

**Utilization of Integrated High-End
Analysis and Design Tools in Real-Time
Concurrent Design Environments**

*Presented
by*

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Jet Propulsion Laboratory
California Institute of Technology

at the

Thermal Fluid Analysis Workshop
Interdisciplinary Paper Session

University of Houston
Bayou Building, 2230
Clear Lake

August 13, 2002

Clear Lake, TX, August 13, 2002

1. Challenge
2. Meeting the Challenge
3. The NPDT
4. Development Path
5. Capabilities/Research/Training
6. Future Plans

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



Contributing Organizations

Jet Propulsion Laboratory (JPL)/California Institute of Technology

- Mission Development
- Modeling and Simulation
- Payload Division
- Ground Operations
- Power
- Science
- Thermal
- Telecom
- Mars Rover Technology

Mars Program Office

NASA

- Code FT HQ
- Marshall
- Langley

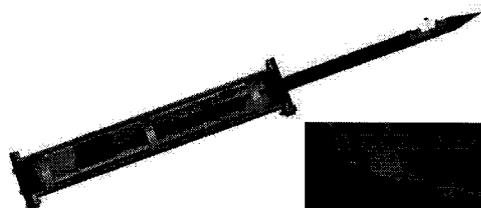
NASDA

- Tsukuba Space Center

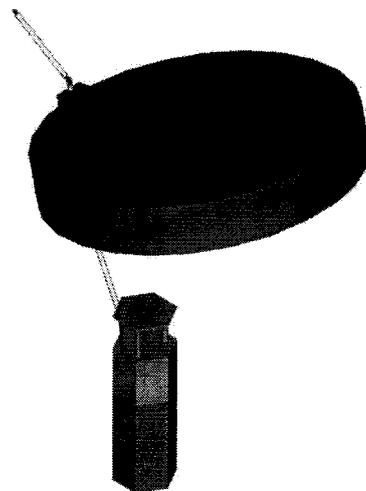
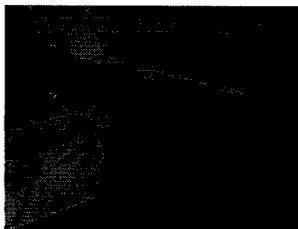
Stanford University, CA

Old Dominion University, VA

Track Record...

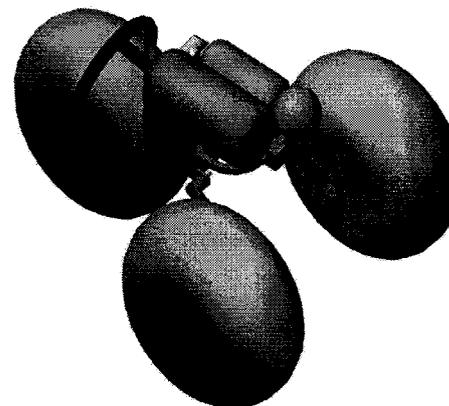


Loihi



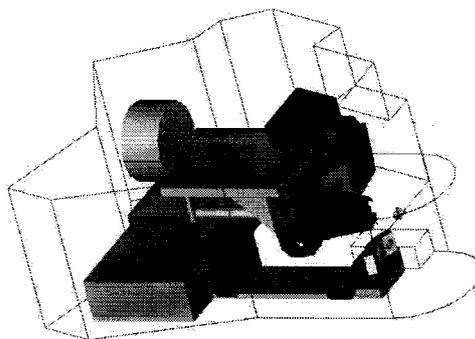
IIP/OSIRIS

Real Missions: HYDROS,
AQUARIUS, CARBON,
Disturbance Reduction
System (ST7), Loihi, etc...



Mars Outpost
Rover

Concurrent Design Teams
Supported ~ 60 Studies
Over the Last 3 Years



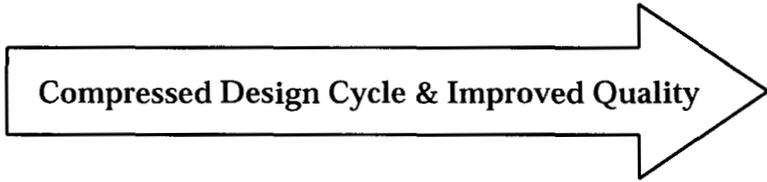
DS (ST)-4/CIRCLE

Design Maturity
Improvements: <10
Time Compression: <4

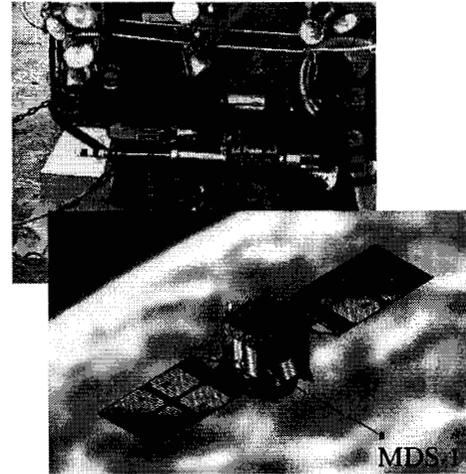
Goal!



Concept

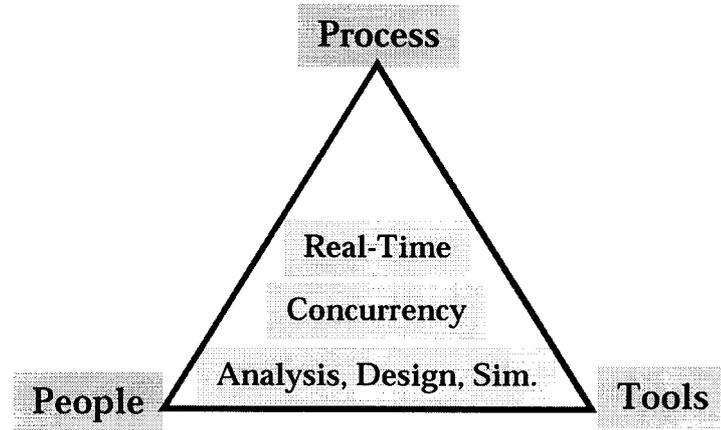
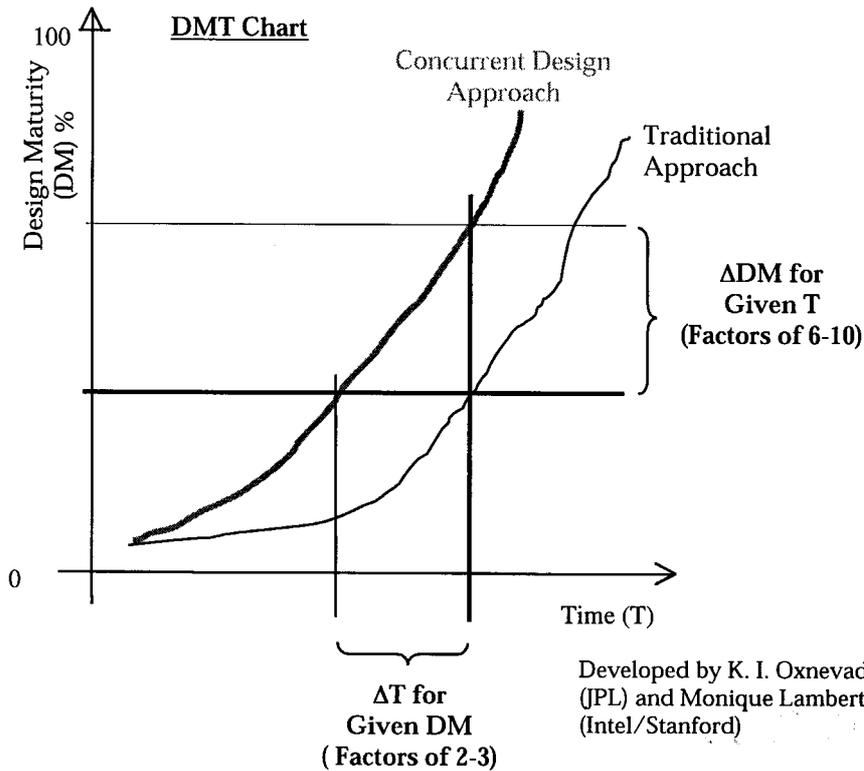


Space System (HW/SW)



Goal!

It's About...



PPT Model

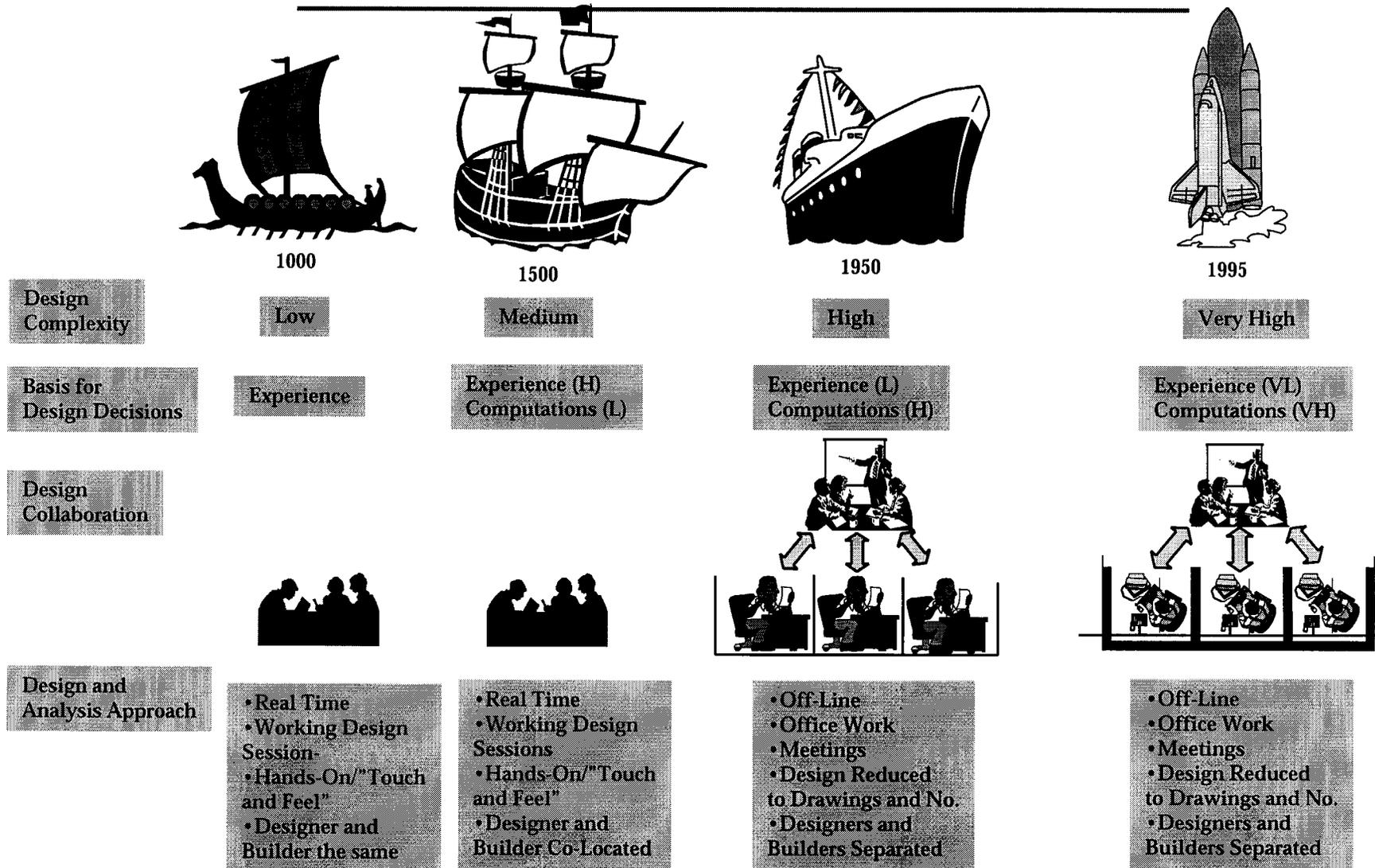
The Challenge

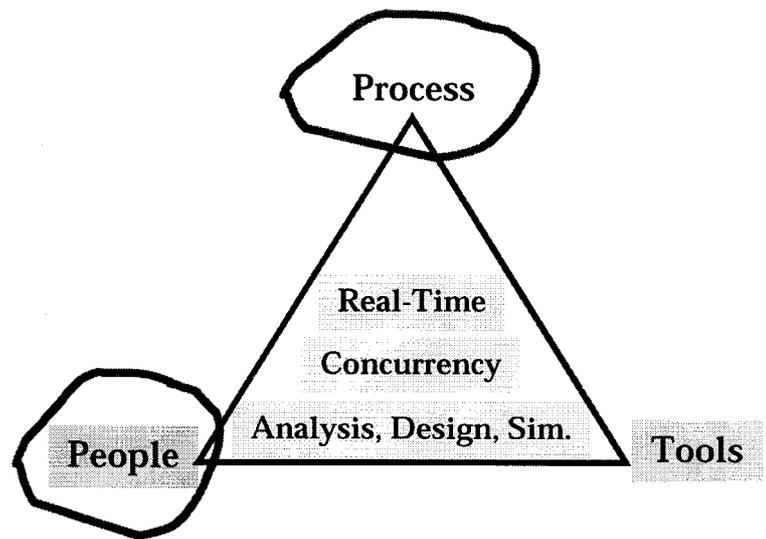
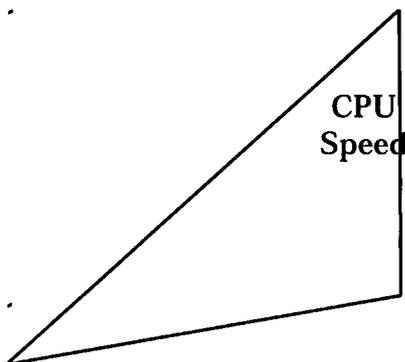
The biggest Challenge facing Space Development today does not lie within a specific **technology/discipline**, but rather in our ability to make these **technologies/disciplines** work efficiently together to achieve our **objectives**.



We must find entirely new ways to achieve our objectives ----- Sean O'Keefe

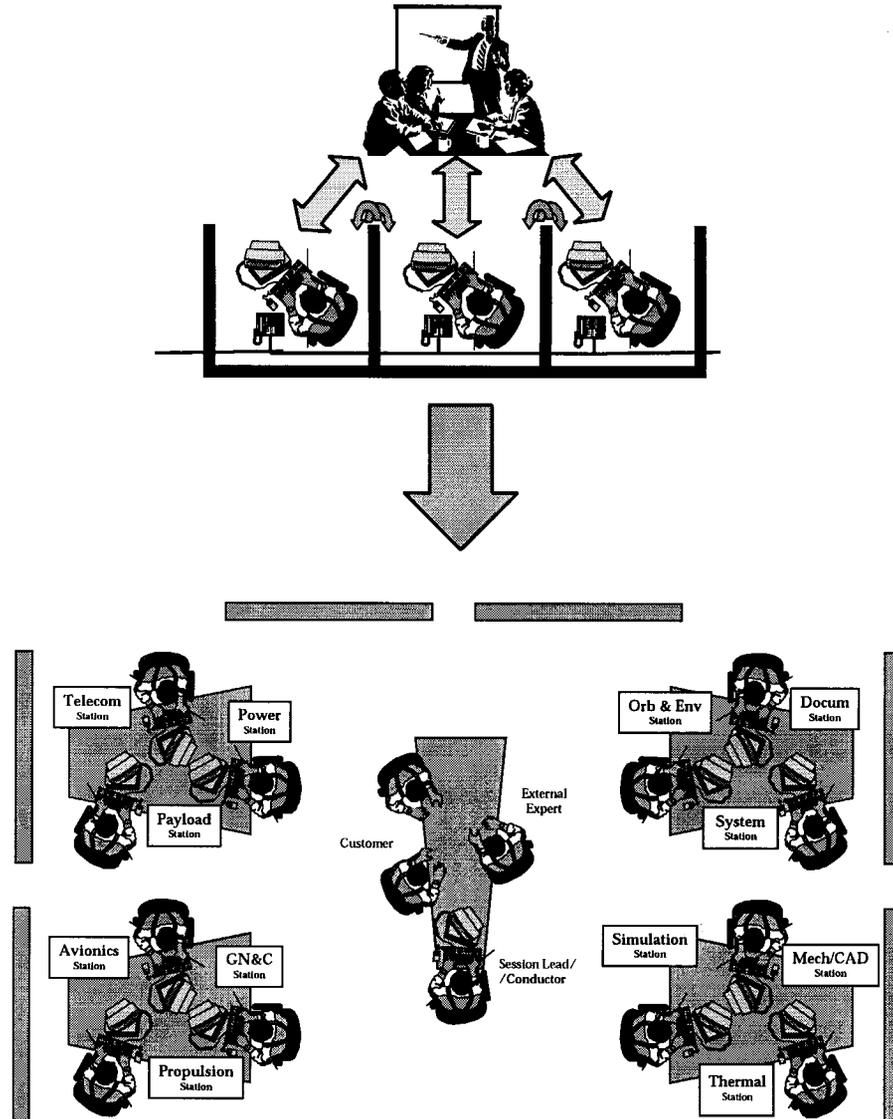
A Historical Perspective





Working Design Sessions

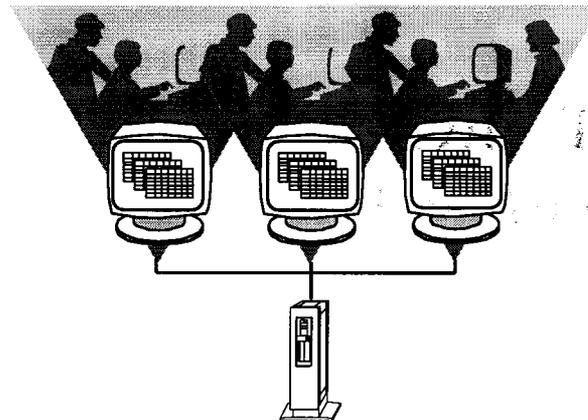
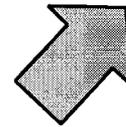
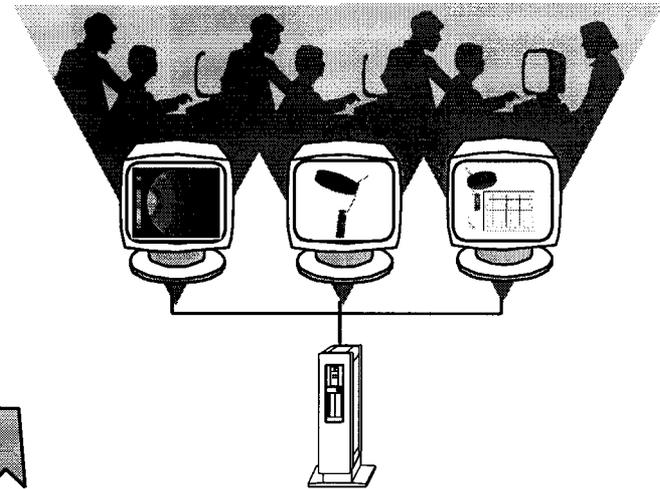
Concurrent Design



Hands-On/”Touch and Feel” Real Time Analysis and Design

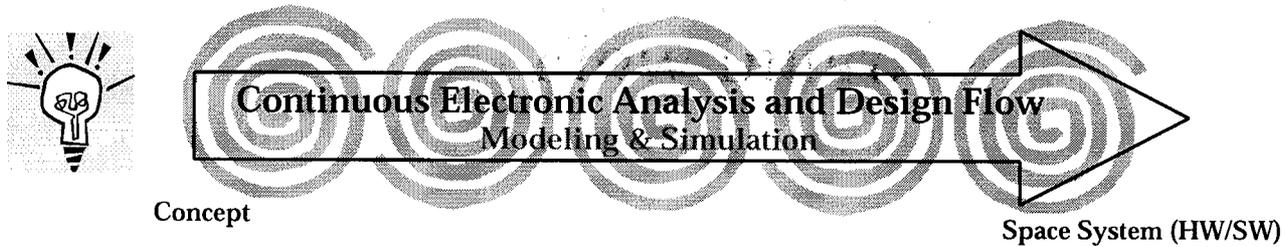
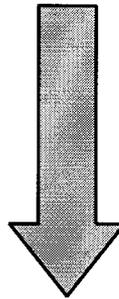
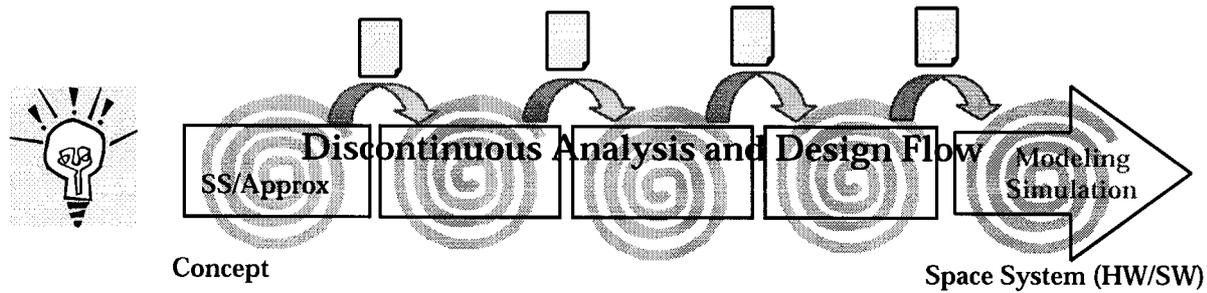
Next Generation Design Approach

- **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



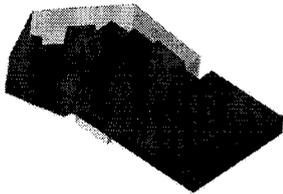
- Numerical Analyses
- Spreadsheet Based
- Mass, Power, and Cost Summaries

Design Flow Improvements

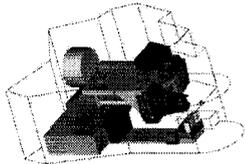


In A Nut Shell

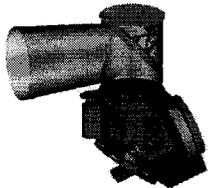
Discovery Phase 1
Gulliver



DS (ST)-4/CIRCLE

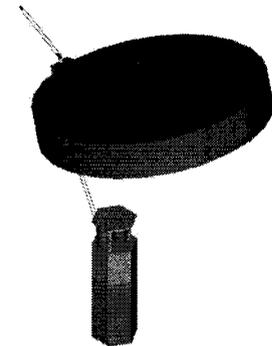


Search Camera for the
CNES Orbiter



- 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 visualNASTRAN + (PowerTool, Telecomm., Avionics)
- 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

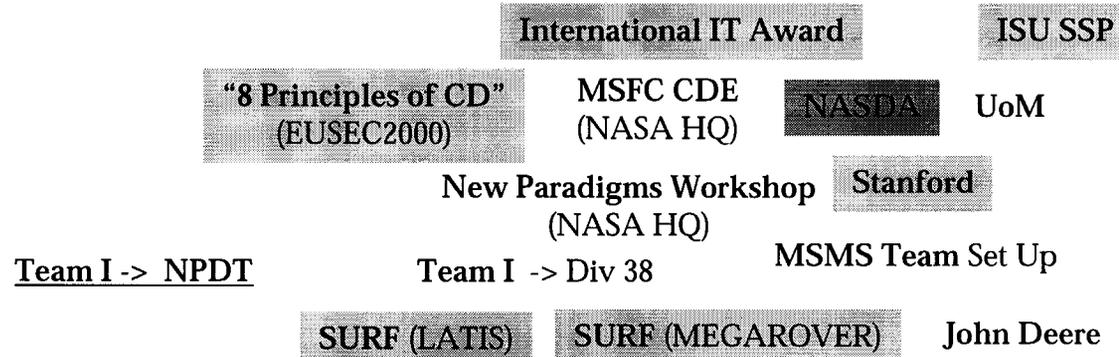


Loihi Deep Ocean,
Volcanic
Vent Probe



The Steps...

Related



R & D

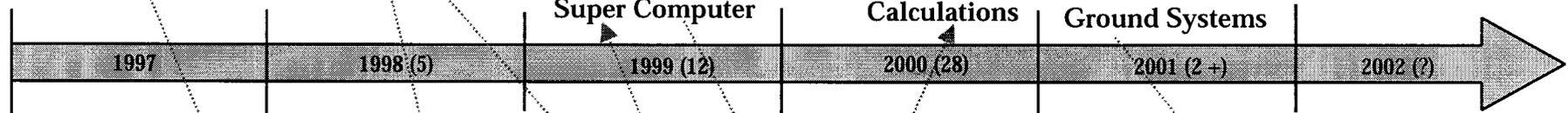
Optical
Mech
Thermal
Syst
Cost

Structural

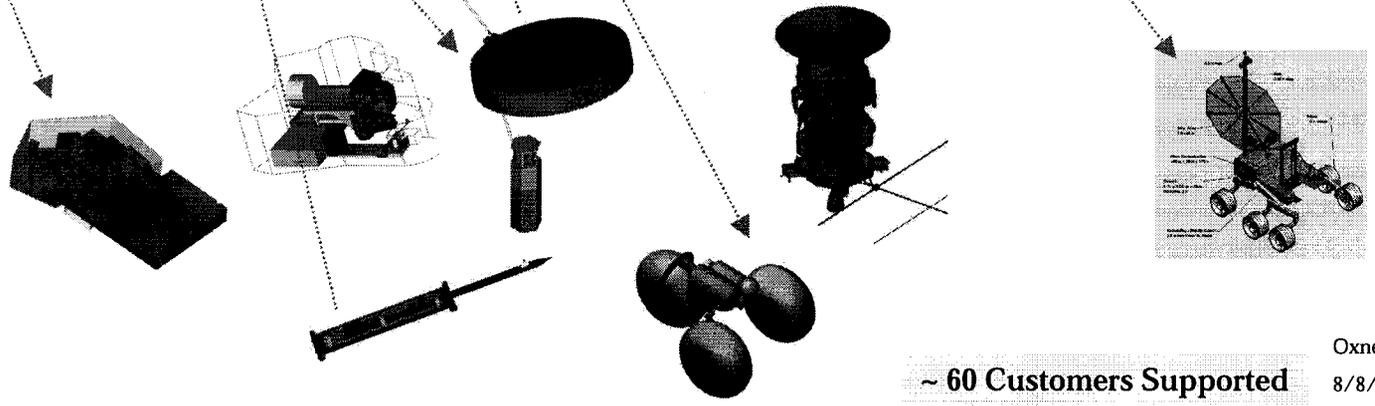
Simulation
End-End Syst
Imp/Exp Ext Files
Super Computer

Radiation
Calculations

Power Sim
Telecom
Avionics
Ground Systems



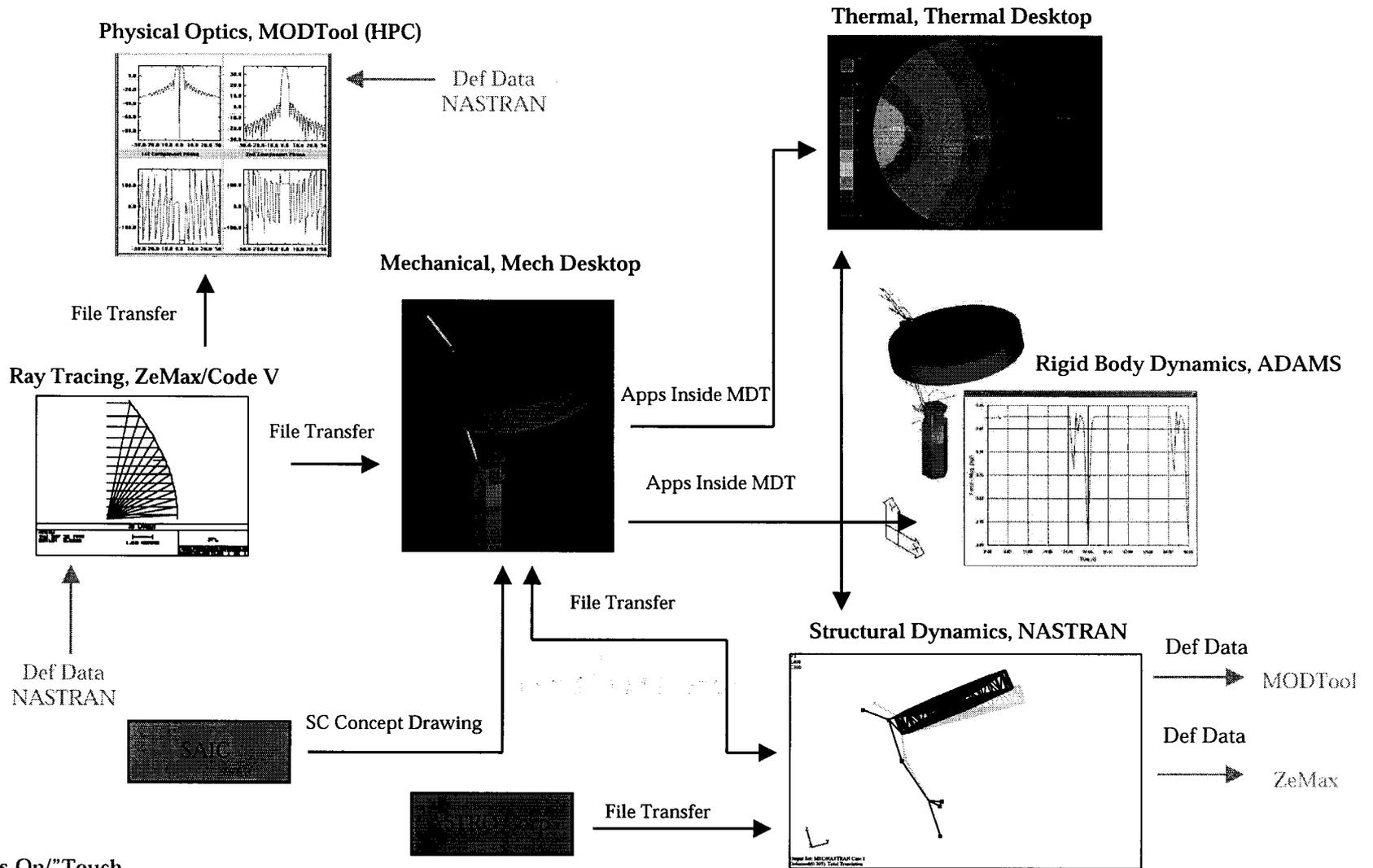
Customer Support



~ 60 Customers Supported

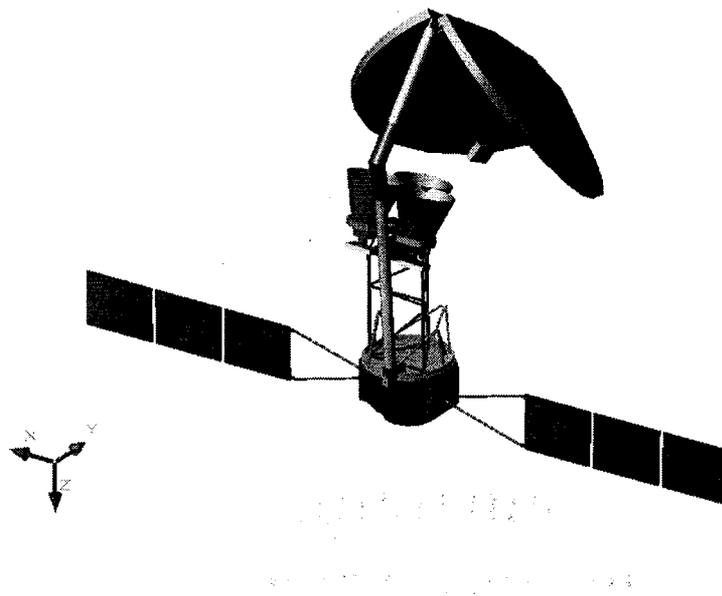


Integrated, High-End Analysis and Design



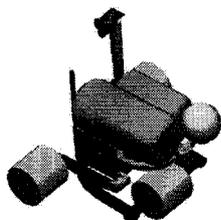
• Hands-On/“Touch and Feel”

Aquarius Early Version

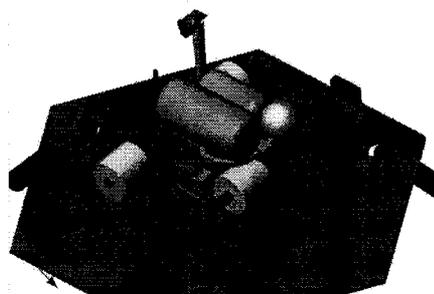


Sizing, Configuration, and Simulation

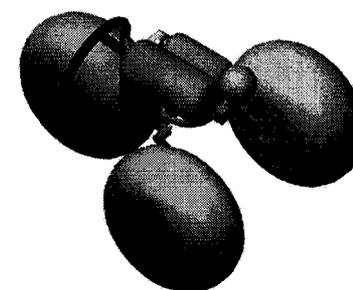
Mars Outpost 50km Fuel Cell Rover



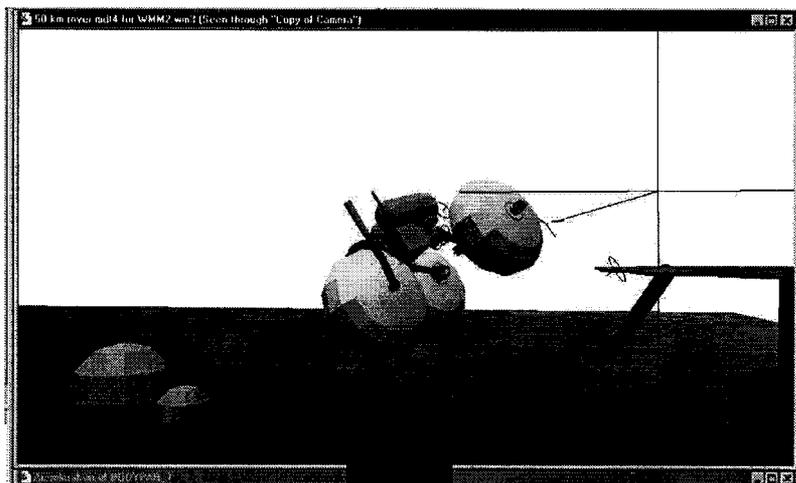
Lander Configuration



Deployment Sequence

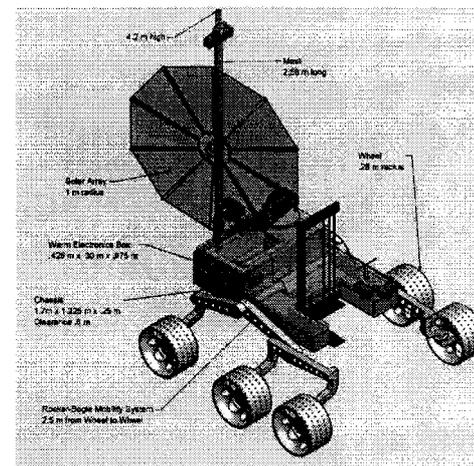


Surface Configuration



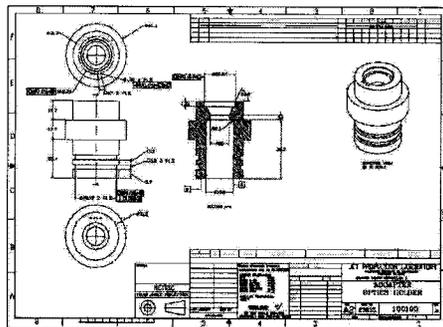
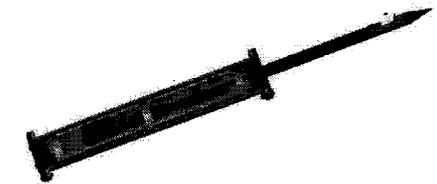
Operational Scenario
Simulation

SURF 2001 Rover
(MSMS Rover Team)



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

Concept, Hardware, Science Data



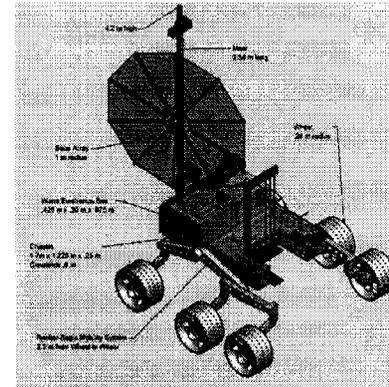
Support: Mechanical (parts and assemblies), Structural, Electronics, Optics, and Engineering Drawings

Mars Surface Mobility Studies

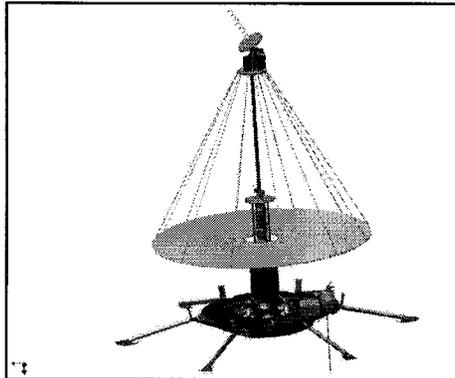
Mars Advanced Studies



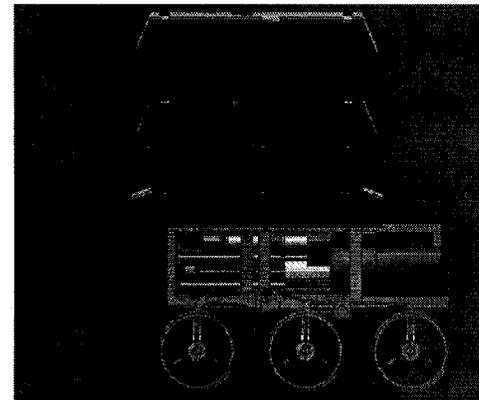
**Volcanology, MER
Derivative**



Polar Layer Deposit (PLD)



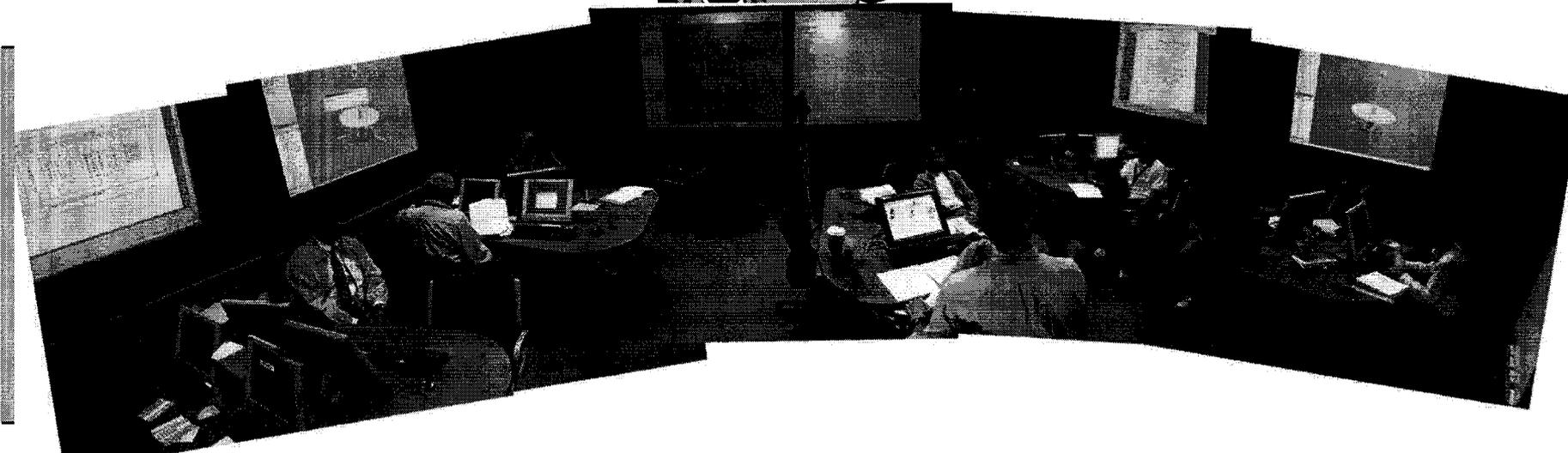
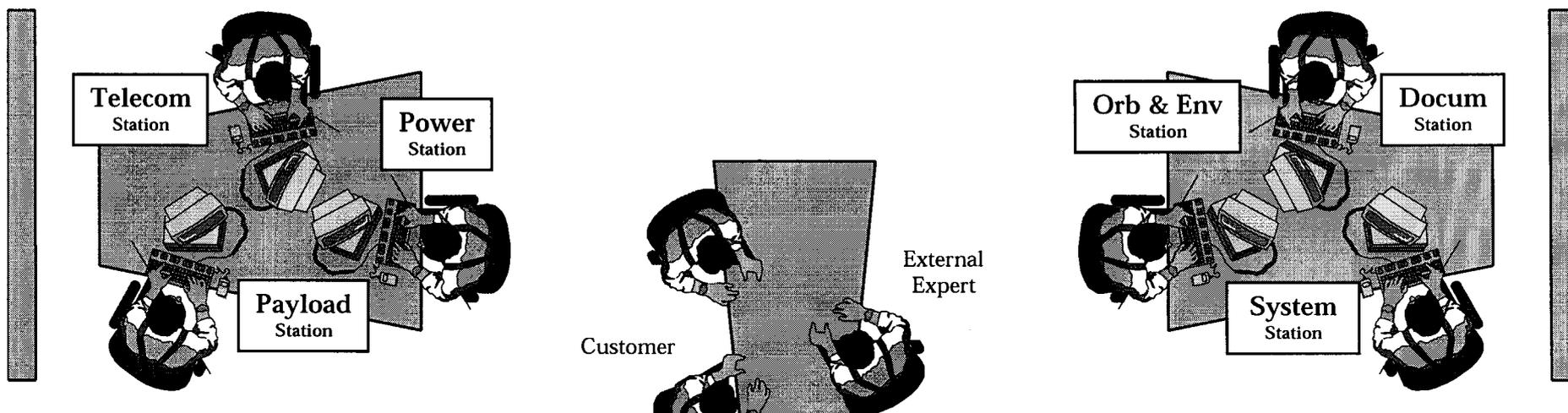
**Fission Powered Polar Based
Cryobot Lander Mission**



**Fission Powered
Rover Mission**

The NPDT

The Mars Surface Mobility Study (MSMS) Team

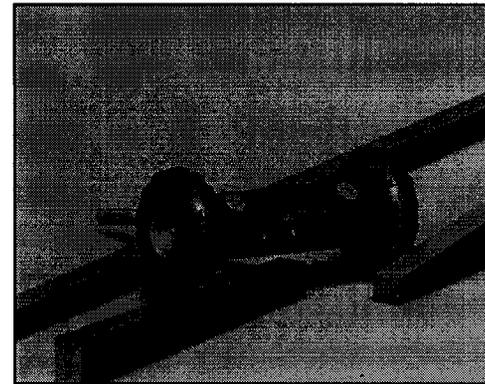
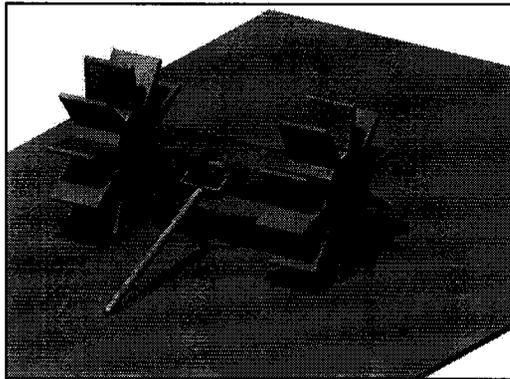


Photo, Courtesy Ben Shaw

Session

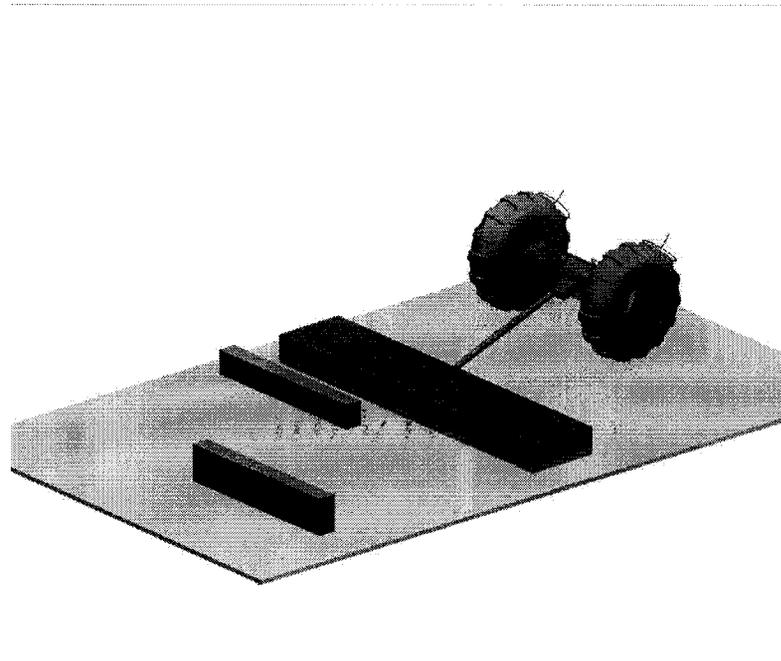
ORNL, 101, 10
8/8/02

Simulation/Virtual Testing



Trades

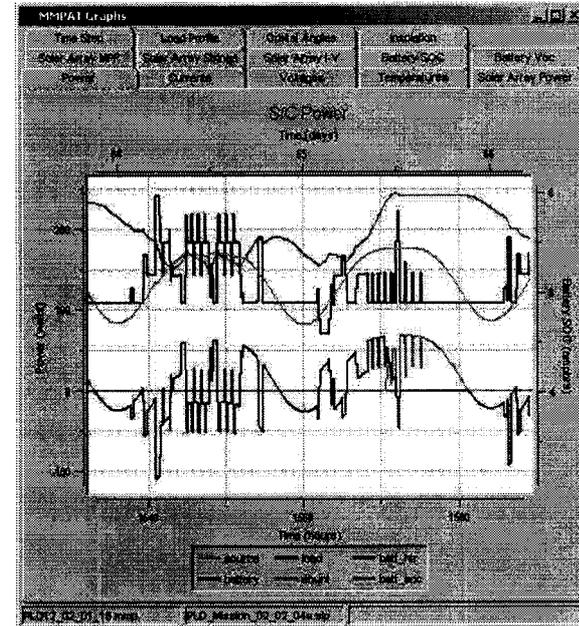
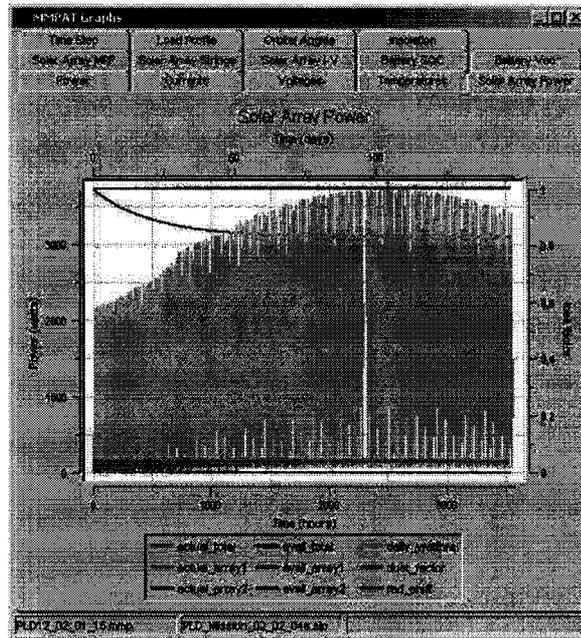
Wheel Diameter
Castor length
Wheel Base
Wheel plus rim
Castor Mass
Axelrod Mass
Axel Mass



Tools Used

Inventor
and visualNASTRAN

Power Analysis/Simulation Tool Mars Mission Analysis Tool (MMAPT)



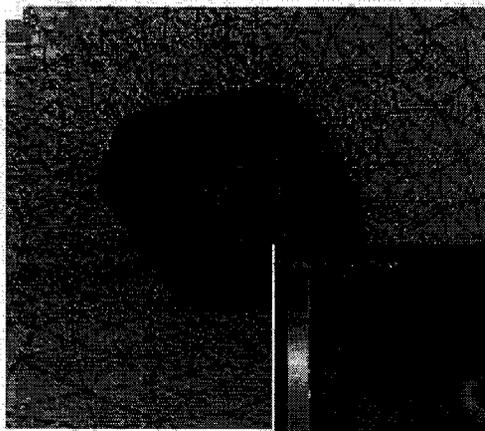
JPL's Mars Mission Analysis Tool (MMAPT) Included in Environment

Calculates, for a Given Location, Date, and Mission Power Profile:

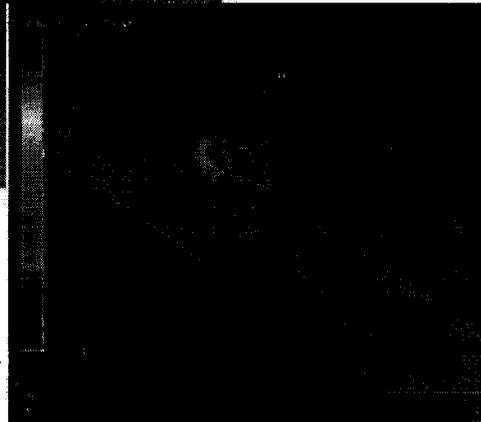
- Solar Power Available
- Battery Charge and Voltage
- Solar Panels and Battery Sizes/Capacities

Plan to Introduce Avionics and Telecom Tools Later

CFD and Immersive 3D COTS Tools



Closeup Meshed probe - CFdesign



Sample temperature distribution - CFdesign



Immersive FEA design and analysis



IR coverage quality

Dr Tibor Balint, Assessment of Commercial Off the Shelf Computational Fluid Dynamics (COTS-CFD) Tools to Enhance the Concurrent Design Environment at NASA-JPL, JPL, May 2002

Yves Rubin, Using 3D Visualization and Virtual Reality to Enhance the Concurrent Design Environment at NASA-JPL, May 2002

Objective

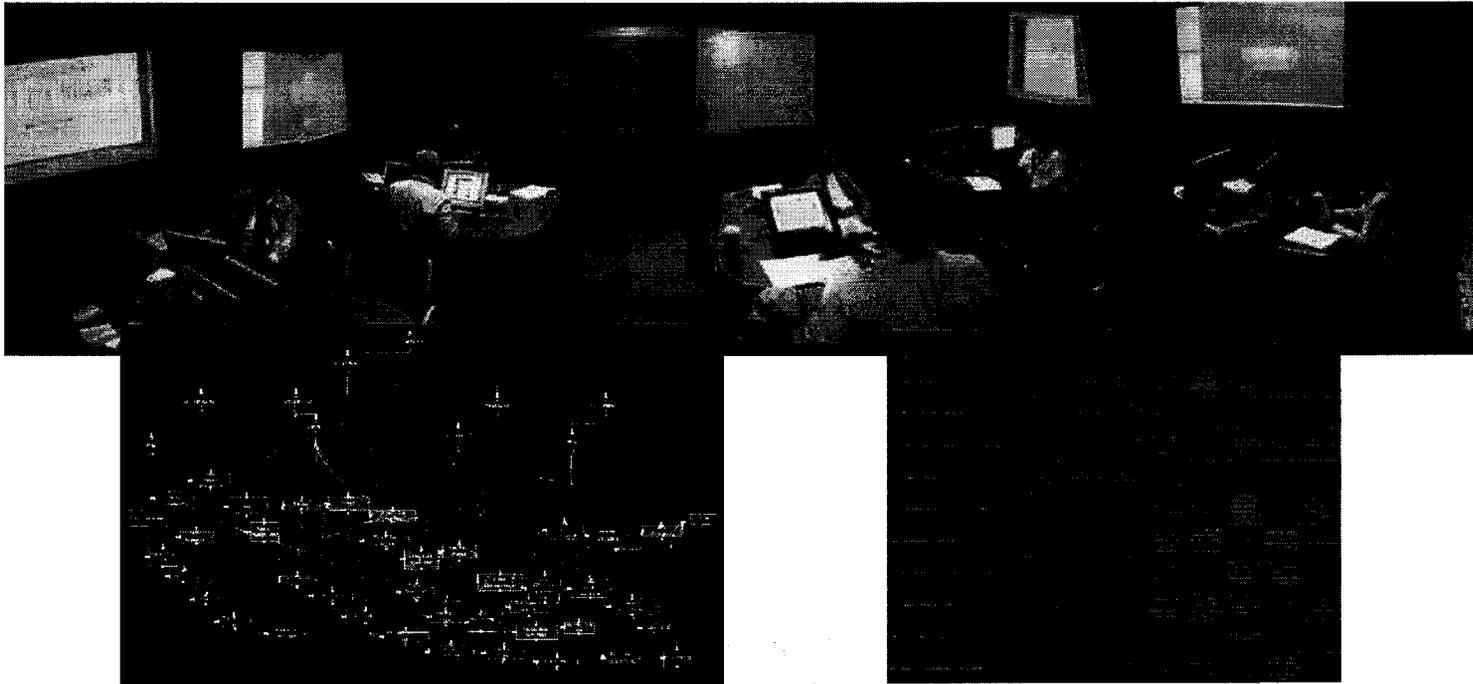
Evaluate CFD and 3D Immersive Tools For use in a Real-Time Concurrent Design Environments

Evaluation and Recommendation Completed

People, Tools, Process Dynamics

Creative Collaboration and Transactive Memory

Investigator Ben Shaw (Royal College of Art, London)
Co-Investigator Monique Lambert (Stanford)



Objective

Create insight into the people, process, and tools dynamics to improve the design/development process.

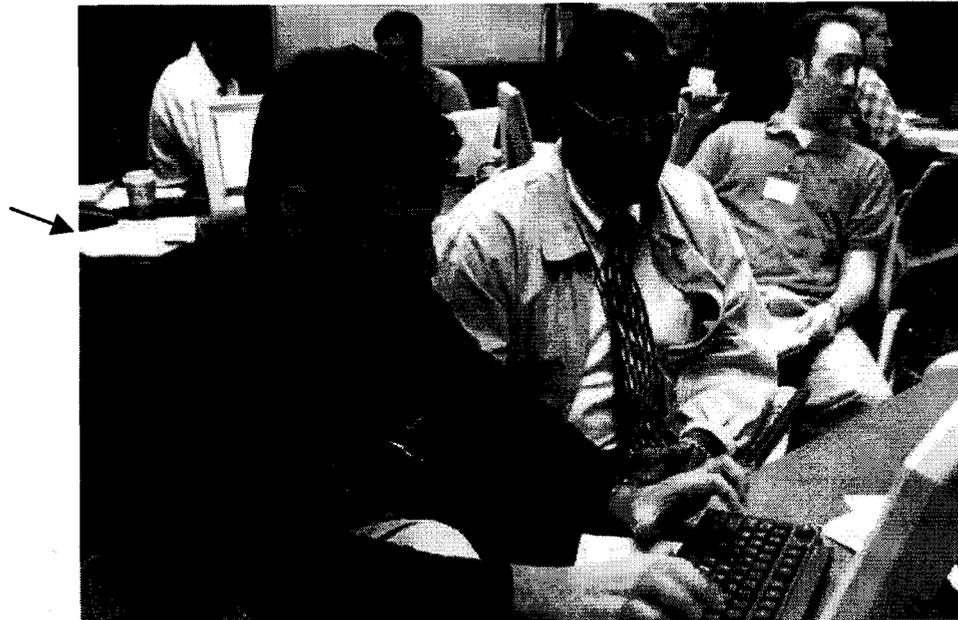
Observational Studies Complete. Results Analysis in Progress

Training/Curriculum Development

1. Concurrent Design Exercise

Let people from Cross-Centers experience working together as a team in a concurrent design environment, utilizing the concurrent design approach, including higher-end tools for develop a specific technology/project/mission.

- Relevant topics to be selected by Programs, Centers, or Enterprises.
- Such an experience possible at a Selected Design Centers: 5-7 days
- Process and Tools Training
- Learn to Live in a Concurrent Design Environment**
- Members and Leaders Training
- History: SURF, University of Michigan (Mars Program)

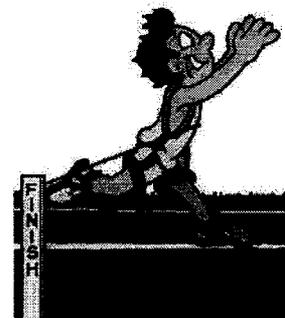
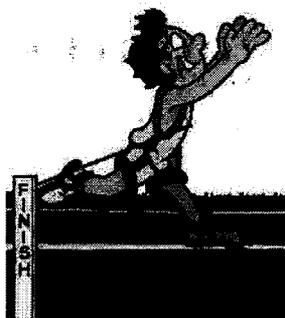
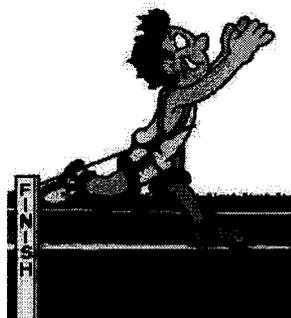
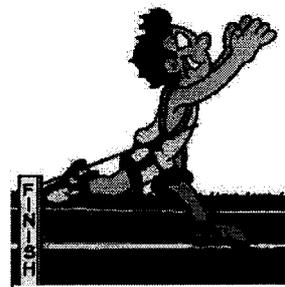
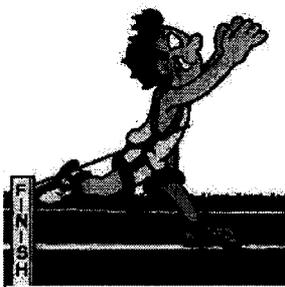
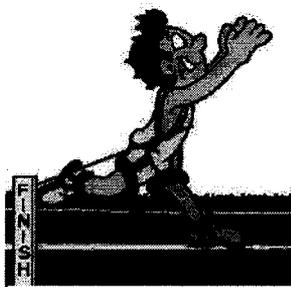


MSR Study, University of Michigan, April 1-5, 2002
Week Training and Problem Solving

Future Directions

- Develop An Art to Part Design Process for space vehicles (Concept to Hardware)
- Better Utilization of COTS tools in the Analysis, Design, and Simulation Areas
- Better Utilization of STEP
- Use of HPC (supercomputers, parallel computing systems)
 - CFD, Thermal, Structural)
- Utilization of Concurrent Design Teams **throughout the Design Process**, and throughout the **Organization**
- Define, train, and set up of new **Design Teams** (JPL, NASA centers [MSFC, LaRC, NARC,], NASDA, **industry**, and academia [Stanford, MIT, University of Michigan])
- Develop a Weeklong Concurrent Design Training Class for NASA Engineers (NASA Code FT)
- Set up **Workshops** to Bring Focus on New Design Paradigms (<http://nsd2001.jpl.nasa.gov>)
- Develop **Working Relationships with Academic Organizations**/Initiate Research
 - Caltech (SURF, on-going)
 - International Space University (ISU)
 - MIT, Stanford, University of Irvine California, Pasadena Art Center, University of Southern California (TBD)
 - University of Michigan (April 2002)
- Port Concurrent Design Approaches to New Sectors

Create Happy Winners!





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TITLE Utilization of Integrated High-End Analysis and Design Tools in Real-Time Concurrent Design Environments	OTHER AUTHORS	<input type="checkbox"/> Premeeting publication <input checked="" type="checkbox"/> Publication on meeting day <input type="checkbox"/> Postmeeting publication <input type="checkbox"/> Poster session <input type="checkbox"/> Handouts
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KEY WORDS FOR INDEXING (Separate items with commas)
Concurrent design, systems, concept-to-hardware

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