Use of Ontologies to Support Design Activities

Dr. Oleg Lukibanov
DaimlerChrysler AG
Vehicle Engineering Goal

- To design a vehicle
  - To specifications
    - Marketing
    - Competitive benchmarking
    - Regulations
    - Standards
  - On time
    - Shortened time to market
  - Within budget
Emerging Engineering Process: Catia V5

- Use of Catia V5 features
  - Parameterized connected templates
  - Embedded checks and validations
  - Templates’ reuse
- With the ‘right’ usage strategy parameterized templates speed-up and simplify engineering process
- CV5 templates allow integration of best practices into design process
Emerging Engineering Process Problems

- Digital Vehicle consists of thousands of “smart” templates and millions of associated parameters
- Relations and dependencies among templates are complex
- Complexity of management CV5 templates within design process is not 100% covered with PDM systems
- The question that we want to address is

How do we manage templates.
Problem: Template Management
Design Objects

- TOP_ExhaustSystem
- TOP_Y_PIPE
- TOP_ExhaustResonator
- ...

Product Development
Lifecycle Management
Design Object with Attributes

Top_ExhaustTailPipe

ATTR:
Exhaust_Pipe_WallThickness = 1.8 mm

GeomAttr:
Exhaust_Resonator_A_Exit_Plane = (x, y, z) (x1, y1, z1)
Design Object with Attributes

Top_ExhaustTailPipe
ATTR:
Exhaust_Pipe_WallThickness = 1.8 mm
....
GeomAttr:
Exhaust_Resonator_A_Exit_Plane = (x, y, z) (x1, y1, z1)
...

Design Object with Attributes

Top_ExhaustTailJoint_2Bolt
ATTR:
Exhaust_Pipe_WallThickness = 1.8 mm
....
GeomAttr:
Exhaust_Resonator_A_Exit_Plane = (x, y, z) (x1, y1, z1)
...
Explicit connection through named attributes/parameters

Implicit dependencies through the engineering process
Problem Statement

● The example had 10 templates and more than 4200 parameters (~150 ‘user parameters’)

● Thousands of templates and millions of parameters create a maintenance challenge

● Updating templates and distributing the latest versions making sure that all associated templates still work will be a full-time job

● It is necessary to develop a tool that would assist template creators and support personnel in managing templates
Ontology as a Solution

- An ontology can serve as a layer that represents the knowledge about the templates and their interconnections.
- Additional development should be done to ensure the transparent interfaces with Catia V5, PDM systems and ontologies.
Why Ontologies?

- Ontologies can represent multiple type of relations among objects
- Ontologies can be integrated with CV5
- Ontologies can be managed outside of CV5
- Ontologies can be automatically processed to find dependencies and detect conflict between objects
Critical Success Factors

- Ability to automatically transfer Catia templates into ontology
- Ability to visually represent relations among templates
- Ability to visually represent cause-effect chain of change in a template on other templates

- Stretch goals:
  - Ability to represent rules and formulae on relations among templates and parameters
  - Ability to automatically update templates where such rules or formulae are stated
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Approach to Building Templates’ Ontologies
Template Ontology Building: From the Source

- Start from already developed Catia V5 templates
- Map the templates to knowledge model
- Allow managing templates outside of CV5 Environment
- Provide mechanism to synchronize ontology to CatProducts
- CatProducts are the ‘masters of information’
The CATProduct is used to export parameters and relationships as Ontology in OntoWorks.
Browse the CATProduct and output path
Show the all the CATParts in the CATProduct and the input parameters in the selected CATPart.
Show the specific parameter Contained in the selected CATPart
Visualization: Next Design Object
Visualization: Has Input Parameter

- Exhaust_Muffler_A_TailPipe_Mounting_Plane
- Exhaust_Muffler_A_Entrance_Center_Point
- Exhaust_Muffler_A_Entrance_Mounting_Plane
- Exhaust_Muffler_A_Exit_Center_Point
- Exhaust_Muffler_A_Rotation_Axis_For_TailPipe
- Vehicle_Coordinate_Origin
- Exhaust_System_SideB_Muffler_EntrancePoint
- Exhaust_MufflerB_Entrance_Center
- Exhaust_MufflerB_Entrance_Plane
- Exhaust_MufflerB.Exit_Point
- Exhaust_MufflerB.Exit_Plane
Ontology in Catia V5
Business Goals

- Develop business process of “how templates to be managed”
- Develop a methodology that supports business process
Business Process (templates update)

1. Template development
2. OntoWorks, Model API Automatically
3. Check dependencies
4. Catia V5
5. Modify dependent templates if needed
6. Repeat if necessary
7. OntoWorks, Model API Automatically
8. Update Template Ontology
9. Parameter Dependencies
10. Optional
11. Manual Mapping of parameters if parameter names are not the same
12. Augmenting parameter relations with rules and formulae
13. OntoWorks or specialized Application
Proposed Architecture

- **Template Manager**: Use CATIA V5 GUI when possible
- **Web Services**: Win 2000, Win XP, AIX, HP, SGI
- ** OntoWorks**: WebServices Enabled Model API
- **Catia V5**: Native Integration
- **VPM Vault**: Native Integration
- **VPM/Enovia V5**: Native Integration
- **Template Ontology**: Maintenance, Authoring, Verification
- **Expert Template**: Maintenance and Authoring
- **Tight Integration using CAA**
Future Directions:
How Does It Bring Us Closer To the Strategic Goal?

Vehicle Structure Knowledge Model
Development of the “Master Vehicle Ontology”

- Integrated Approach
  - Use globally and locally accepted vehicle decomposition methods and develop localized ontologies representing sub-systems working-out inter system relationships along the way
Other Ontologies at DaimlerChrysler

- Materials’ Ontology
- Fasteners and Common Components Ontology
- Ergonomics Rules Ontology
- Safety Rules Ontology
- Value Chain Ontology
- Projects and Systems Ontology
- …
Results of Templates Ontologies Activities

Product Development
Lifecycle Management
Vehicle Structure 1

Body in White

Interior

Electrical

Chassis

PWT

Reqs

Materials
Vehicle Structure 2
Questions