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

Presented
by
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at the
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Interdisciplinary Paper Session
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1. Challenge
2. Meeting the Challenge
3. The NPDT
4. Development Path
5. Capabilities/Research/Training
6. Future Plans

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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...

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

Loihi

IIP/OSIRIS

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

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Goal!

Compressed Design Cycle & Improved Quality

Concept

Space System (HW/SW)

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It's About...

DMT Chart

Concurrent Design Approach

Traditional Approach

$\Delta T$ for Given DM (Factors of 2-3)

Developed by K. I. Oxnevad (JPL) and Monique Lambert (Intel/Stanford)

$\Delta$DM for Given T (Factors of 6-10)

Process

Real-Time

Concurrency

Analysis, Design, Sim.

People

Tools

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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

1000
- Design Complexity: Low
- Basis for Design Decisions: Experience
- Design Collaboration: 

1500
- Design Complexity: Medium
- Basis for Design Decisions: Experience (H)
- Design Collaboration: 

1950
- Design Complexity: High
- Basis for Design Decisions: Computations (L)
- Design Collaboration: 

1995
- Design Complexity: Very High
- Basis for Design Decisions: Experience (VL)
- 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
Working Design Sessions
Concurrent Design
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

- Numerical Analyses
- Spreadsheet Based
- Mass, Power, and Cost Summaries
In A Nut Shell

• 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
The Steps...
Integrated, High-End Analysis and Design

Physical Optics, MODTool (HPC)

File Transfer
Ray Tracing, ZeMax/Code V

File Transfer

Def Data
NASTRAN

Mechanical, Mech Desktop

File Transfer

Rigid Body Dynamics, ADAMS

Structural Dynamics, NASTRAN

SC Concept Drawing

Hands-On/"Touch and Feel"

Thermal, Thermal Desktop

Def Data
MODTool

Def Data
ZeMax

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Aquarius
Early Version
Sizing, Configuration, and Simulation

Mars Outpost
50km Fuel Cell Rover

Lander Configuration
Deployment Sequence
Surface Configuration

SURF 2001 Rover
(MSMS Rover Team)

Operational Scenario Simulation

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

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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

Images Courtesy Hovik Nazaryan and Guillermo Olarte

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The Mars Surface Mobility Study (MSMS)
Team
Simulation/Virtual Testing

**Trades**
- Wheel Diameter
- Castor length
- Wheel Base
- Wheel plus rim
- Castor Mass
- Axelrod Mass
- Axel Mass

**Tools Used**
- Inventor
- visualNASTRAN

Images Courtesy Hovik Nazaryan and Guillermo Olarte

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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**

**Objective**

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

**Evaluation and Recommendation Completed**

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

Sample temperature distribution - CFdesign

Closeup Meshed probe - CFdesign

Immersive FEA design and analysis

IR coverage quality

Courtesy, Dr. Tibor Balint and Yves Rubin, 2002
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

Images Courtesy, Ben Shaw, 2002
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)
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!
JPL

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