The NPDT

Designing the Next generation Design Process

Presented
by
Dr. Knut I. Oxnevad

at
the CSMISS IT Symposium 2002

Cross-Cutting Themes
Session

Jet Propulsion Laboratory
California Institute of Technology

November 4, 2002

CSMISS

Pasadena, CA, November 4, 2002

1. Basics
2. Building Blocks
3. General Principles
4. Steps
5. Successes
6. To the Next Level: Research
7. 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.

The NPOT

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

Concurrent Design Laboratories - CDL

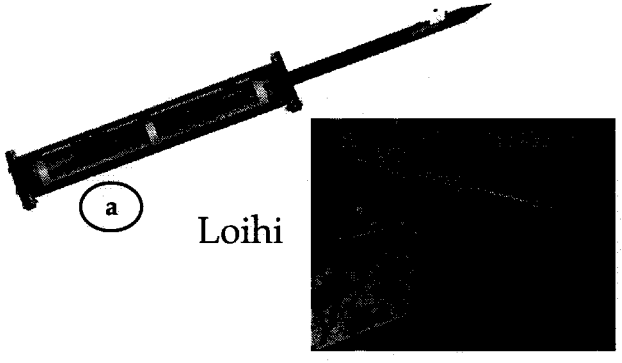
Stanford University, CA

Old Dominion University, VA

The NPDT

Track Record...

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



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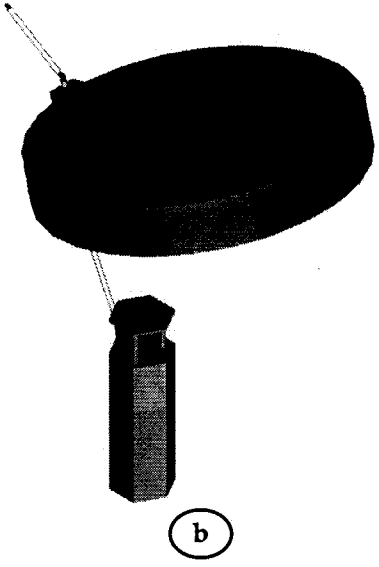
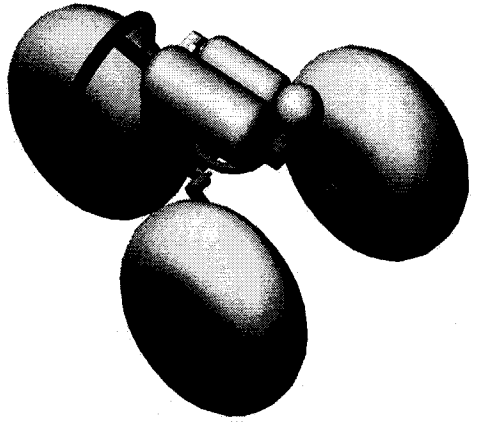


b

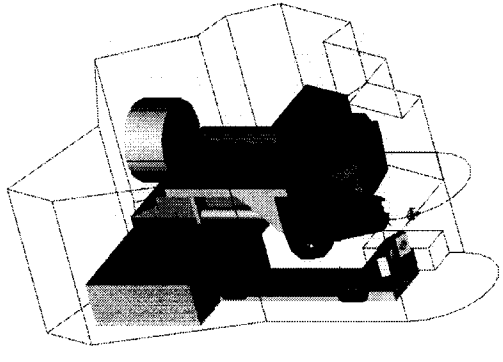
IIP/OSIRIS

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



Mars Outpost Rover

The Next generation Project Development Team (NPDT) Family: <u>Team I and Mars Surface Mobility Study (MSMS) Team</u>



DS (ST)-4/CIRCLE

Design Maturity Improvements: <10 Time Compression: <4

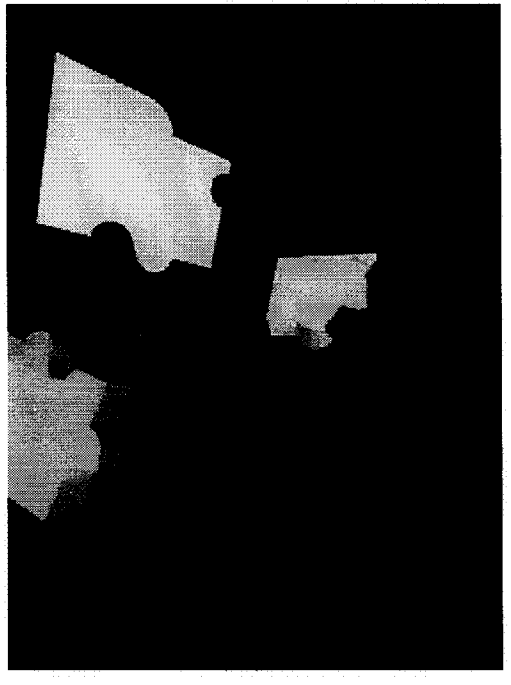
© CDL

The NPOESS

The Driver

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.***

----- *Knut I. Oxnevad*



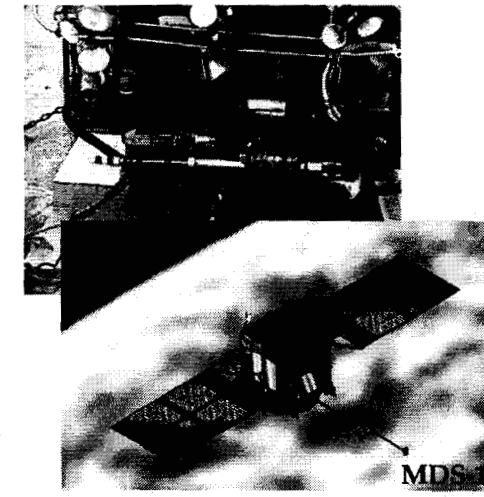
We must ***find*** *entirely* ***new ways*** *to achieve our objectives* ------ *Sean O'Keefe*

Goal!

Concept

Compressed Design Cycle & Improved Quality

Space System (HW/SW)



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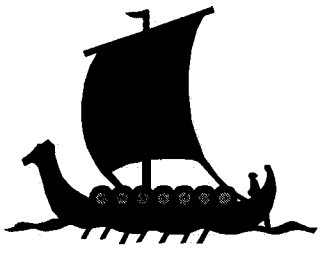
The NPDT

A Historical Perspective



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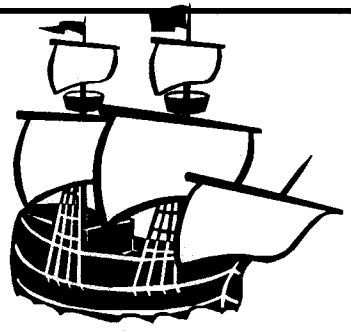

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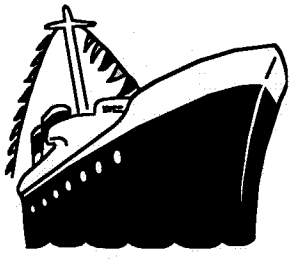

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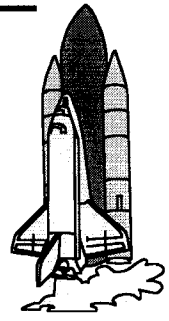
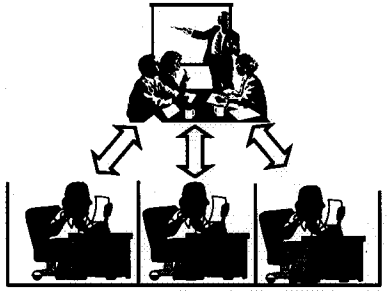
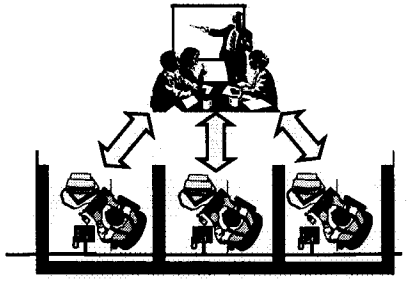
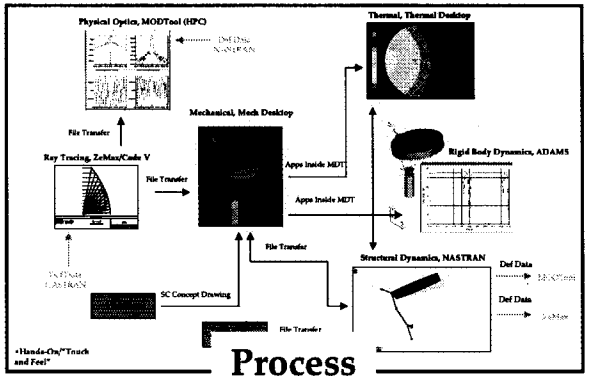


1995

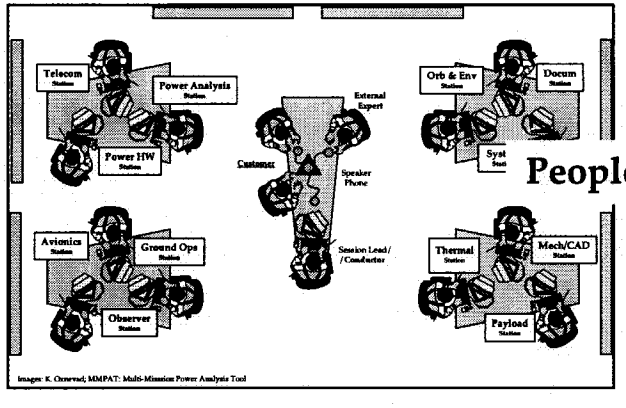
Design Complexity	**Low**	**Medium**	**High**	**Very High**
Basis for Design Decisions	**Experience**	**Experience (H) Computations (L)**	**Experience (L) Computations (H)**	**Experience (VL) Computations (VH)**
Design Collaboration				
Design and Analysis Approach	•Real Time •Working Design Session- •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

The Building Blocks



Process



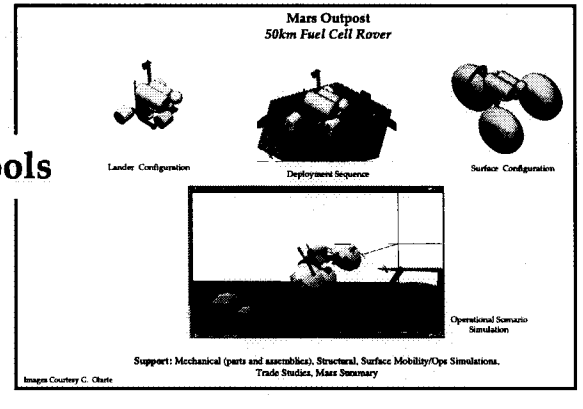
People

Real-Time

Concurrency

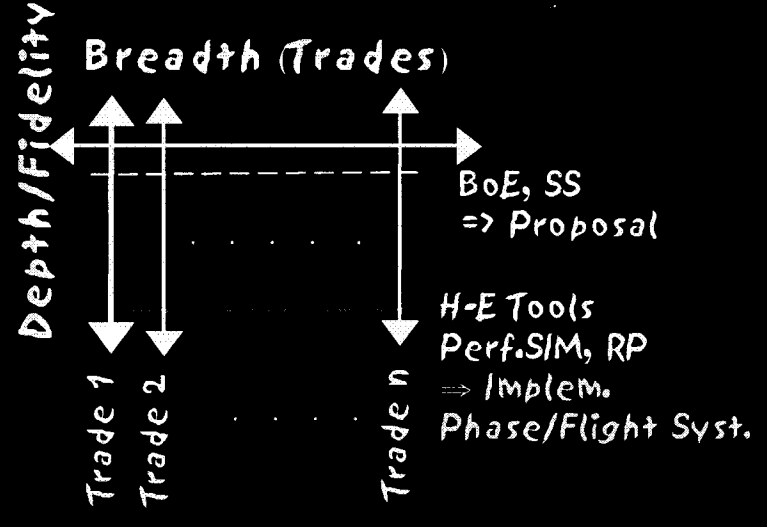
Analysis, Design, Sim.

Tools



PPT-Model

The NPDT "The Eight Principles of Concurrent Design"



(1) Analysis and design activities are performed by a **MULTI-DISCIPLINARY** design team

(2) Design team members work together in **CONCURRENT SESSIONS**

(3) "Customers" and team members participate in the concurrent sessions

(4) Analyses and design activities take place in a **CONCURRENT, AND NEAR REAL-TIME** fashion

(5) **INTER-LINKED HIGH-END COMPUTER TOOLS** are utilized in the concurrent sessions by the team members

(6) These high-end computer tools are used **FROM THE EARLY PARTS OF THE DESIGN CYCLE**

(7) **COMMON** geometrical **DATA** (CAD) is **SHARED** electronically **BETWEEN** the **TOOLS**

(8) CAD, structural, thermal, and optics data can be **IMPORTED** and **EXPORTED** to and from the design team.

EUSEC 2000

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The NPDT

The Steps...

Related

ISU SSP

"8 Principles of CD" (EUSEC2000)

MSFC CDE

NASDA

Stanford

UoM

John Deere

Team I -> NPDT

Team I -> Div 38

MSMS Team Set Up

SURF (LATIS)

SURF (MEGA)

NRO/DARPA

R &D

Optical
Mech
Thermal
Syst
Cost

Structural

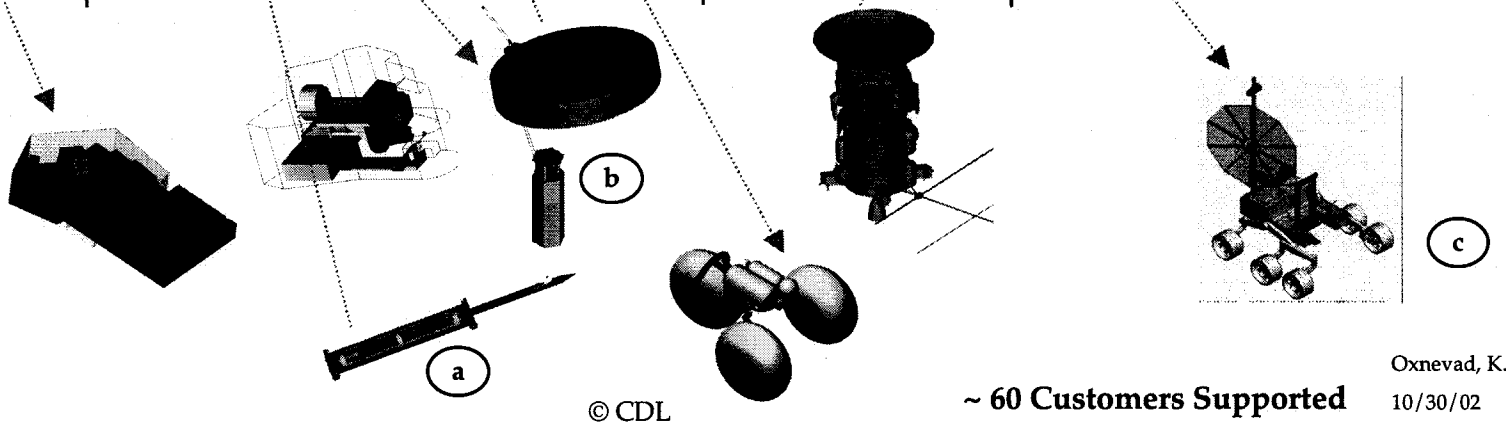
Simulation
End-End Syst
Imp/Exp Ext Files
Super Computer

Radiation
Calculations

Power Sim
Telecom
Avionics
Ground Systems

1997 | 1998 (5) | 1999 (12) | 2000 (28) | 2001 (2 +) | 2002 (?)

Customer Support



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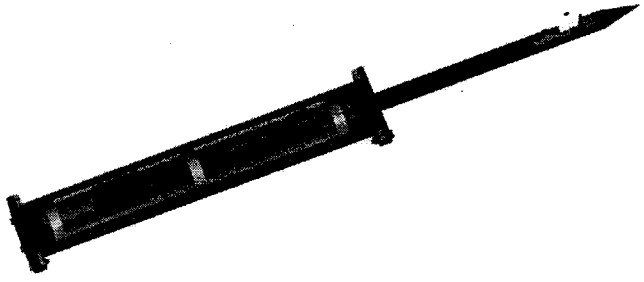
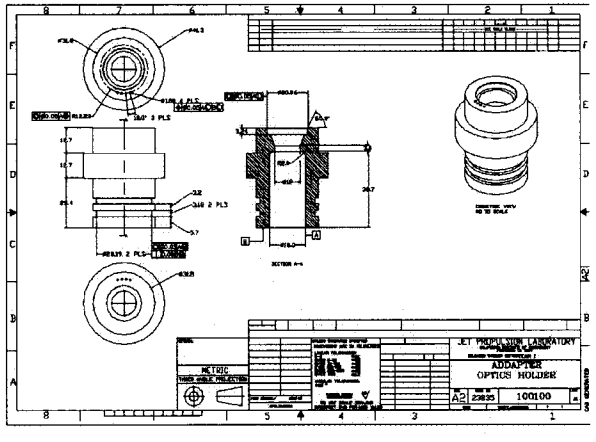
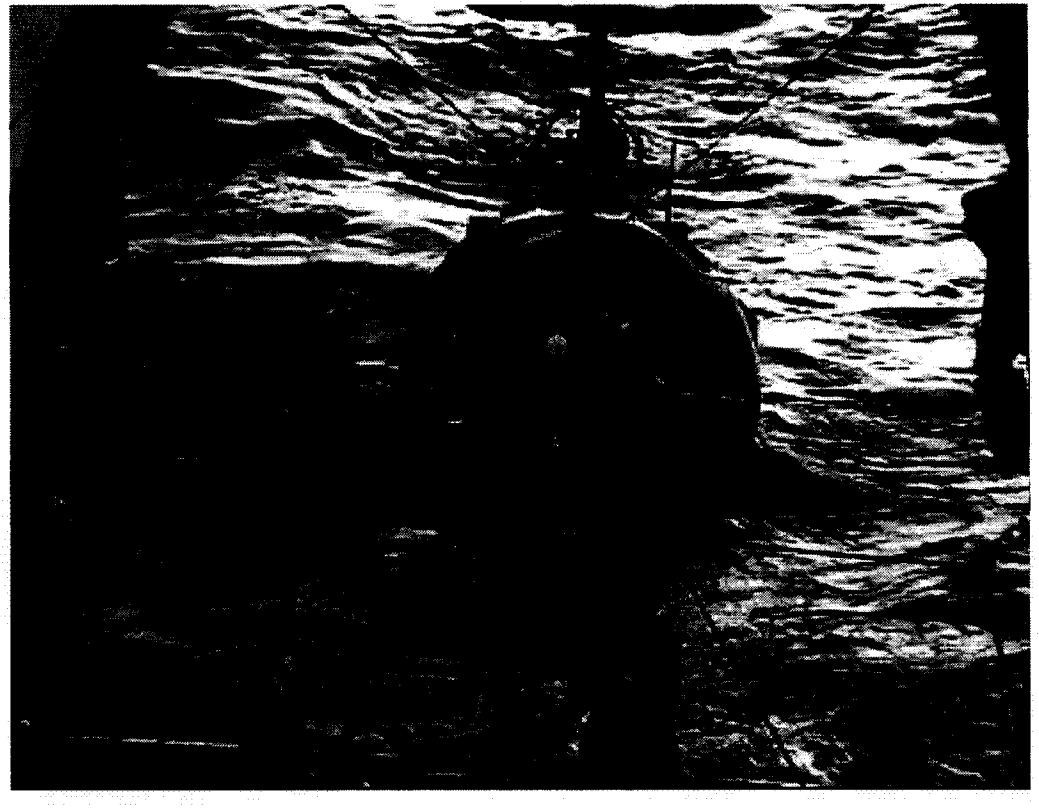
~ 60 Customers Supported

Concept -> Eng Drawing Qual in 3 Weeks

Intergrated: Opt, Mech, Struct







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

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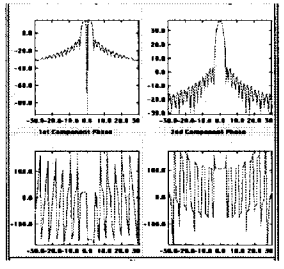
Images Courtesy G. Olarte & G. French

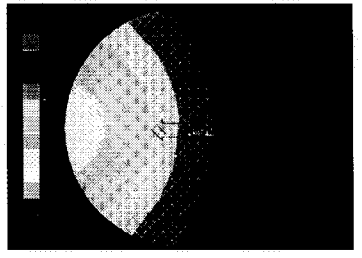
Integrated, High-End Analysis and Design

Physical Optics, MODTool (HPC)

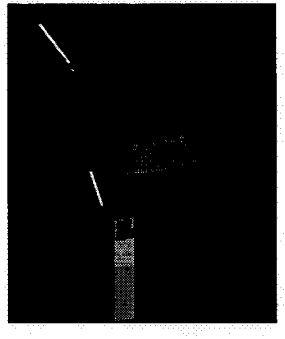


Def Data
NASTRAN

Thermal, Thermal Desktop

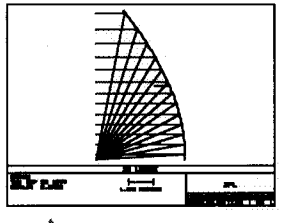


Mechanical, Mech Desktop



File Transfer

Ray Tracing, ZeMax/Code V

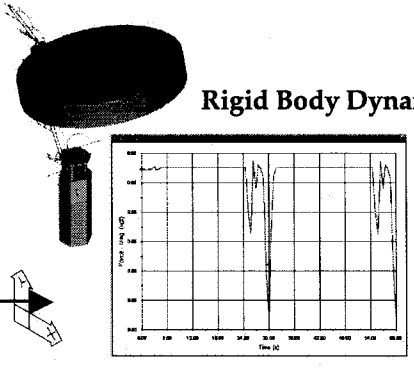


File Transfer

Apps Inside MDT

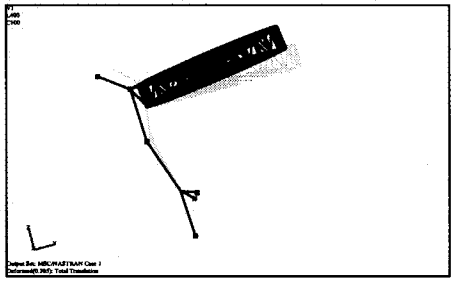
Apps Inside MDT

Rigid Body Dynamics, ADAMS



File Transfer

Structural Dynamics, NASTRAN



Def Data
NASTRAN

SC Concept Drawing

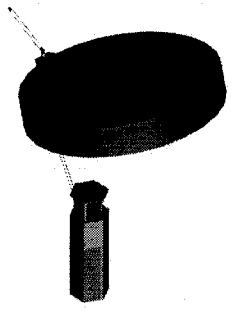
File Transfer

Def Data → MODTool

Def Data → ZeMax

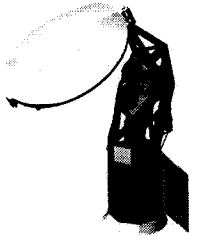
•Hands-On/"Touch and Feel"

OSIRIS -> AQUARIUS and HYDROS
Genealogical Path



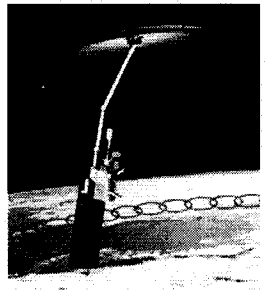
OSIRIS/IIP
(SPIN/2)
Taurus 2210/SA 200 HP

OSSM/ESSP
STATIC/3
Taurus 2210/SA 200 HP



AQUARIUS/ESSP
(STATIC/3)
Delta II 7320/ CONAE SAC A-C

NEXT



HYDROS/ESSP
(SPIN/1)
Taurus 2210/SA 200 HP

(b) ·····> **NDPT/(TD): Data, Geometries, Analysis Results (DGAR)**

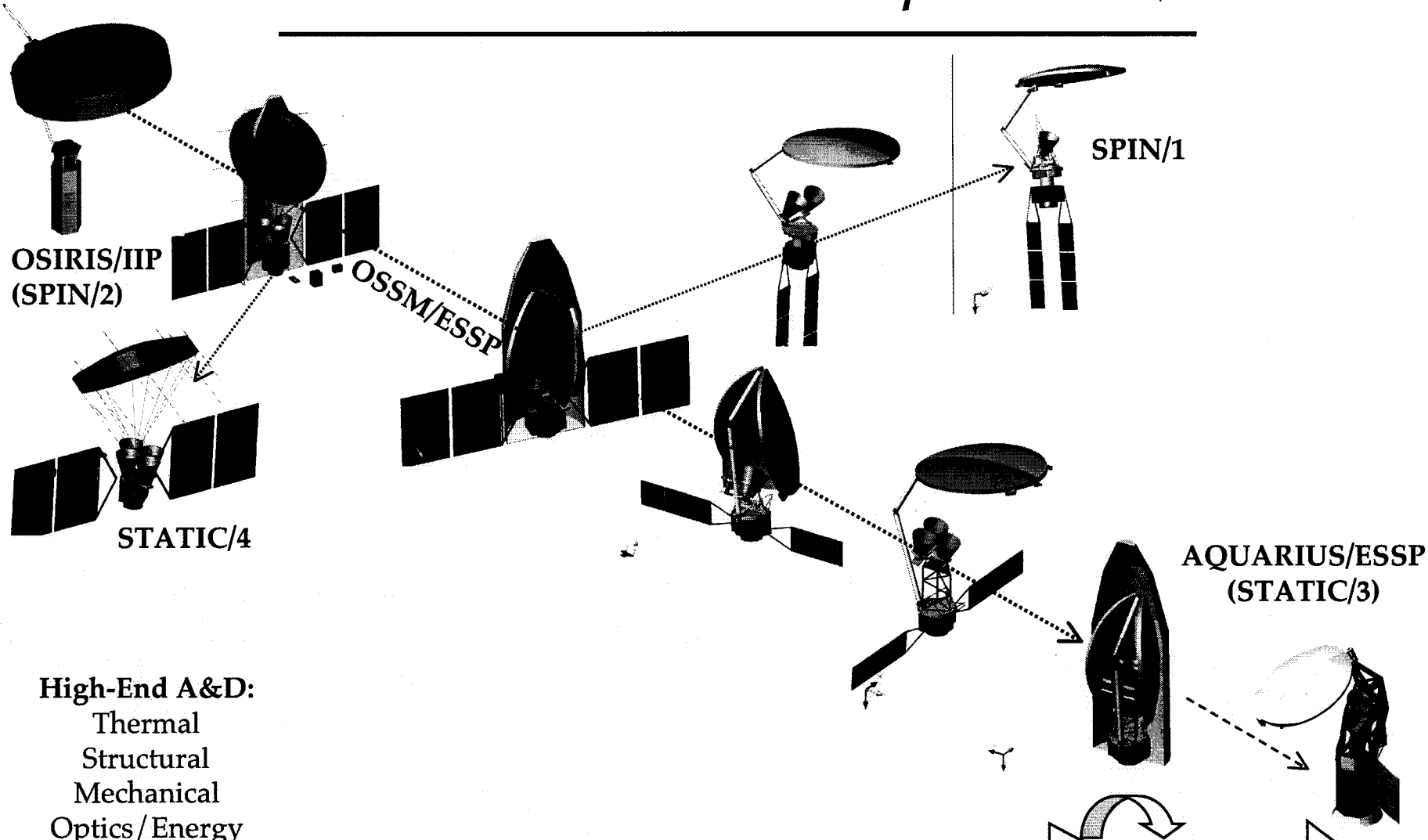
------> **TD: (DGAR)**

SA: Spectrum Astro
SAC A-C: Satélite de Applications Cientficas A -C
CONAE: Comisión Nacional De Actividades Espaciale de Argentina or the National Commission On Space Activities of Argentina
OSIRIS: Ocean-salinity Soil-moisture Integrated Radiometer-radar Imaging System

Images Courtesy G. Olarte & ESSP/HYDROS URL & S. Yueh

© CDL

OSIRIS to AQUARIUS
Breadth and Depth



High-End A&D:
Thermal
Structural
Mechanical
Optics/Energy
Sizing & Configurations
Manufac/Materials/Test

NPDT/(TD): Data, Geometries, Analysis Results (DGAR)

TD:~(DGAR)

Images Courtesy G. Olarte & Simon Yueh

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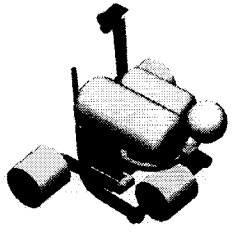
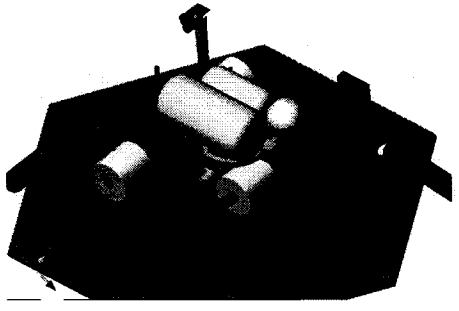
Sizing, Configuration, and Simulation

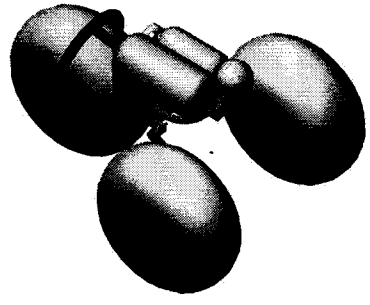
Mars Outpost
50km Fuel Cell Rover



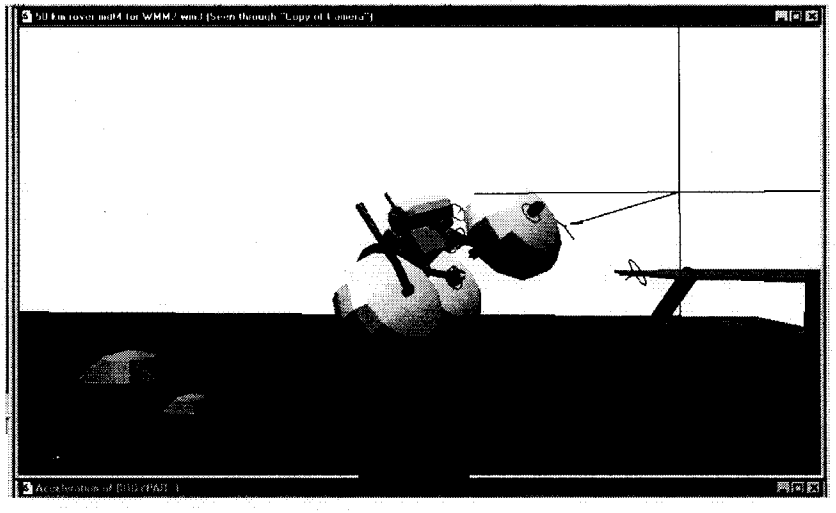
Lander Configuration



Deployment Sequence



Surface Configuration

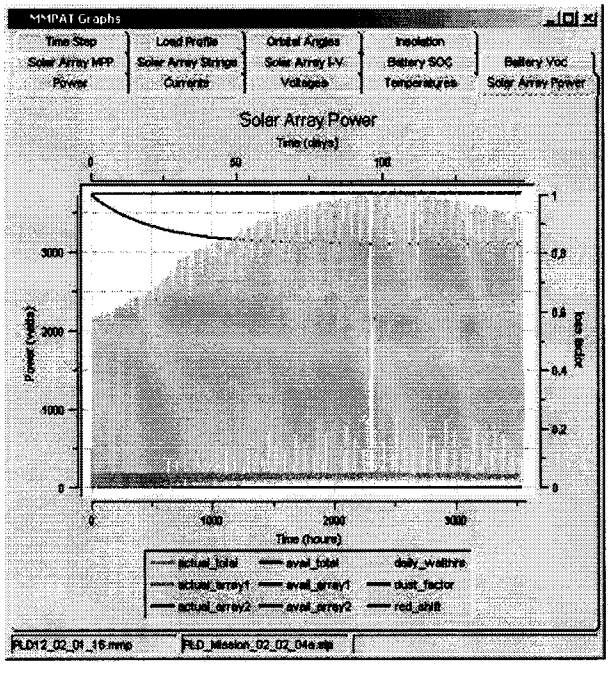


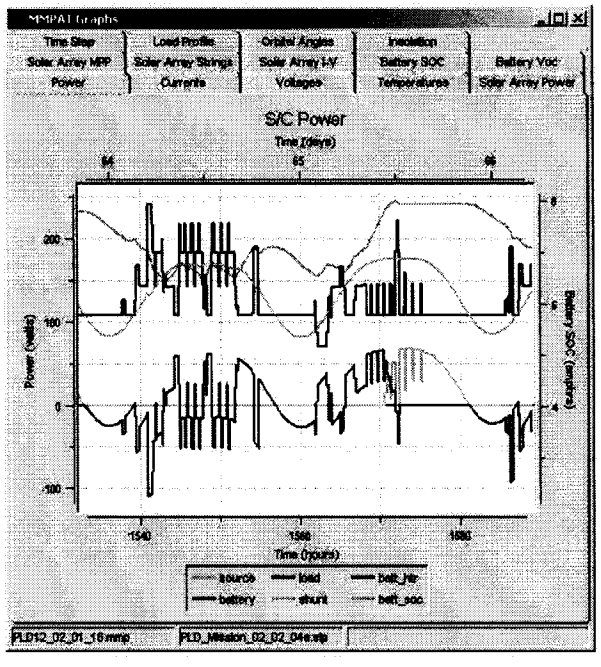
Operational Scenario Simulation

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

Images Courtesy G. Olarte

Power Analysis/Simulation Tool
Multi-Mission Power Analysis Tool (MMPAT)





JPL's Multi-Mission Power Analysis Tool (MMPAT) 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

Images Courtesy Erik Wood

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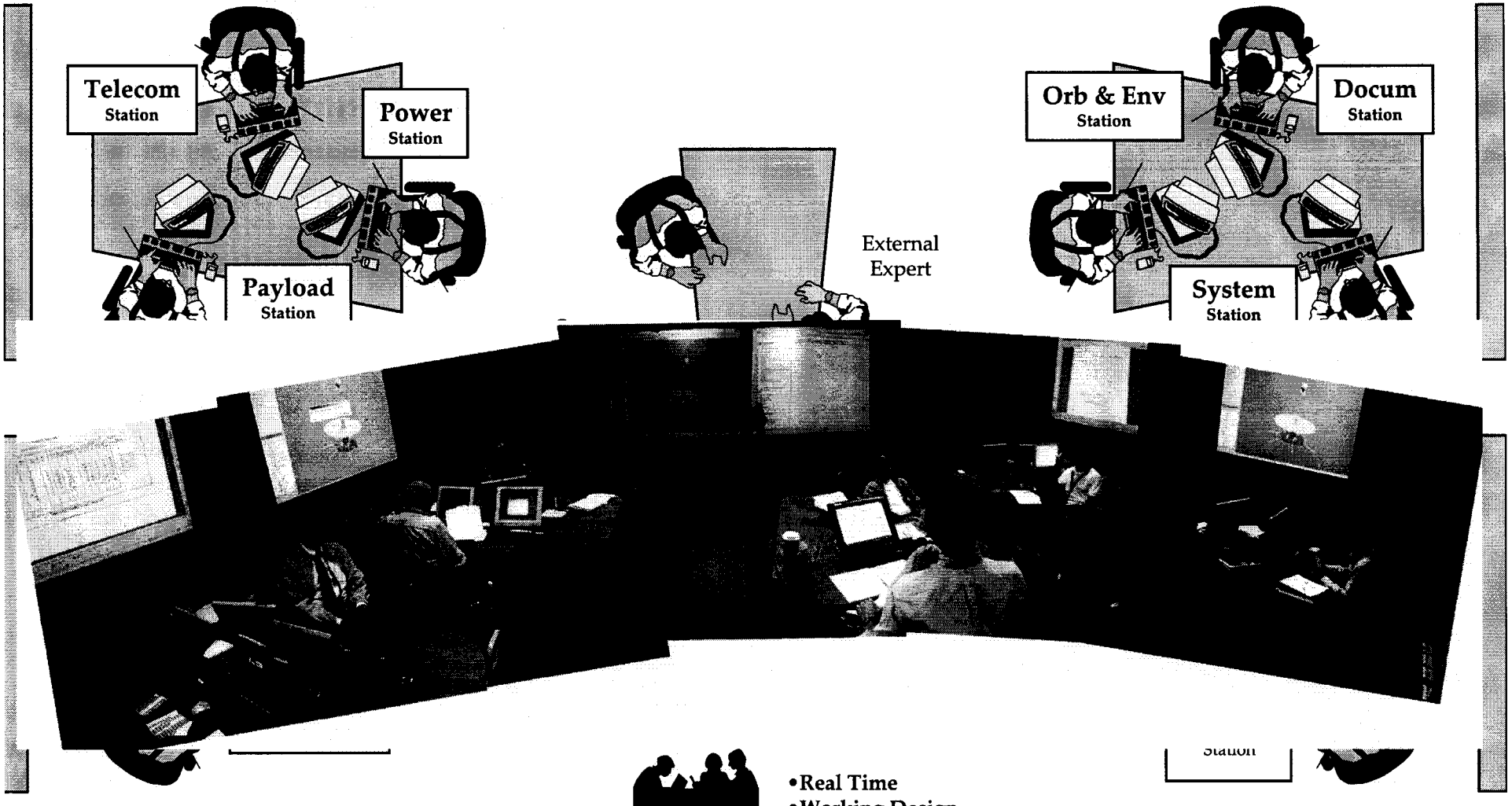
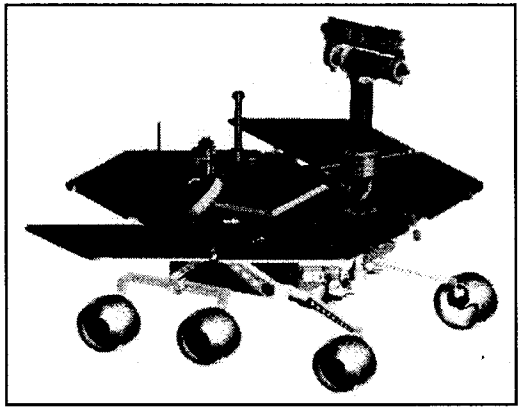
The Mars Surface Mobility Study (MSMS) Team



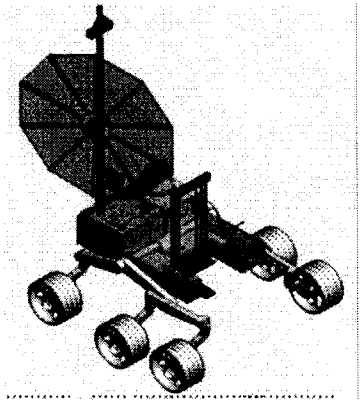
- Real Time
- Working Design Session

Photo, Courtesy Ben Shaw

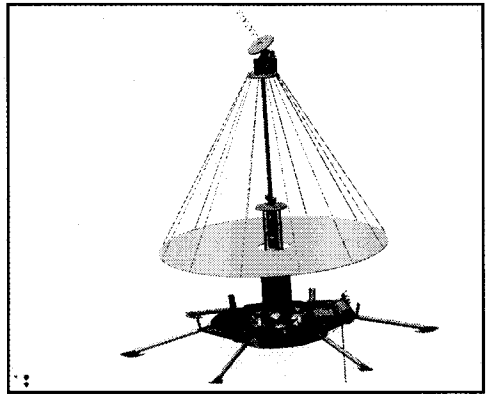
Mars Surface Mobility Studies
Mars Advanced Studies



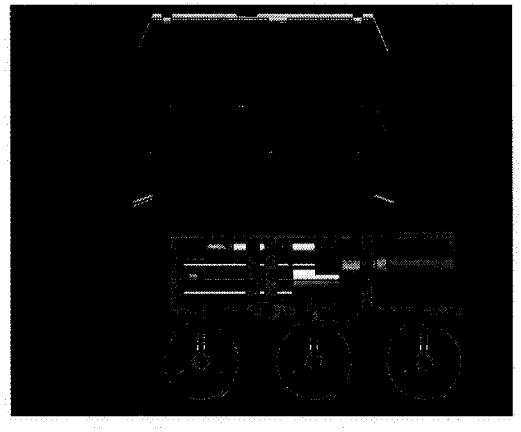
Volcanology, MER Derivative



Polar Layer Deposit (PLD)



Fission Powered Polar Based Cryobot Lander Mission



Fission Powered Rover Mission

JPL, DoE, Los Alamos, Sandia

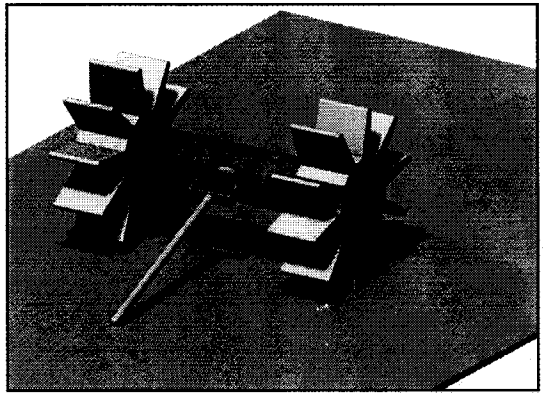
Images Courtesy Hovik Nazaryan and Guillermo Olarte

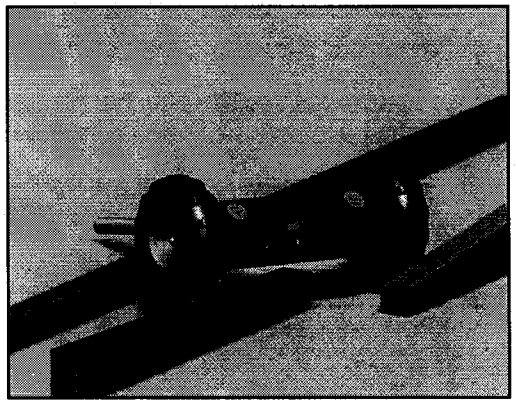
The NPDT

The Next Level: Research

Simulation/Virtual Testing

The Axel Robot

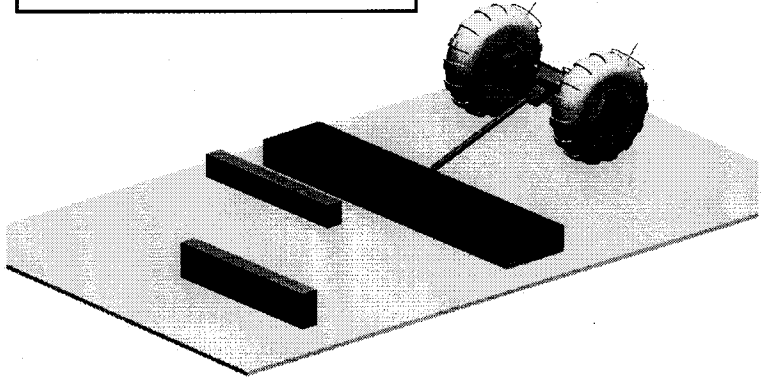




Trades

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

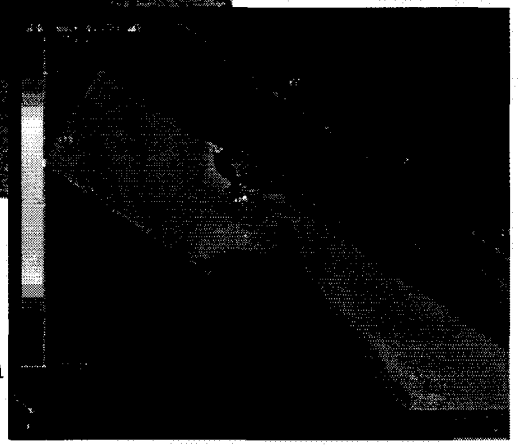
Tools Used
Inventor
and visualNASTRAN



Images Courtesy Hovik Nazaryan and Guillermo Olarte; and Axel Robots: D. Helmick, A. Howard, B. Werger, R. Christian, P. Stewart, and I. Nesnas

CFD and Immersive 3D COTS Tools

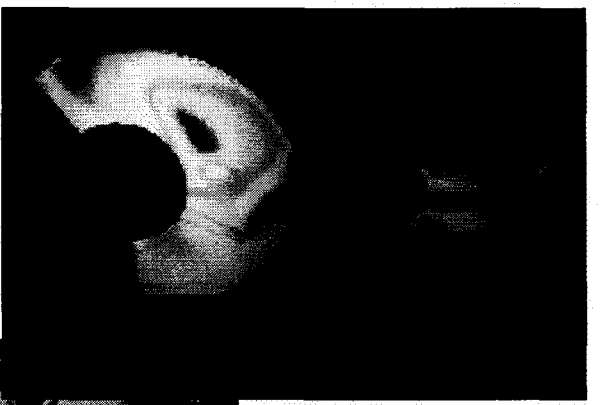
Closeup Meshed probe - CFdesign

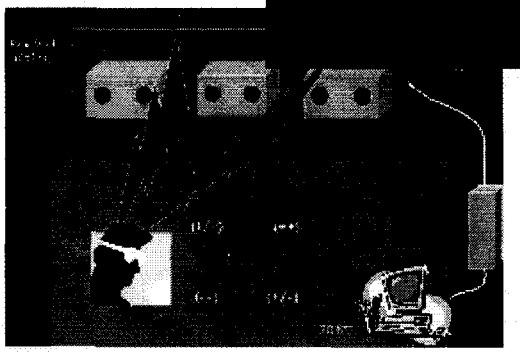


Sample temperature distribution - CFdesign

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

Immersive FEA design and analysis





IR coverage quality

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

Courtesy, Dr. Tibor Balint and Yves Rubin, 2002

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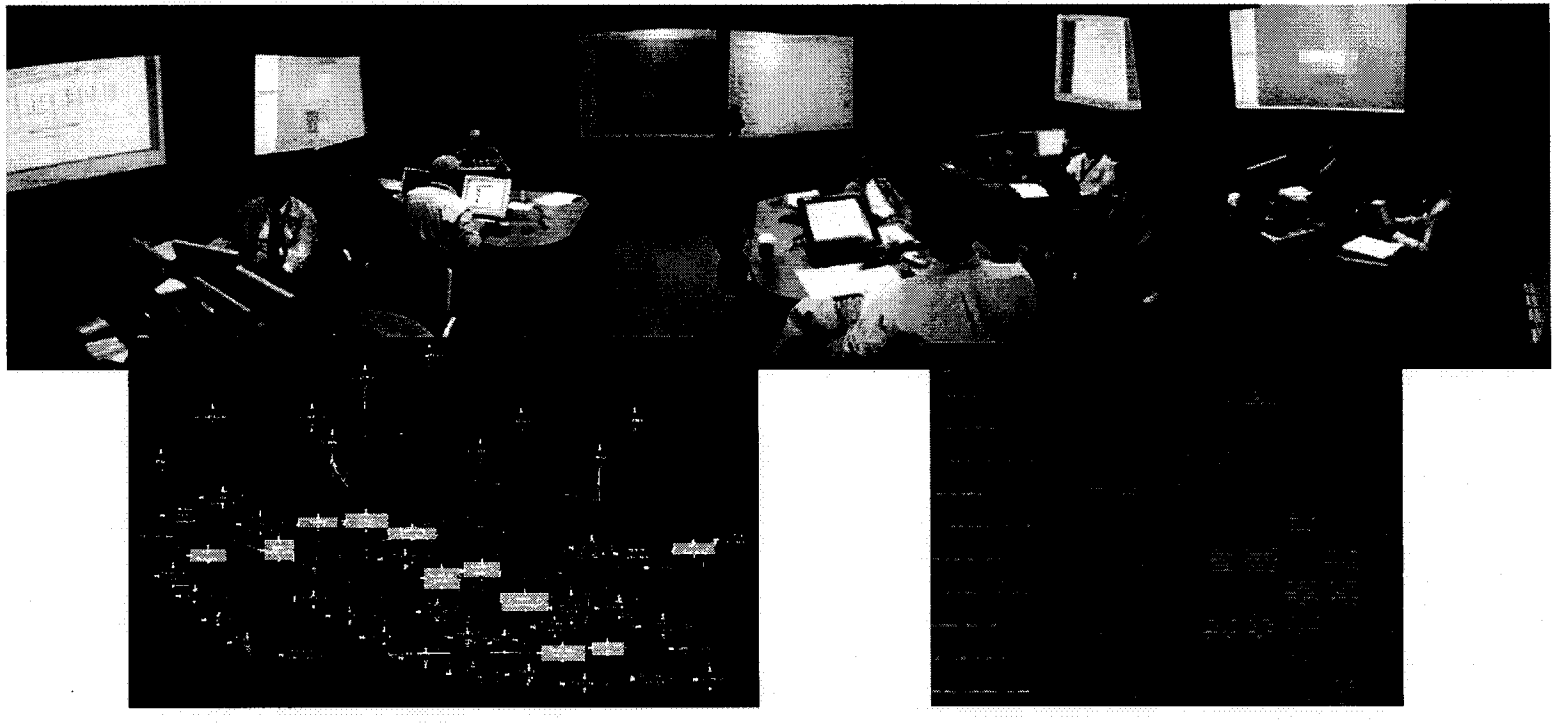
The NPDT

People, Tools, Process Dynamics

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

Images Courtesy, Ben Shaw, 2002

The NPDT

Future Directions

- **"The 3 Weeks by 3 Month Micro SC"** (Concept to Prototype (3 weeks) and Concept to Flight Ready System (3 months) Funded by NRO and DARPA

- **New Design Paradigms** Series of **Workshops** (http://newdesignparadigms.jpl.nasa.gov)

- Define, train, and **set up of new Design Teams** at **JPL**, and NASA (MSFC, LaRC), NASDA, **industry**, and University of Michigan])

- Develop a **Weeklong Concurrent Design Training Class** for NASA Engineers (NASA Code FT)

- **Integrate new JPL developed tools** such as Multi-Mission Telcom Analysis Tool (MMTAT), Mission Survivability Tool (MIST) into the Concurrent Design Process

- Utilization of Concurrent Design Teams **throughout** the **Design Process**, and throughout the **Organization**

Integration and **Effective Utilization** of **IT** in the **People, Process**, and **Tools Framework** is **Critical** for "Designing the Next generation Design/Development Process"

.....we are just scratching the surface!