Requirements for a CAE Data Model

Design/Simulation Integration Workshop

Collaborative Product Development Associates, LLC

March 15th, 2006

Atlanta, Georgia

Clark Briggs
Jet Propulsion Laboratory

Jim Stuckey
General Motors Powertrain

UGS Aerospace Special Interest Group Organization

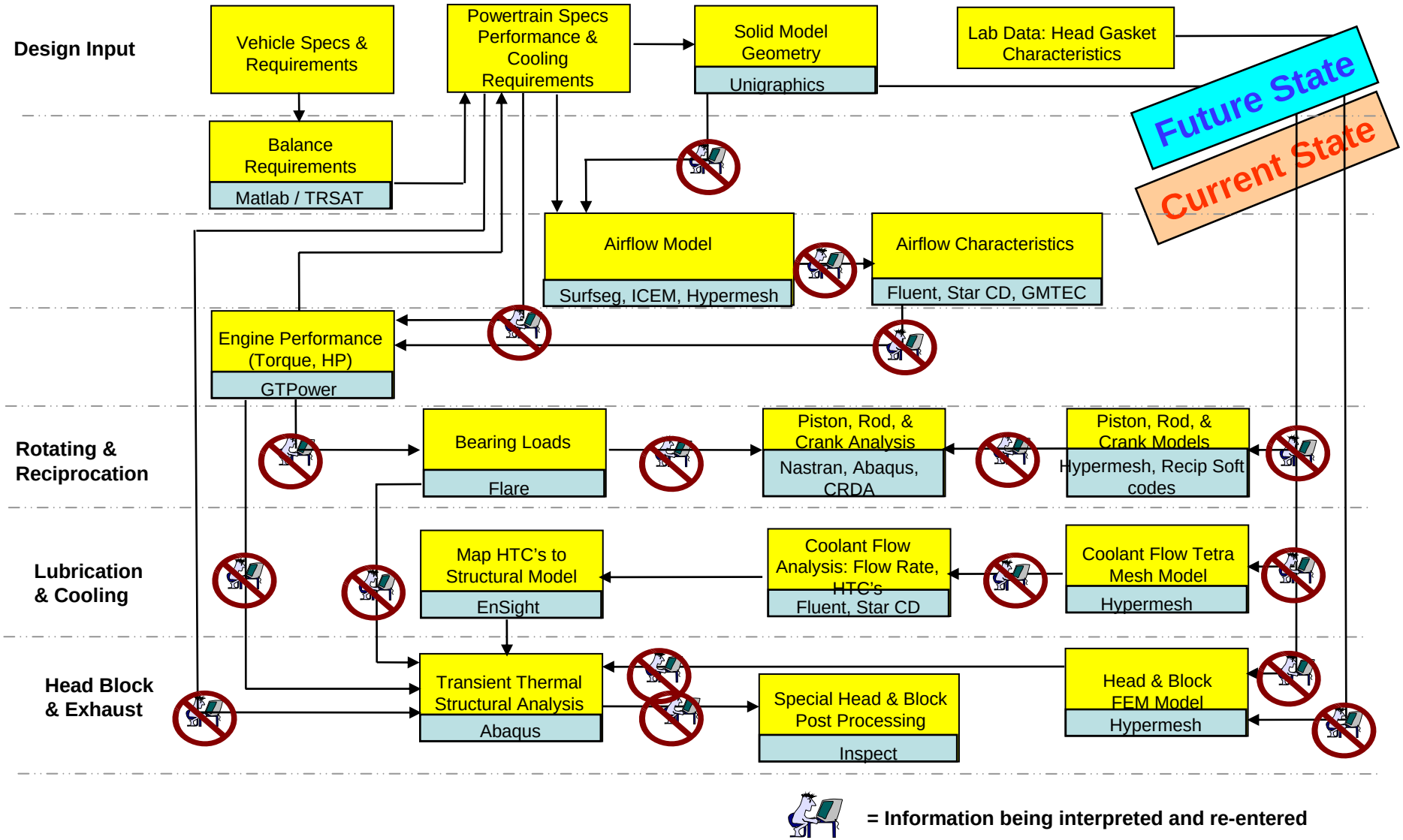
The UGS/ASIG organization is a successful example of a software vendor company working closely with its customers on a regular basis in the joint development of UGS products. The ASIG began operation in March 1993 at the request of four aerospace companies who were UGS customers: Boeing, GE Aircraft Engines, Northrop-Grumman, and Pratt & Whitney. The ASIG meets at least three times per year to report on deployment and development projects and to advise UGS on product development directions. The objectives of the ASIG organization are specifically to :

- Provide a unified set of prioritized product and process level aerospace requirements that influence the UGS activities
- Provide feedback to UGS on their UG product direction
- Provide an opportunity for members to share product development, support processes and techniques
- Provide a forum for aerospace customers, prime contractors and subcontractors to explore approaches to exchange UG product definition data

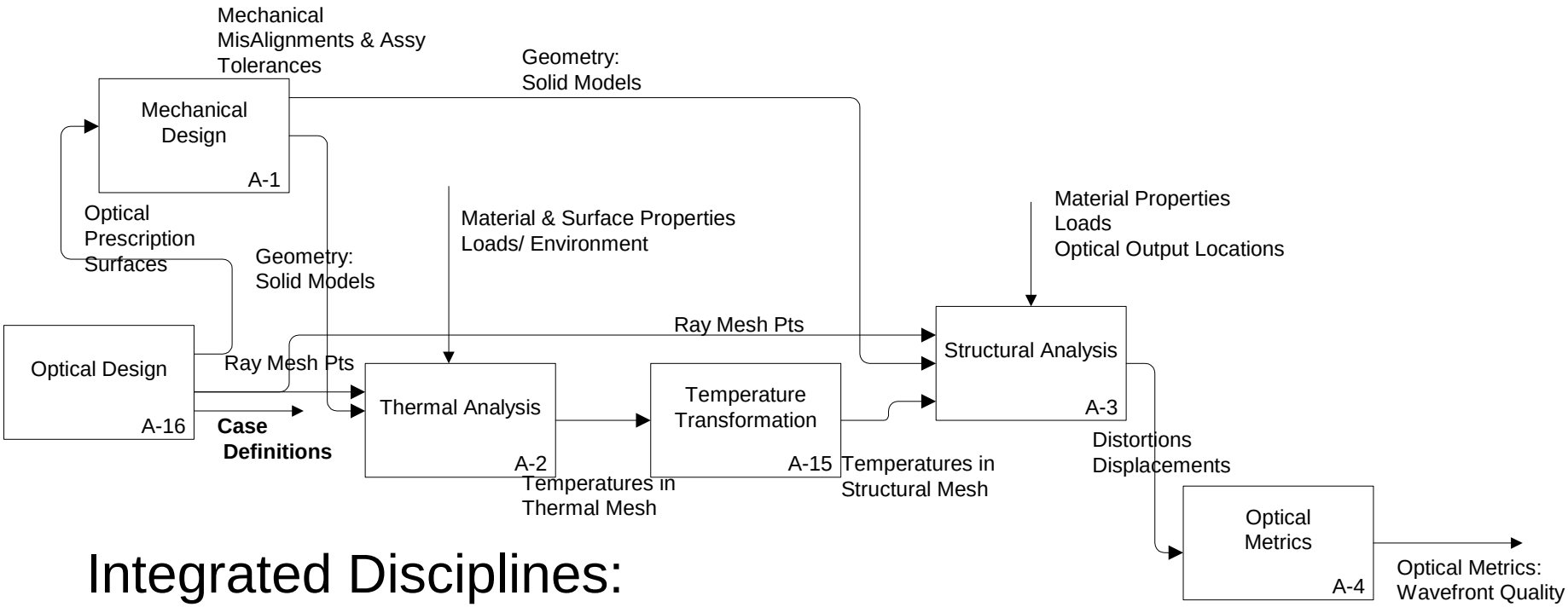
Current ASIG Membership

Represents approximately 25,000 UGS NX/iDEAS licenses and 120,000 Teamcenter (Metaphase/Enterprise/Engineering) licenses

GMPT CAE Workflow



JPL Integrated Modeling Process



Integrated Disciplines:

- Design, Structural Analysis, Thermal Analysis, Optics

Detailed Design Phase Capabilities

- Large Models
- Configuration Control

CAE Data Management Requirements

1. Capacity and Performance
2. Accessibility
3. Object Retention
4. Security
5. Bill of Analysis (BoA)
6. Application Integration
7. Data Query
8. Meta Data
9. Change Management
10. Legacy Data Base Access
11. Report Generation
12. Interface
13. Assembly and Transformation
14. Non-Colocated Teams

Issues

- Finding data required for an analysis is very difficult and time consuming, often resulting in rework of data that cannot be efficiently located.
- Determining data pedigree is difficult—if not impossible—due to the multiple input sources and assumptions involved
- Data handoffs between design organizations are often unstandardized, point-to-point transactions between two or more individuals and prone to human error.
- Data handoffs with external partners, contractors, and global locations can involve a host of manual steps and data synchronization is difficult.
- As data evolves during the concurrent design/analysis processes, additional complexity is added when updated data sets need to be synchronized. Updates require human intervention and are not guaranteed to be in sync with the latest data revisions available.
- Formatting and transforming results from an analysis into inputs for a downstream analysis can be very laborious. See “GMPT CAE Workflow” earlier.

1. Capacity and Performance

1. Scalable to accommodate increasing analysis capabilities and large data sets
2. Peak number of concurrent users: ~100
   - Global GMPT is estimated to range between 100 and 150.
3. Total user population: ~250 users and is globally distributed.
   - GMPT includes US, India, Italy, Germany, Sweden, Australia, France and Japan.
   - JPL includes Australia and Spain.
4. User datasets size from <1 MB to ~9 GB.
   - This is expected to grow proportionally with desktop disk capacity and clock speed.
   - The GMPT total estimated consumption of space for simulation data is estimated at ~10 terabytes per year.

2. Accessibility

1. Data access control based compliance with government export control laws.
   - Designated user citizenship status
2. High availability
   - 24/7 to support Global activities
3. Global and domestic accessibility
   - For company employees, contractors, suppliers and any other designated entities.
4. Access through firewalls
   - Compliant with company IT policies and practices

3. Object Retention

1. Retention schedules
   - Assigned to objects
   - Maintained with user defined operating procedures & policies
2. Users notification of Retention Life Cycle events
   - E.g., expiration of referenced objects
3. Retrievable data format for the lifecycle of the object

4. Security

1. Access control lists (ACL) for individual objects
   - Security policy based assignment by admin and users
2. Specify ACL for groups of objects as well
3. Access to data management tools controlled by security policies.

5. Bill of Analysis (BoA)

1. The BoA defines the configuration for an analysis
   - A structure in the PDM system
   - Collects the various analysis objects
   - Objects listed in Table 1 following
2. Rapid construction of new BOA
   - Ease of use, e.g. drag and drop objects into the structure
   - Clone structures from one structure to the next derivative
   - Inherit objects by reference and/or by a new copy
   - Rule based reference vs deep copy
3. Hierarchical structure of analyses
   - Supports inclusion of fixtures, devices, jigs, etc
   - Aides in management of complex set ups
4. CAD geometry not required
   - BoA hierarchy construction w/o geometry
   - FEM only BoA
   - After the fact association with CAD geometry

Object Types for BOA

Item Type	Description
CAD (geometry)	This shall be a link to the design (CAD) item consisting of the appropriate context model.
Discrete Domain	A mesh (or grid) definition consisting of nodes and elements (or cells). Multiple representations (e.g. point mass, 2D axi-symmetric, 3D fine, 3D course) may be used to represent the same CAD object. Segregating this as an object will promote reuse for other applications
Loading and Boundary Conditions	Loads and boundary conditions to be applied to the CAE model. This shall be a dataset of files or a reference to an exiting result set from another analysis. It shall contain multiple load sets based on time or varying conditions.
Material	References to a proprietary database containing material properties or a dataset of material property information.
Utility	Specific scripts that need to be retained for reprocessing the analysis.
Results	Results of an analysis. Shall be capable of representing multiple load cases with time varying data.
Report	A summarized view of the data which allows light-weight browsing of the primary output data for an analysis

6. Application Integration

1. Tight integration of key applications
   - Manage application data
   - User author, edit, and review of data
   - Automate data upload/download
2. Large number of the primary applications
   - Simulation at GMPT includes 56 COTS and internal tools.
   - Several aerospace companies list 200 to 400 tools.
3. Support loosely coupled applications
   - Assist in data management & upload/download.
   - Mark the data set as outside PDM control.

7. Data Query

1. Search based on meta-data
   - Use wildcards and popular search engine syntax
2. Advanced search with multiple fields and conditions
3. Search across all meta-data fields for user-specified text
4. Wizard-based query building
5. Stored queries
   - To support user re-use
   - To support delivery of common searches
6. Search exposed internal object data

8. Meta-Data

1. A rich set of meta-data for analysis objects
   - To facilitate queries and filtering
   - Tailored to analysis life cycle and activities
   - E.g. product line, module, type of simulation, description of simulation, etc
2. Meta-data fields can be mandatory or optional
   - Set by an administrator
3. Easily configured attribute lists
4. Free-form fields configurable for spell checking
   - System and user dictionaries
   - To avoid user error
   - To enhance search productivity

9. Change Management

1. Level of completeness and usability status for each revision
   - E.g. work-in-progress, released, preliminary
   - Potential subcycle to revision change
2. Objects associated with referencing BoAs
   - Assist entangled BoA change management
3. Up-to-date status indication
   - E.g. a flag indicating changes in parent objects.
4. Maintain object history
   - Audit support
   - Origin
   - Which users have edited and accessed the data
5. Store and track multiple revisions
6. Notifications on change
   - Dependent or reference object change
7. Comparison methods
   - Visualize differences
   - Navigate changes between revisions
   - Across different BoAs
   - I.e. a function similar to a text file “diff”
8. Integrated validation to ensure the quality of data
   - E.g., mesh quality, error norms
   - Results stored in the system

10. Legacy Database Access

1. Minimize data migration from legacy databases
   - Support links and references
   - Encapsulate data transport
2. Support legacy data migration
   - Include meta-data migration
3. Manage cache of legacy data in PDM

11. Report Generation

1. Template driven report formatting
   - Support quick user review
2. User-defined reporting
   1. Generate and customize report layout and content
   2. High level definition interface
3. Lightweight interface for viewing
   - Graphical results
   - Large tabular results
4. Capture and management
   1. Reports are PDM managed object
   2. Integrated into BoA version and configuration management
5. CAE equivalent of Virtual Mockup.
   - Assembled 3D model view w/ BoA management
   - Lightweight simulation results viewer
   - Common across all applications.
   - Analysis modes such as transient animation and multiple load cases

12. Interface

1. Provide a progress bar indicating operation completion percentage and status information for any non-instantaneous operation (particularly data transfers).
2. Minimize the number of steps required for a user to: store, retrieve, query, browse, approve, and compare data in the system. (Metrics will be tracked on number of steps required for each major task.)
3. Provide command line access from all platforms to enable batch mode operation.
4. Provide a web-based portal interface.
5. Provide an application programming interface (API) to facilitate automation and integration.

13. Assembly and Transformation

1. Maximize interoperability of data
   - Across analysis codes and between code versions
   - I.e. store/access data in a standard format
2. Automate geometric transformations
   - Upon assembly into BoA
   - Avoid manual reorient
   - Handle varying coordinate systems, unit systems, scaling factors, etc.
   - Support user-defined methods for transformations
3. Support field data transfer and mapping
   - Data such as convection coefficients, temperatures, pressures, displacements
   - Across domain analysis tools
   - Between meshes
   - Enable integrated modeling
4. Integrated Visualization
   - Assembled 3D model view
   - Data field visualization

14. Non-Colocated Teams

1. Integrate with PDM design (CAD) support
2. Support Current PDM Architectures
   - Heterogeneous PDM-to-PDM
   - Homogeneous PDM-to-PDM
   - Centralized Single PDM
3. Align with Corporate IT Security
4. Operate over Public Insecure Internet
5. Rule and Policy Based Security and Transfer Automation
6. Object Mapping to Assist with Schema Alignment
7. Automated and User Initiated Transfers
8. Supports Tool-Independent Model & Results Viewer

CAE PDM Value Drivers

- Reuse of Process and Analogous Results
- Configuration Control and Data Management
- Team-Based Analysis
- Audit & Validation

Acknowledgement

This work was performed in part at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.