Concurrent Design Approaches at JPL

Presented
by

Dr. Knut I. Oxnevad

at the
New Design Paradigms Workshop
-Cross-Industrial Session-

June 26-28, 2001

Pasadena , CA, June 26 , 2001

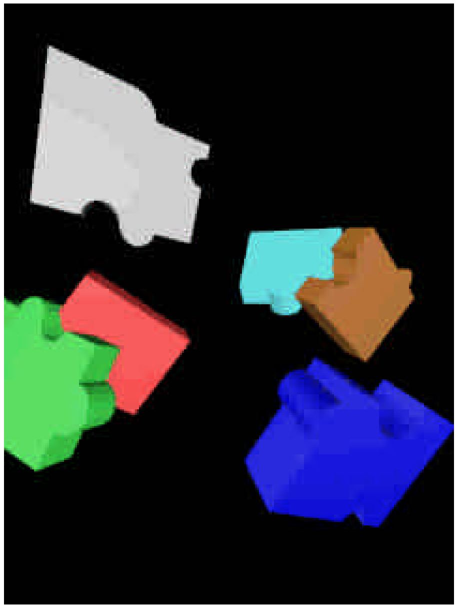
1. Concurrent Design in Perspective
   - a, The Challenge
   - b, Lessons from History
   - c, Back to Basics
2. Status
   - a,The NPDT in a Nutshell
   - b, Areas of Expertise
   - c, Approach (Design Paradigm)
   - d, Design and Analysis Capabilities
   - e, Potential Space Shuttle Payload Application
3. Future Directions
   - a, Spin-Offs
   - b, HPC
   - c, Concept to Hardware
   - d, Concurrent Design Throughout the Organization
4. Conclusions & Summary

The work described in this presentation was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

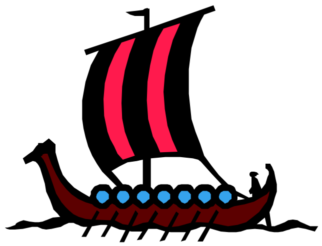
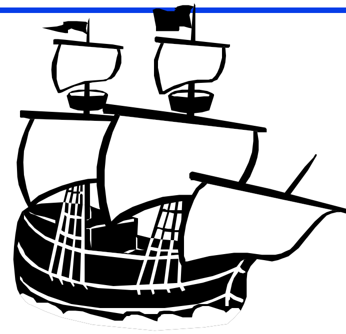
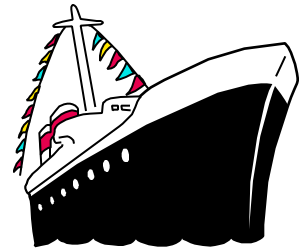
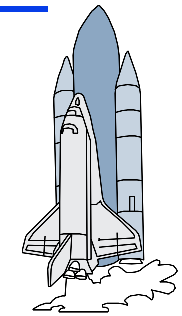
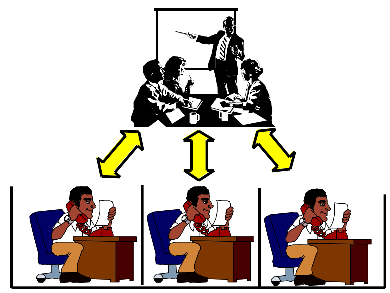
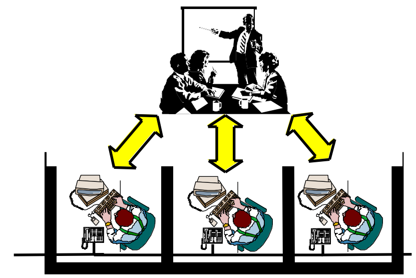
The Challenge

The biggest Challenge facing Space Development today does not lie within a specific technology, but rather in our ability to make these technologies work efficiently together to achieve our objectives.

-Knut I. Oxnevad



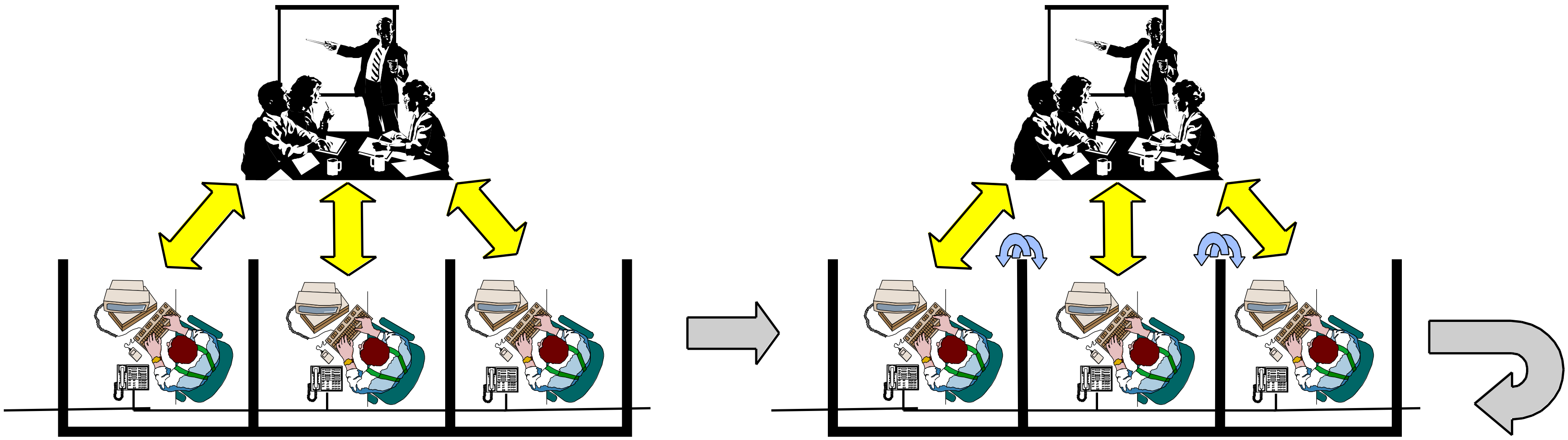
Lessons from History

	1000	1500	1950	1995
				
Design Complexity	**Low**	**Medium**	**High**	**Very High**
Basis for Design Decisions	**Experience**	**Experience (H)** **Computations (L)**	**Experience (L)** **Computations (H)**	**Experience (VL)** **Computations (VH)**
Design Collaboration				
Design and Analysis Approach	**•Real Time** **•Working Design Session-** **•Hands-On/"Touch and Feel"** **•Designer and Builder the same**	**•Real Time** **•Working Design Sessions** **•Hands-On/"Touch and Feel"** **•Designer and Builder Co-Located**	**•Off-Line** **•Office Work** **•Meetings** **•Design Reduced to Drawings and No.** **•Designers and Builders Separated**	**•Off-Line** **•Office Work** **•Meetings** **•Design Reduced to Drawings and No.** **•Designers and Builders Separated**

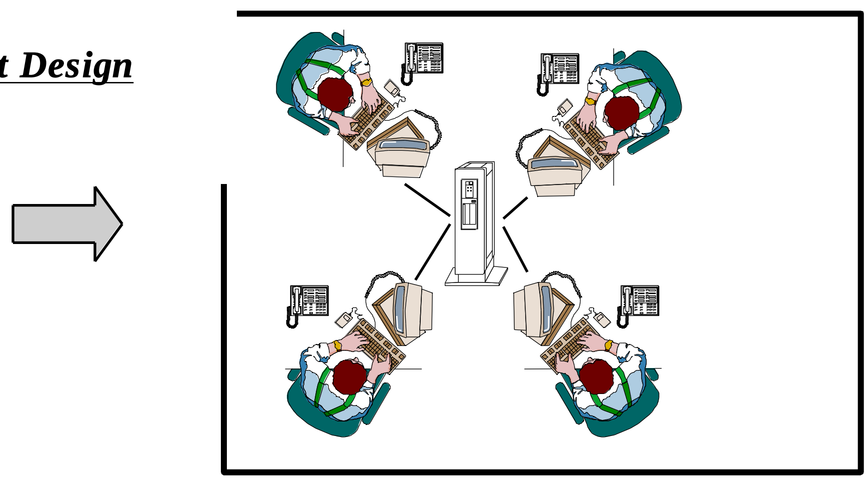
The NPDT

Back to Working Design Sessions

Concurrent Design



Concurrent Design



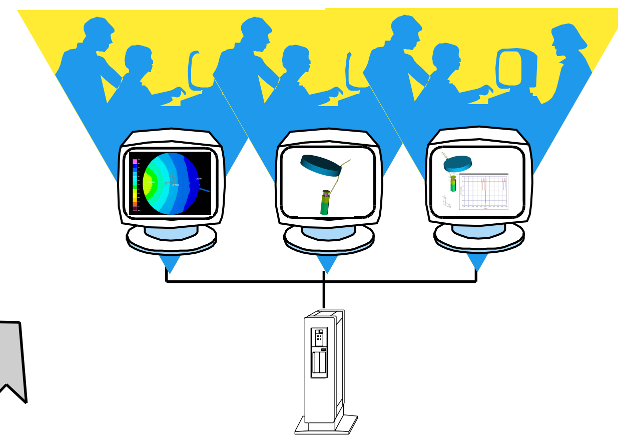
• Working Design Sessions

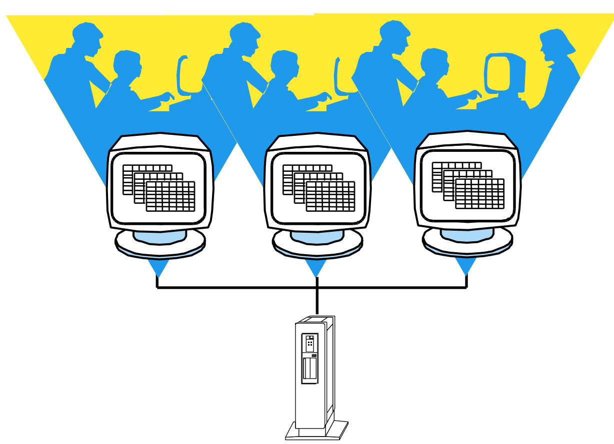
The NPDT

Back to Hands-On/"Touch and Feel"
Real Time Analysis and Design

- ***Real-Time Analyses, Design, and Simulations,*** *using interconnected High-End SW Tools*
- ***Hands-On/"Touch and Feel"*** *from 3D representation of Design on Computer*
- *Powerful HW has made this approach possible*
- *Deliver mass, power, summaries, high-end analysis results, CAD drawings, and engineering Drawings*
- *Compress the full life cycle*

Next Generation Design Approach

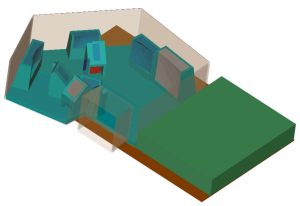




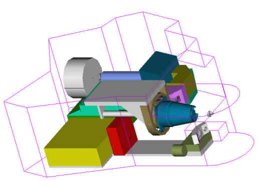
- *Numerical Analyses*
- *Spreadsheet Based*
- *Mass, Power, and Cost Summaries*

In A Nut Shell

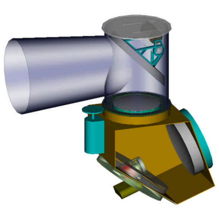
Discovery Phase 1 Gulliver



DS (ST)-4/CIRCLE

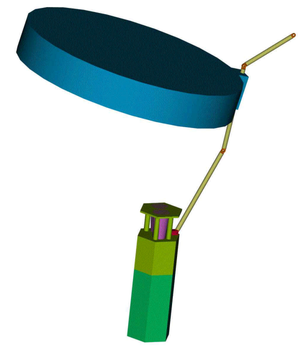


Search Camera for the CNES Orbiter

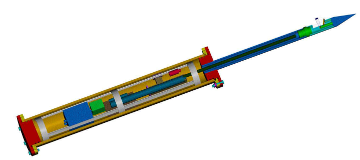


- *Concurrent **Design** and **Analysis** Environment*
- ***Real-Time** Analysis and Design*
- *Total **Systems** Approach, Multi-Disciplinary Team*
- *Standing Design Team*
- ***Customer** Actively Participates in the Design Sessions*
- *Input Parameters are Challenged in Real-Time*
- *Involved External Experts in the Design Sessions*
- *Joint Sessions with other NASA Centers*
- *From Concept to Engineering Drawings*
- ***Interconnected, High-End** Optical, Microwave, Mechanical/CAD , Thermal, Structural, Dynamics, Simulation, Orbital, Electronics Analysis and Design Tools, such as Code V, ZeMax, Mechanical Desktop, (Inventor), NASTRAN, Thermal Desktop, Adams,MODTool, and Working Model*
- *Applications Utilize a **Common** CAD Developed **Geometry***
- *Open Environment, import/export of STEP, NASTRAN files, etc., from/to JPL, other NASA centers, and Industry*
- *Technology Insertion Through Cooperation with MDL/TAP*
- *Analysis and Design Time Cut from Months to Weeks*

IIP/OSIRIS



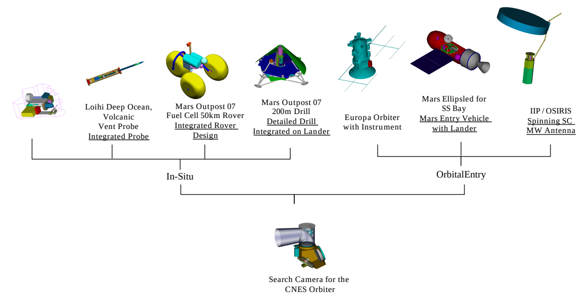
Loihi Deep Ocean, Volcanic Vent Probe



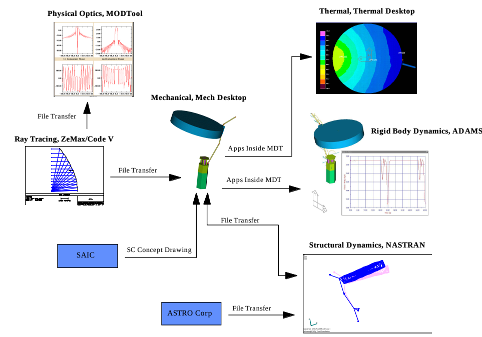
The NPDT

The Two Elements
Expertise and Approach

1. Expertise



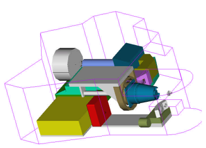
2. Approach (Design Paradigm)



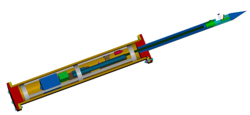
The NPDT

Expertise

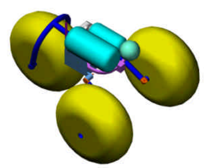
- *Expertise*
  - *Synthesis, Analysis, Simulation, and Design Support*
  - *Orbital and In-situ Payloads*
  - *Instruments to Fully Integrated Probes/Spacecraft*
    - *Optical, Microwave, Mass Spectrometer Instruments*
    - *Surface/Subsurface Pronbes. Rovers, Atmospheric Entry Vehicles, Dedicated SC.*



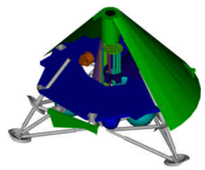
DS (ST)-4 / CIRCLE*



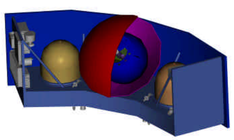
Loihi Deep Ocean, Volcanic Vent Probe
<u>Integrated Probe</u>



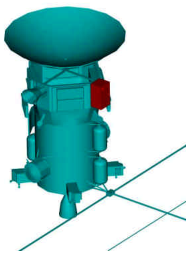
Mars Outpost 07 Fuel Cell 50km Rover
<u>Integrated Rover Design</u>



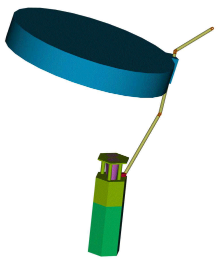
Mars Outpost 07 200m Drill
<u>Detailed Drill Integrated on Lander</u>



Venus Probe on Ariane VI PB
<u>Integrated SC and Probe Design</u>



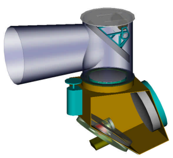
Europa Orbiter with Instrument
<u>Instrument Design and Integration</u>



IIP / OSIRIS
<u>Spinning SC MW Antenna</u>

In-Situ

OrbitalEntry

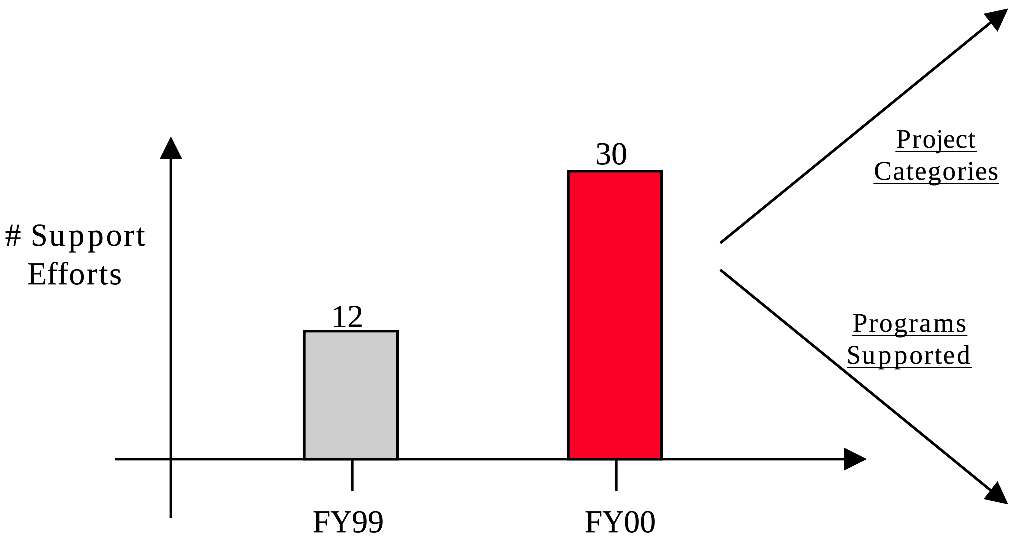


Search Camera for the CNES Orbiter*

* UV, V, and IR Systems now Handled by Instrument Team (Team I)

The NPDT

Customers FY2000 Categories



Project Categories

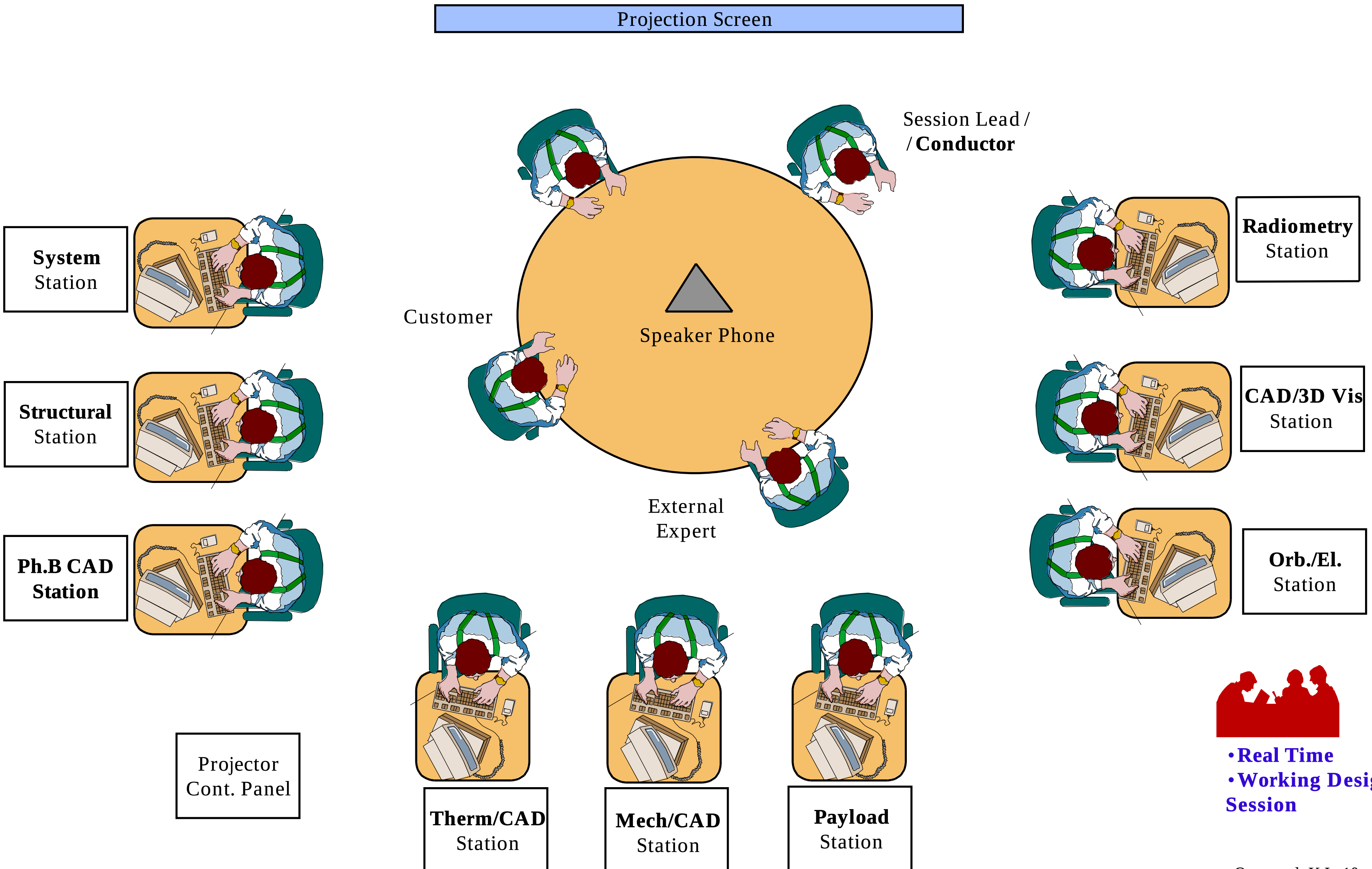
Imager/spectrometer integrated with SC/aircraft/UAV/lander/SSI/NGST: 17
Mars descent imager integrated with lander: 1
Hyperspectral imager integrated with SC: 3
Imager and Radiometer integrated with probe: 1
Telescope design: 1
Atmospheric Entry Vehicle: 1
Mars Lander Based Drill: 1
Mars Rover: 2
Mars Rover Mission (cruise, orbiter, lander, rover, and instruments): 1
SEP launch vehicle integration: 1
Micro/millimeter wave antenna configuration/fitting: 1

Programs Supported

CodeY: 1
CISSR: 1
Discovery: 8
Europa Orbiter: 3
Pluto: 1
NGST: 2
NRA/UVA: 1
Mars: 6
Mars 03 Orbiter: 2
ESSP/NGST: 2
Space Station/UNESS: 1
SEP: 1
CSMAD/SURF:1

The Lohii ocean floor volcanic vent probe developed in the NPDT was successfully taken down to 1.6 km

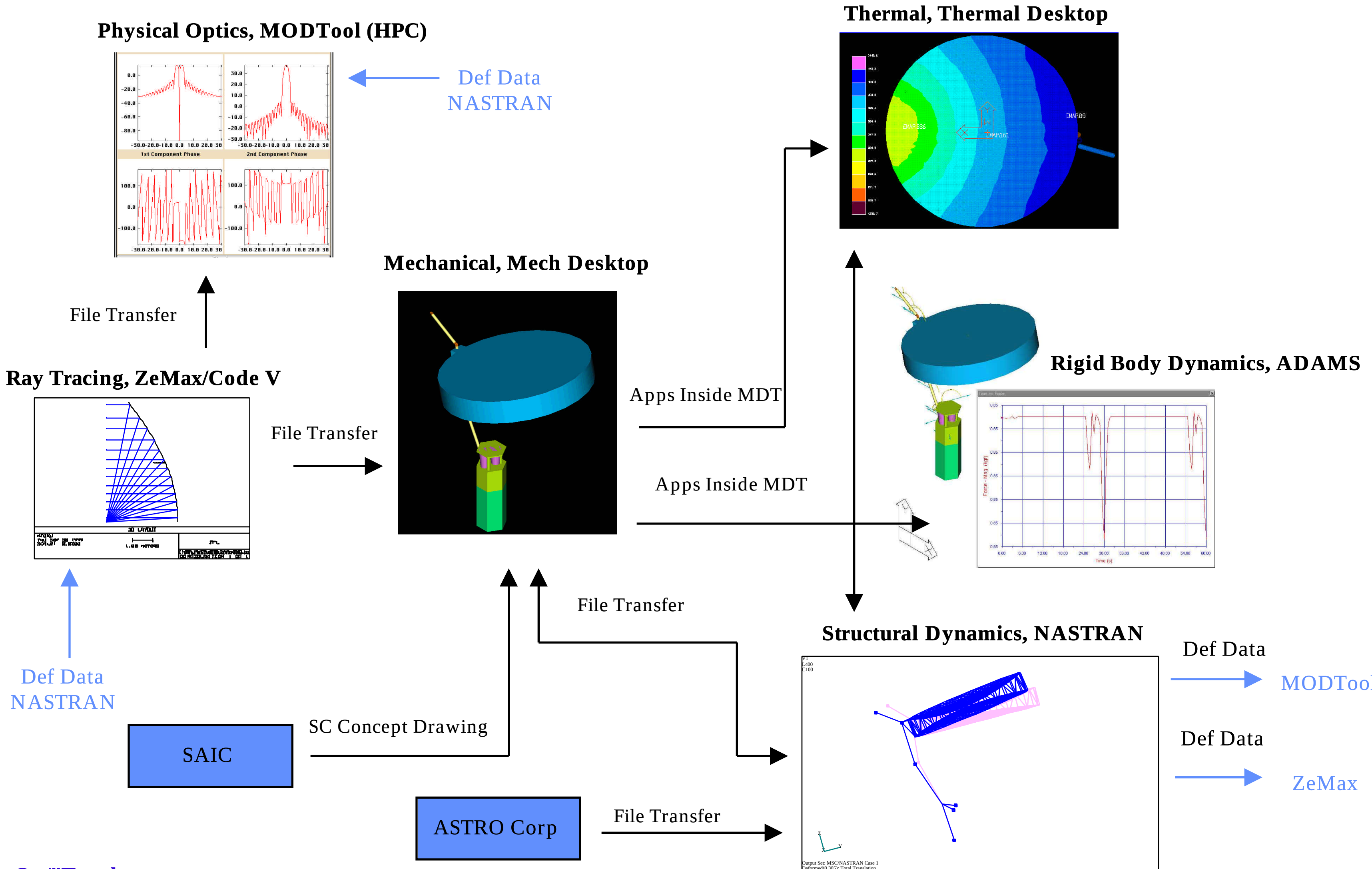
Approach
Concurrent Session



- **Real Time**
- **Working Design Session**

The NPDT

Approach (Design Paradigm):
Integrated, High-End Analysis and Design

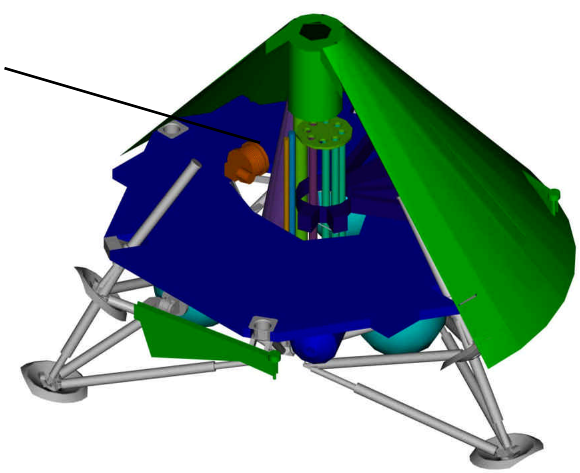


• Hands-On/"Touch and Feel"

The NPDT

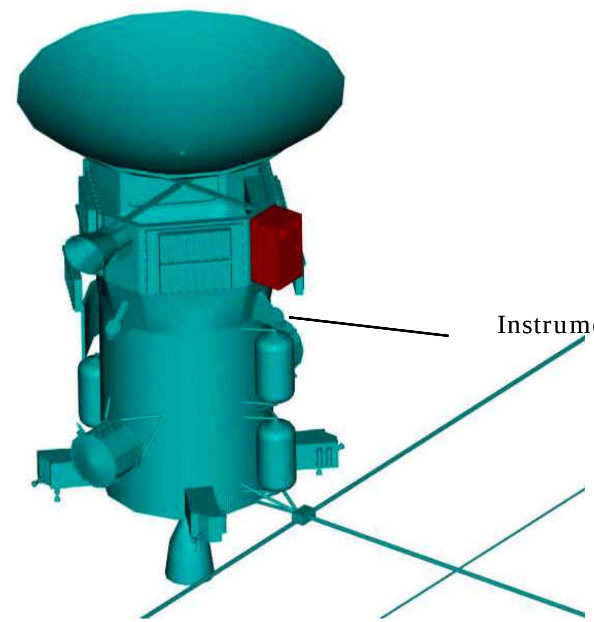
Approach
Integration of Payload and SC/ Lander

Modified 03 Lander



Support: Mechanical (parts and assemblies), Assembly simulation, Mass, and Cost

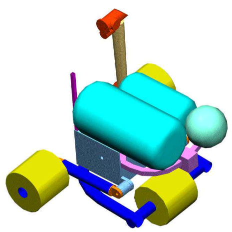
Europa Orbiter



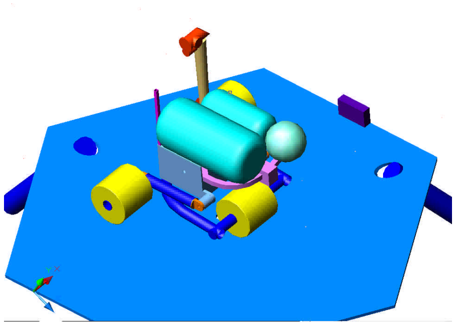
Support: Mechanical (parts and assemblies), Optics, Electronics, Orbital, Thermal, Mass, Power, and Cost

Approach
Sizing, Configuration, and Simulation

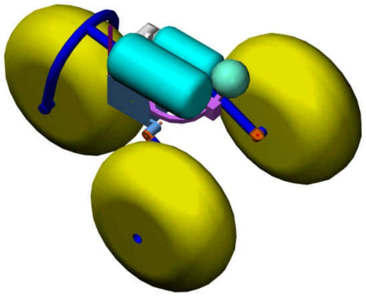
Mars Outpost
50km Fuel Cell Rover



Lander Configuration



Deployment Sequence



Surface Configuration

Support: Mechanical (parts and assemblies), Structural, Surface Mobility/Ops Simulations, Trade Studies, Mass Summary

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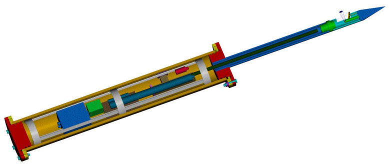
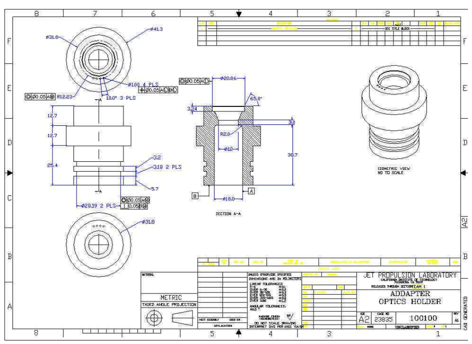
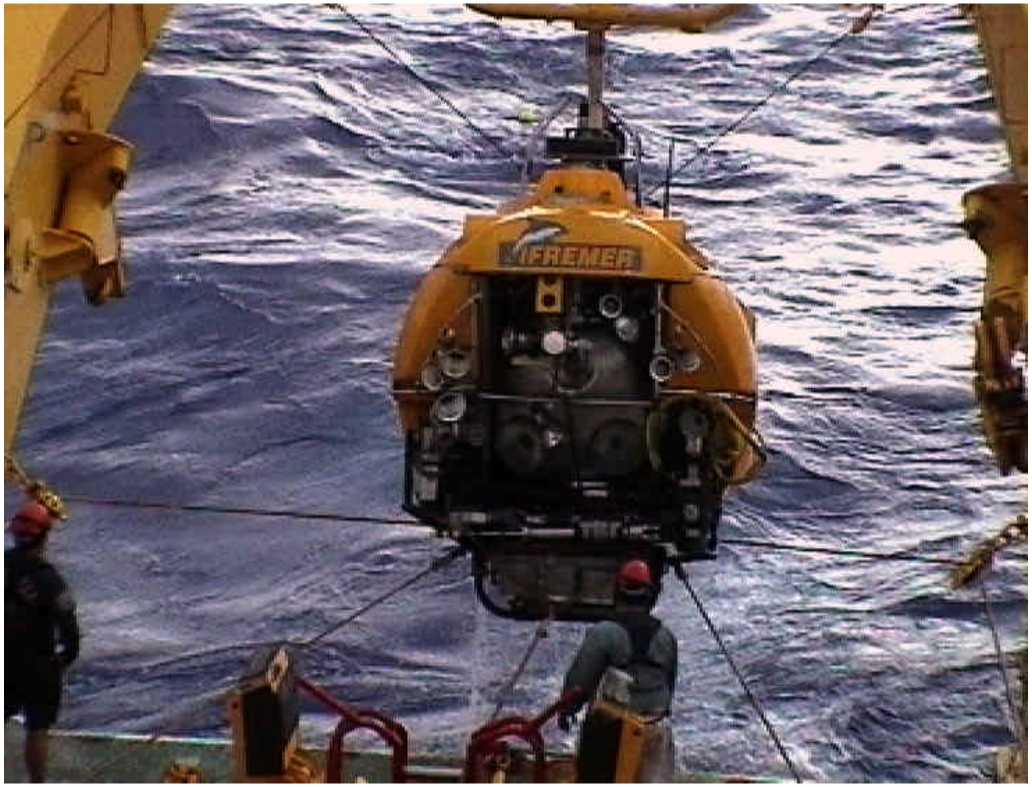
Approach

Concept, Hardware, Science Data







Support: Mechanical (parts and assemblies), Structural, Electronics, Optics, and Engineering Drawings

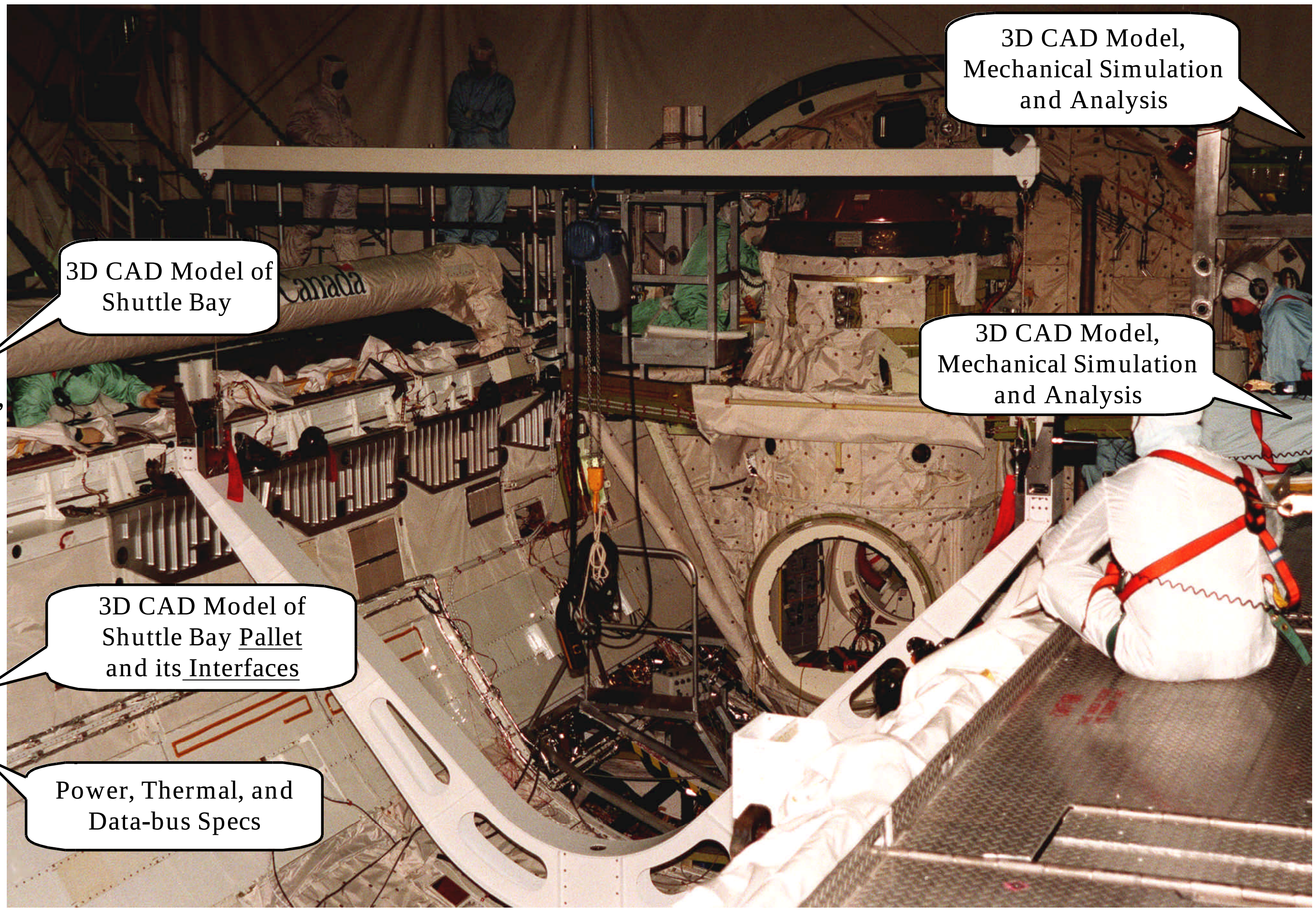
The NPDT

Space Shuttle Bay Payload Integration
A Potential Application

<u>Objective:</u>
Integration of a Payload in the Shuttle Bay

<u>Bay Specs.:</u>
Allocated Payload Volume, Stay-out Areas, Distance to Bay Walls and Sub Systems, CG Specifications

<u>Payload - Pallet Interfaces:</u>
Physical, Power, Thermal, and Data Interfaces, Time On-Off

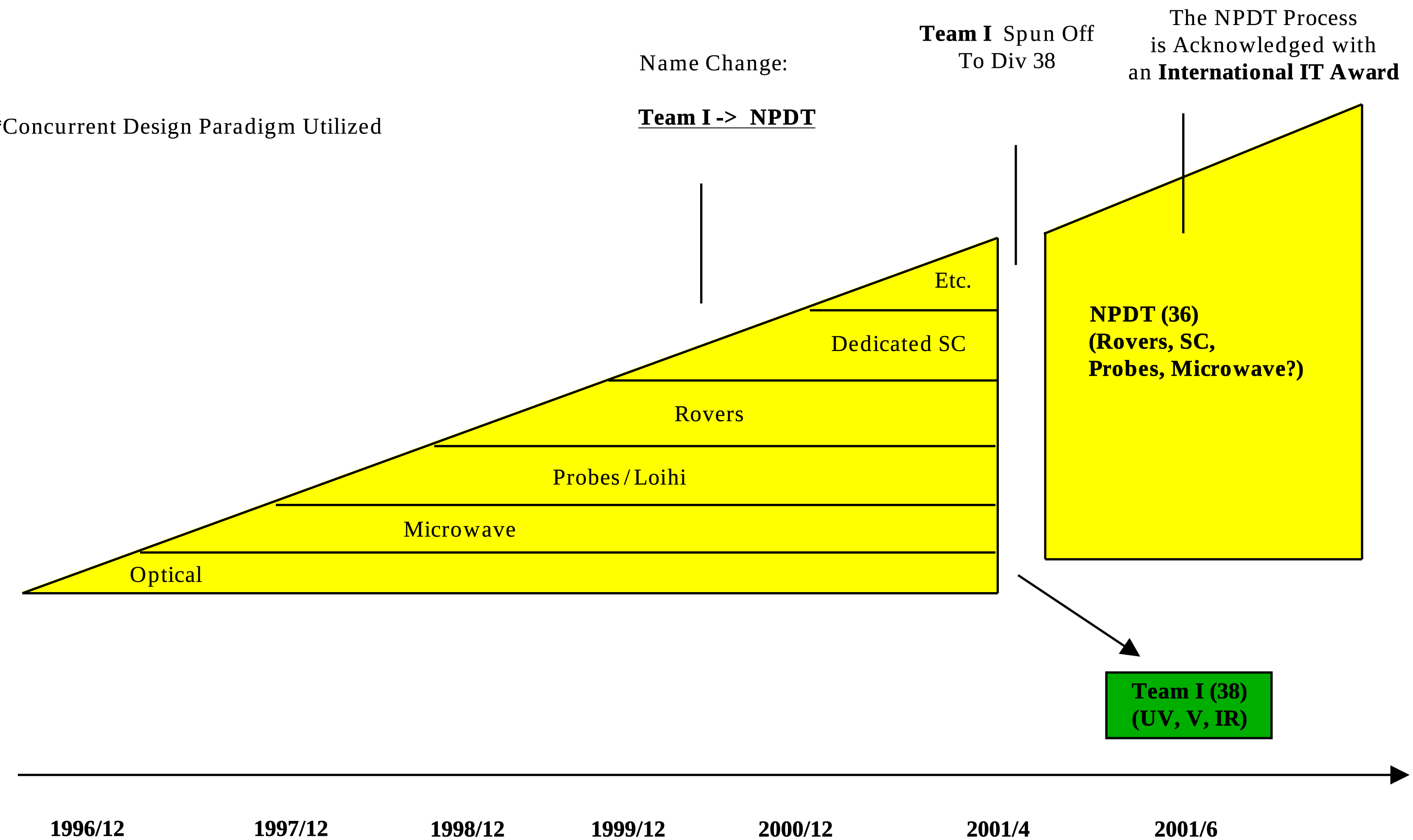


<u>Placement and Installation of Payload in Bay:</u>
Crane Reach and Capacity, People Reach and Limitations

<u>Pay Load Deployment:</u>
Shuttle and SSI Robotic Arm Interfaces, and Movement Constraints, CG, SSI Interfaces

Future Directions

*Concurrent Design Paradigm Utilized



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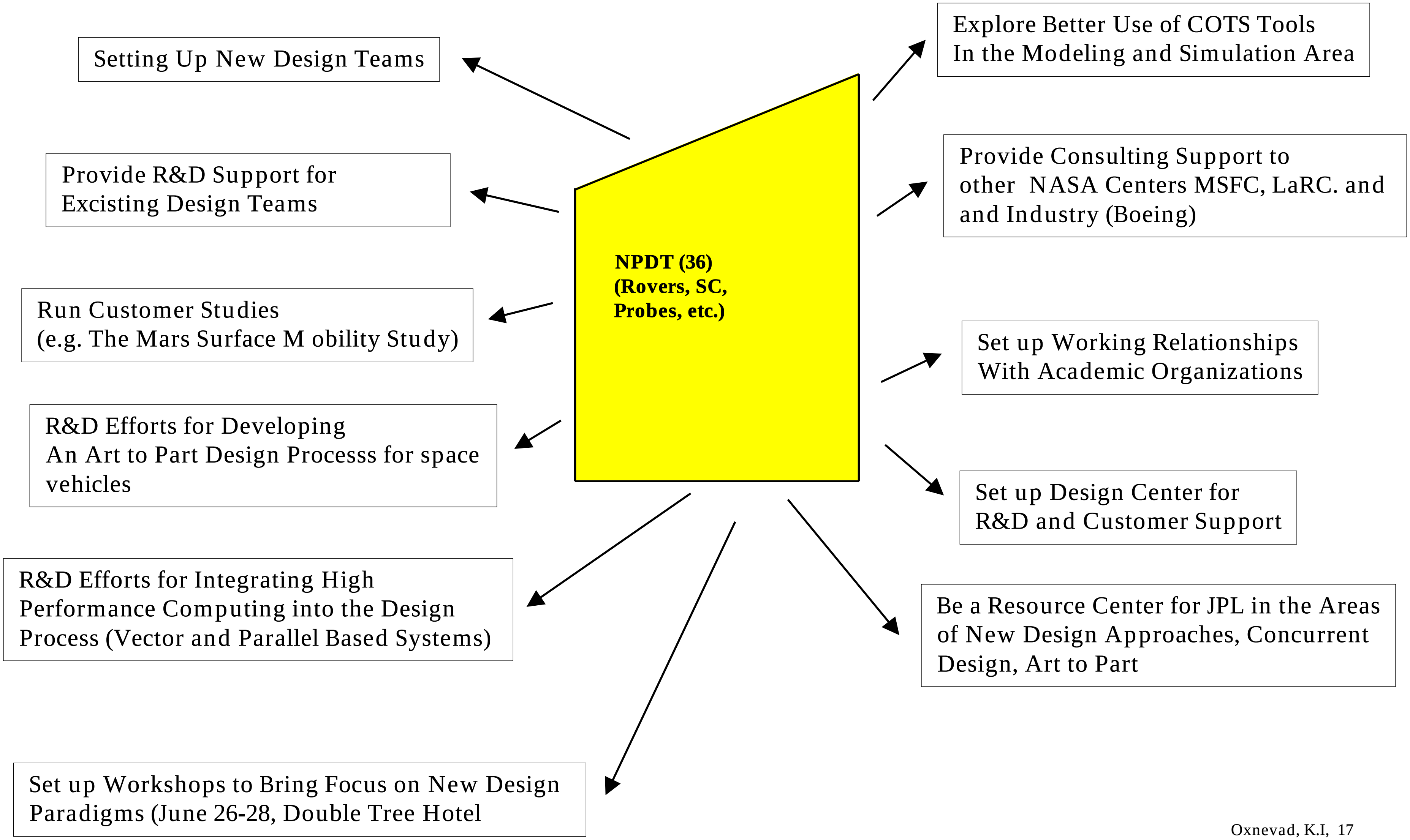
Future Directions



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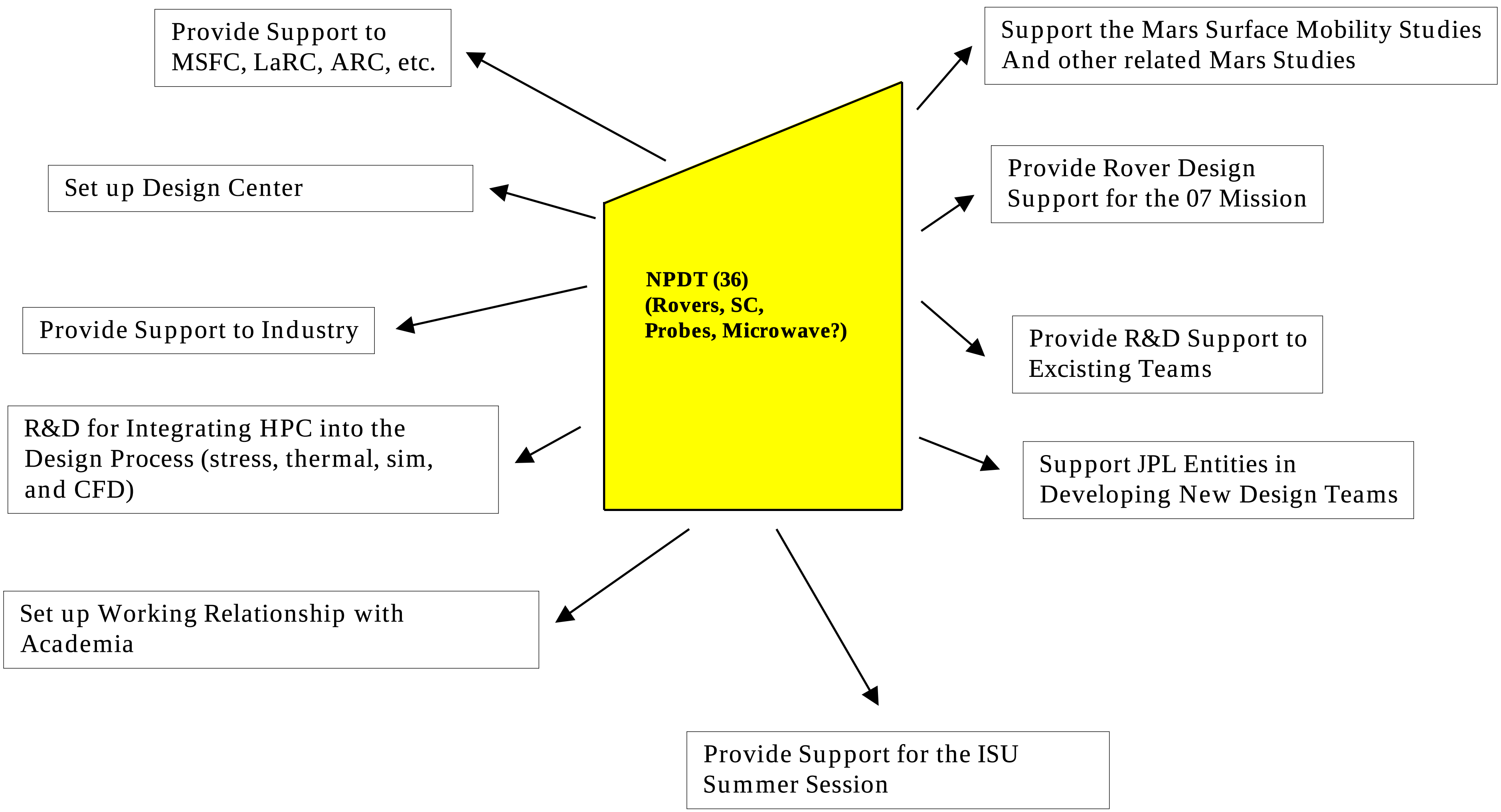
Future Directions
NPDT FY2002 Plans



The NPDT

Summary and Conclusions

- *A New and Unique Design Paradigm*

- *Customers Clearly See Benefits: Development Time Reduced and Quality Increased*

- *The NPDT Environment Consequently Can Be Seen As a **Laboratory for Developing Effective Conceptual Design Environments/Processes** for Demanding Types of Space Instruments , Probes, Rovers , Other Types of Surface Systems, Telecomm Systems. and SC.*

- *NPDT Related Procedures and Processes are Beginning to Radically Change the Instrument/Probe Design Process at JPL.*

- *The Concurrent Design Paradigm and Design Approaches Discussed here have the Potential of Bringing Great Benefits to any Large and/or Complex Design and Analysis Problem Countered when Developing Space Projects.*

The NPDT

The Winner Takes it All!