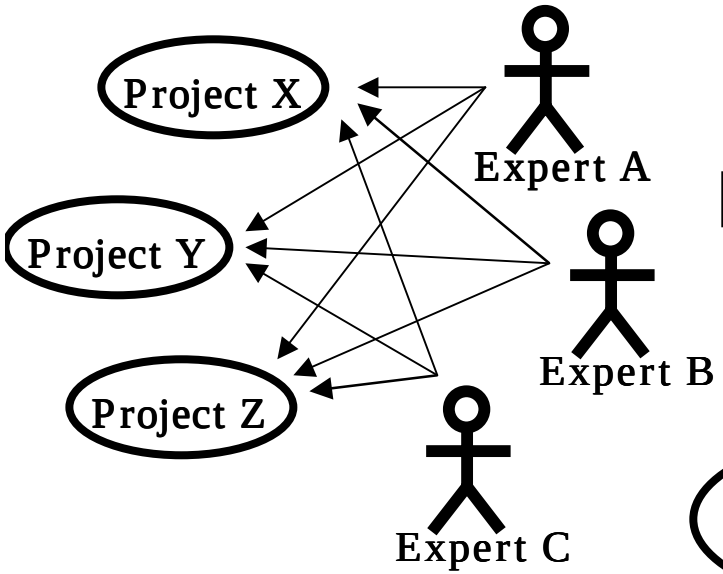
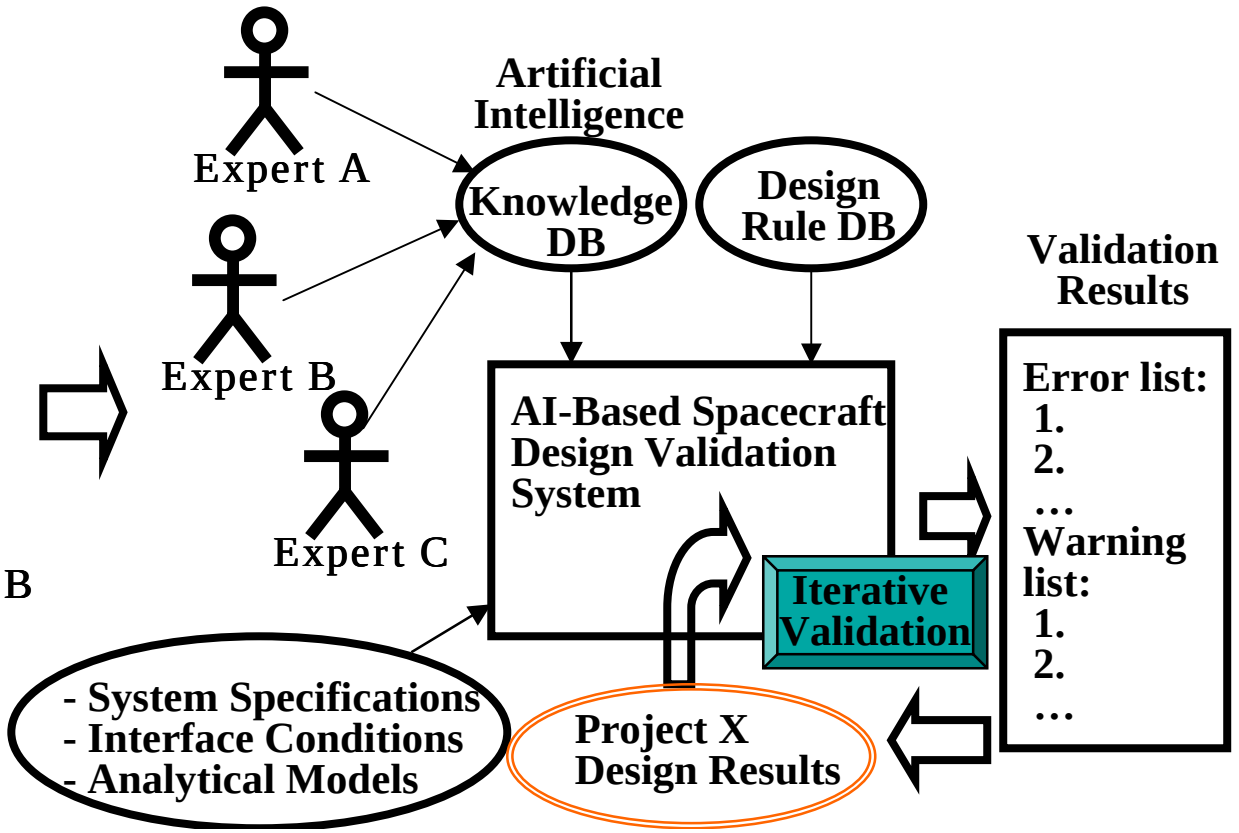
Design Review Example

Expert's Review on
- **Design condition**
- **Satisfaction of two-fail safety requirement**
- **Margin assured**



Spacecraft Design Validation System using Artificial Intelligence



Artificial Intelligence Applied to Spacecraft Design Validation System

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Scope

- Validation of the consistency in design rules and interface conditions exceeds human capability due to extremely high complexity of space systems.
- Spacecraft Design Validation System using Artificial Intelligence incorporating skilled engineers is expected.
- This system will be useful at all the design phase for project engineers to validate:
  - Design consistency with specifications
  - Interface compatibility of components/subsystems, subsystem/system

Object Oriented Spacecraft Design

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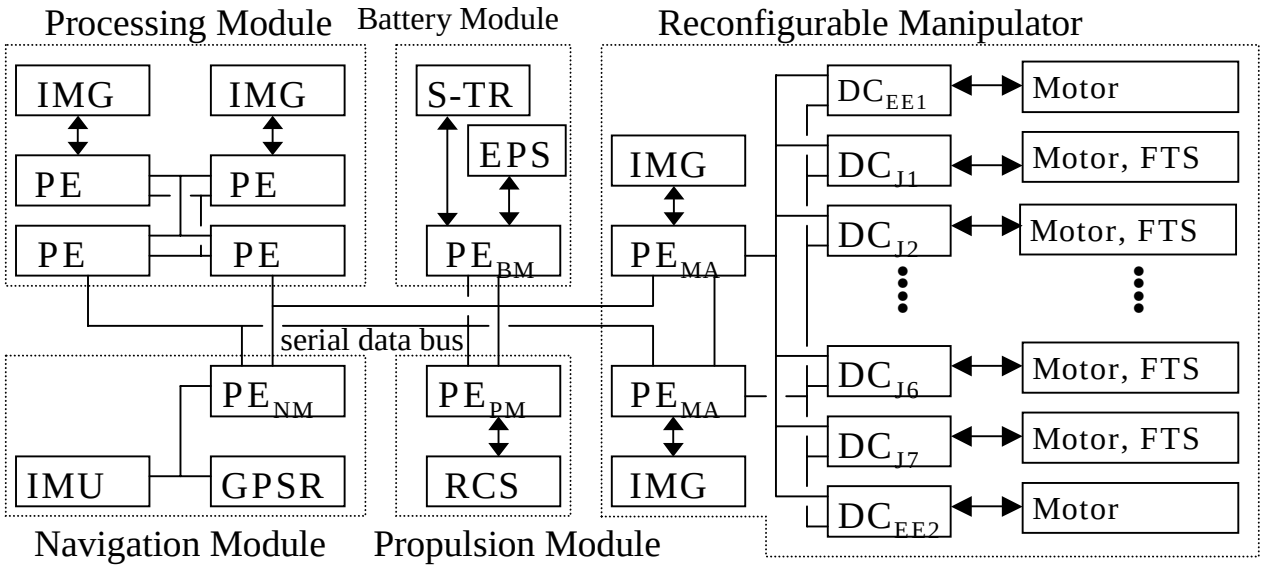
Major Characteristics

- The system divided into subsystem modules enabling system reconfiguration
- Subsystem modules free from interferences with other modules
- Subsystem modules connected by serial data bus
- Embedded Processor Element (PE) for system and interface management



PE: Processor Element
PE_{MA}: Manipulator Controller
PE_{BM}: Battery Module Controller
PE_{NM}: Navigation Module Controller
PE_{PM}: Propulsion Module Controller
RCS: Reaction Control Subsystem
GPSR: GPS receiver
EPS: Electric Power Subsystem
IMG: Camera
S-TR: S band Transponder
DC: Joint Controller
FTS: Force-Torque Sensor
Jx: Joint
IMU : Inertial Measurement Unit

Example of Object Oriented Spacecraft (Hyper-OSV)

Virtual FTB - Flying Testbed

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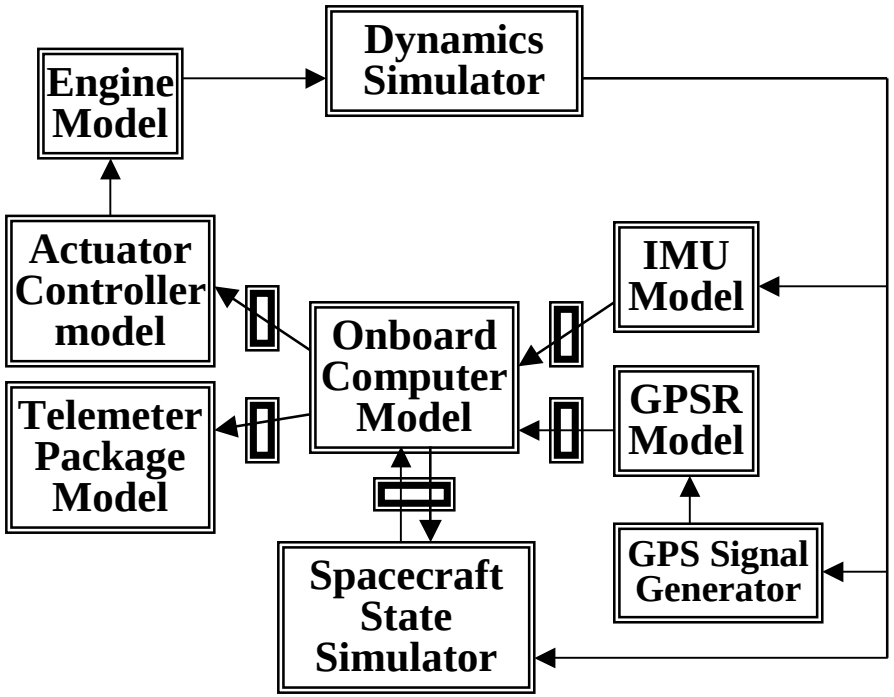
- Model-based, hardware-in-the-loop simulation system on high performance computers to reduce resources spent for complicated hardware interface tests



Conclusions

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- The Government-guided "Information Technology (IT) Revolution" driving agencies of Japan
- NASDA expected as a precursor of IT revolution by advancing the high technologies of space
- Various plans proposed – most under trial and public acceptance yet to be explored even inside NASDA
- Cultural change from hardware-oriented mind to software-oriented framework – A real breakthrough
- IT expected in more general sense to maintain the heritage of manufacturing in small industries