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Power of Ordered Geometrical Sets and KBE to Handle Modeling Complexity 610 (KBE)

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COE 2010 ANNUAL
PLM CONFERENCE
AND TECHNIFAIR
April 18-21, 2010 • The Rio All-Suite Hotel • Las Vegas, Nevada

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Introduction

- Today's Product Development Environment
  - Multidisciplinary control systems
  - Collaboration across organizations
  - Shrinking timeline & costs

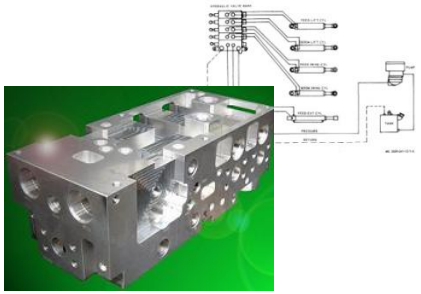
Agenda of Session

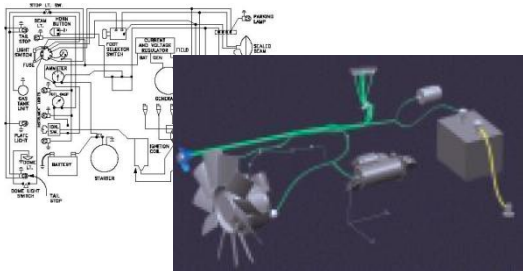
- Development of Control System
  - Challenges of packaging
  - Expectations from integrated packaging
- Proposed architecture on CATIA-V5
  - Description of original & dummy problem
  - Use of PowerCopy with OGS
  - Enhancing PCs with KW functions & Automation
- Implementation results & Conclusion

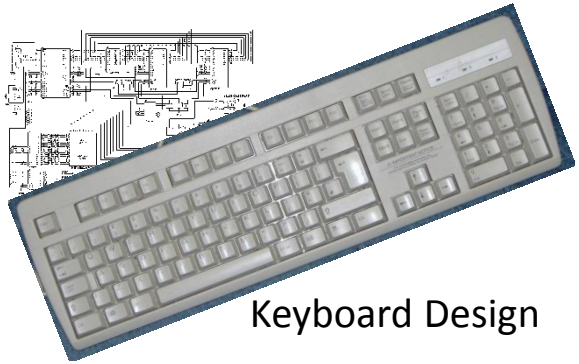
Packaging of Control System

- New products involve multiple systems – Mechanical, Electronics, Hydraulics
- System design defines control flow which is realized by physical design aka Packaging

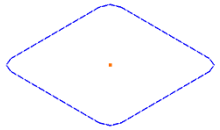
- Packaging constraints – Operating Clearances, Minimum wall thickness, etc.
- Packaging is trial and error process
  - Engineers try different combinations
  - Must retain system integrity
  - Must meet constraints
- Change propagation is tricky
  - System & Packaging association
  - Small change upsets whole packaging


Fluid Control System

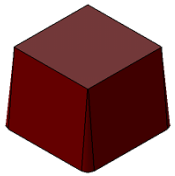

Wiring Harness


Keyboard Design

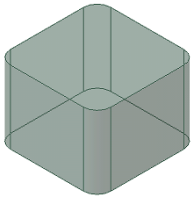
Expectation from Packaging System



Lightweight Schematic

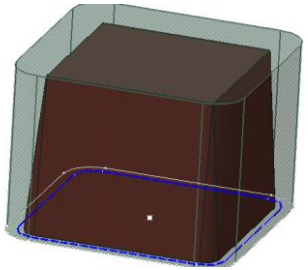


Full 3D Shape



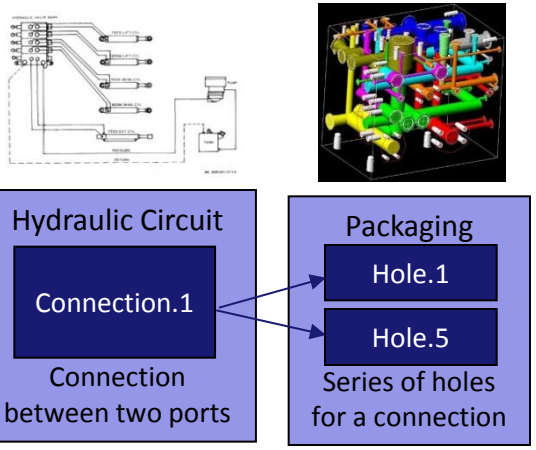
3D Envelope

- Manage multiple representations
  - Lightweight for quick viewing
  - Realistic shape in 3D solid
  - Envelope for Operating clearances



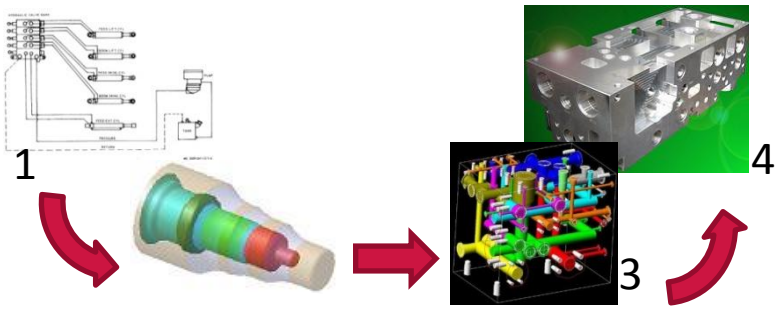
Model with 3 representations

- Ability to freely move the components
  - Manage representations as associative unit
  - No hard positioning of components
  - Minimal dependencies across components



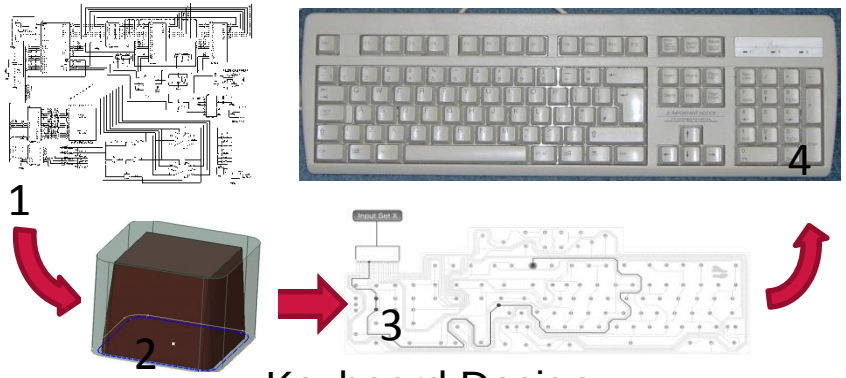
- System & packaging design correspondence
  - Correlate physical connections with a system connection
  - Retain integrity of system design, while breaking / merging physical connections
  - Allow change of components with minimal impact on connections

Problem Description



Fluid Control Design

1. Hydraulic Circuit, 2. Creation of components & connections 3. Positioning of components & connections, 4. Block Manifold



Keyboard Design

1. Electronic System Design, 2. Creation of keys & connections 3. Positioning keys & connections, 4. Design of keyboard body

Overview

- **Original Problem –** Fluid Control System
- **Dummy Problem** - Design of keyboard

Dummy Problem - Keyboard Design

- Electronic system design
- Creation of keys & connections
- Packaging
  - Placement of components (i.e. key)
  - Routing of connections
- Design of keyboard body & enclosures

Design Context

Part OR Product Environment

- Both part & product can meet requirement
- Part environment is preferred
  - Eases break / merge connections in routing
  - Allows assembling of all bodies for enclosure design
- In Part environment, Key & Connection are represented by templates

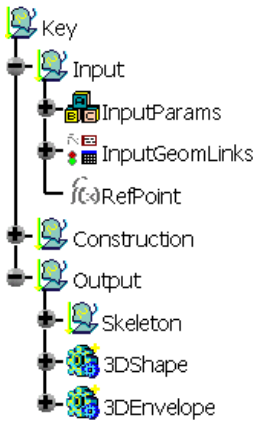
UDF OR PowerCopy Template

- UDF creates single unit for all three representations
- PowerCopy (PC) is chosen over UDF
  - Allows to activate / deactivate 3 different representations
  - No special license requirements
- PC will replicate all template entities, when instantiated. This must be managed properly.

Managing PowerCopy

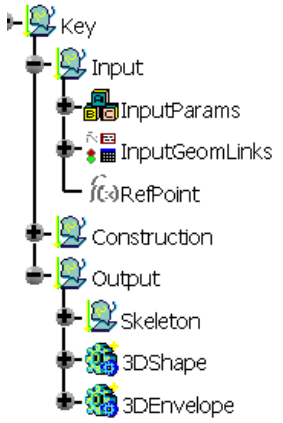
- Content of PowerCopy
  - Construction geometries
  - Output – Skeleton
  - Output – Full 3D Shape
  - Output – Envelope
  - Knowledgeware entities
- PowerCopy MUST be managed in single container for
  - Deleting / Replacing
  - Manipulating as single unit
- Only 'Ordered Geometrical Set (OGS)' can contain all types

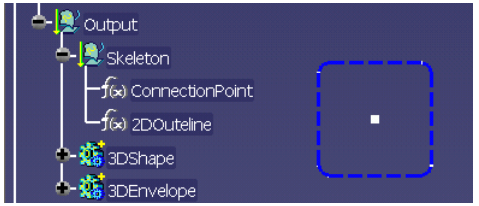
	GS	OGS	Body
Geometrical Set (GS)	X		X
Ordered Geometrical Set (OGS)		X	X
Body		X	
Knowledgeware Entities (Parameters, Relations)		X	
Solid features			X
Point, Wire / Sketch, Surface	X	X	X
Volumes	X	X	

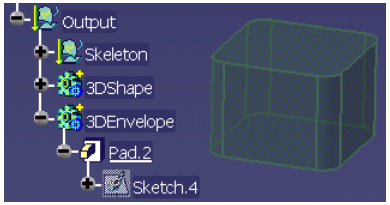


Structure of Key PowerCopy

- Inputs
  - Dimension parameters and control flags
  - KW Parameters linked to positioning point
- Construction
  - Support planes, Reference lines, etc
  - Sketch forming the shape of key
- Output
  - Skeleton – Connection point & Lightweight outline
  - 3D Shape – Key shape with pad / draft
  - 3D Envelope – Sketch offset and pad

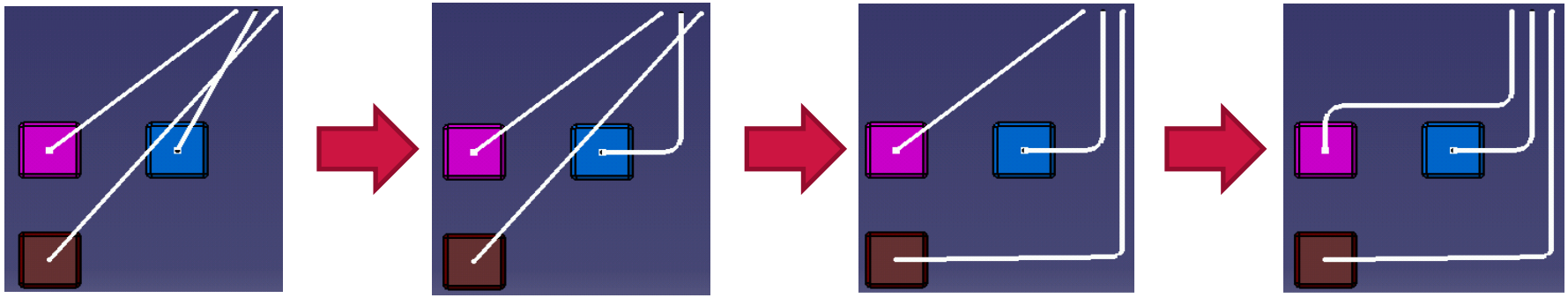




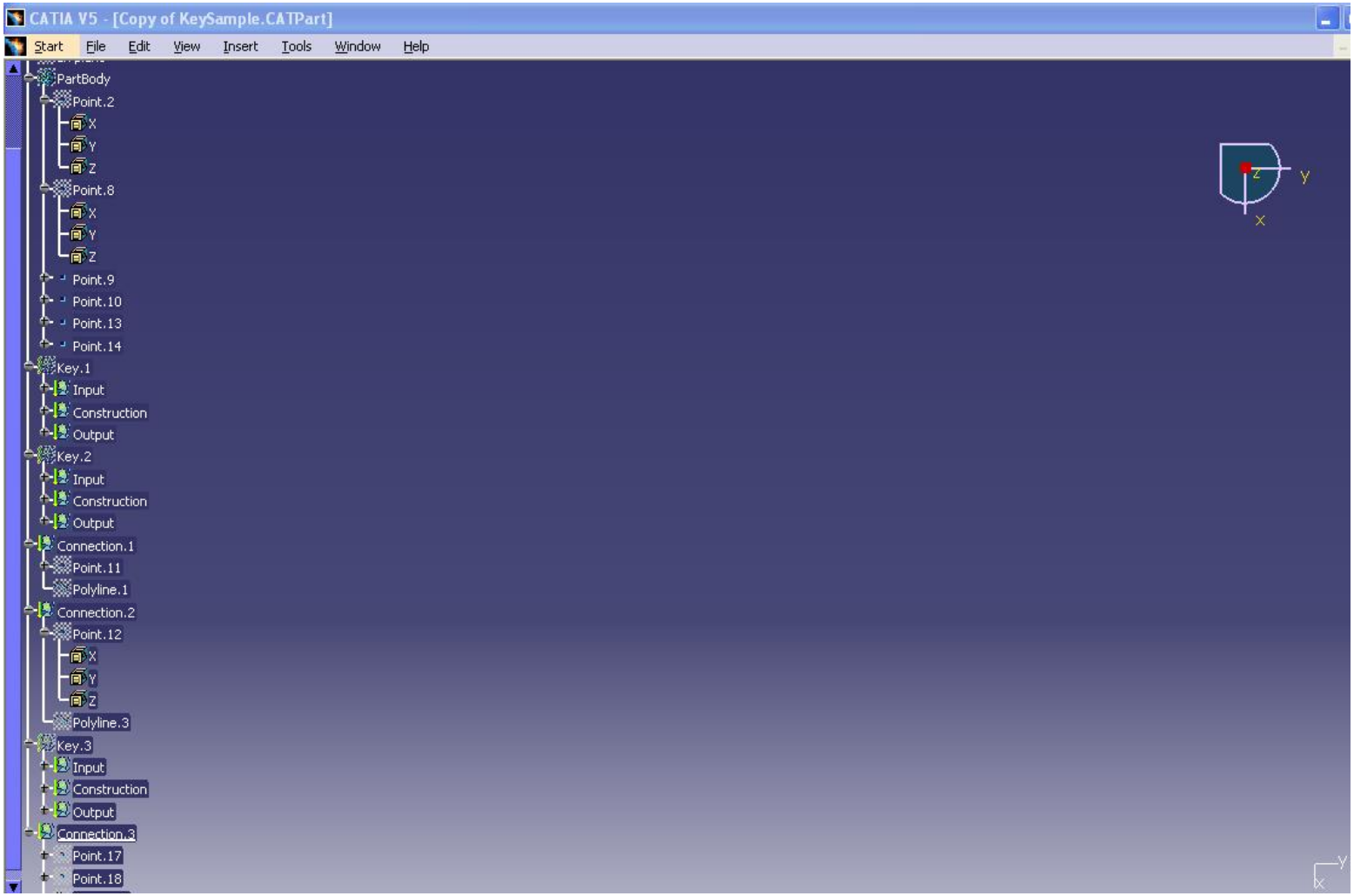


Structure of Connection PowerCopy

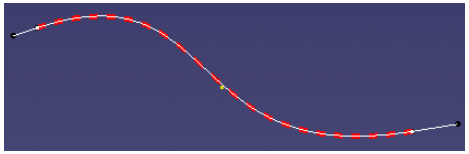
- Inputs
  - Dimension parameters and control flags
  - KW Parameters linked to inputs – Start / End and other points on path
- Construction
  - Polyline passing through the points
  - Profile sketch controlled through parameters
- Output
  - Skeleton – Polyline representing connection path
  - 3D Shape – Sweep using the profile and polyline
  - 3D Envelope – Sweep with clearance to maintain minimum gap



Demo - Key / Connection Manipulation



Scalability of PowerCopy



```
if StartExtn > 0mm and EndExtn <= 1mm
{
        GSDOperatorsPC\Output = GSDOperatorsPC\JoinSta
}
else if StartExtn <= 1mm and EndExtn > 0mm
{
        GSDOperatorsPC\Output = GSDOperatorsPC\JoinEnd
}
else if StartExtn > 0mm and EndExtn > 0mm
{
        GSDOperatorsPC\Output = GSDOperatorsPC\JoinBot
}
else
{
        GSDOperatorsPC\Output = GSDOperatorsPC\JoinNon
}
```

GSDOperatorsPC
- Line.1
- Line.2
- JoinBoth
- JoinStart
- JoinEnd
- JoinNone
- Output

```
Let Point1(Point)
Let Line1(Line)
Let Curve1(Curve)

Curve1 = InputCurve\Sketch.1

if StartExtn > 0mm
{
        Point1 = pointoncurveRatio(InputCurve\Sketch.1, NULL, 0, TRUE)
        Line1 = linetangent(InputCurve\Sketch.1, Point1, 0, StartExtn, FALSE)
        Curve1 = assemble(Line1, Curve1)
}
if EndExtn > 0mm
{
        Point1 = pointoncurveRatio(InputCurve\Sketch.1, NULL, 1, TRUE)
        Line1 = linetangent(InputCurve\Sketch.1, Point1, 0, EndExtn, TRUE)
        Curve1 = assemble(Curve1, Line1)
}

Output = Curve1
```

RulesPC
- Output

Description	Size of 5 PC instances	Time to update
GSD Approach	111 kB	2.29 sec
Rule Approach	61 kB	0.81 sec

Scalability Issues

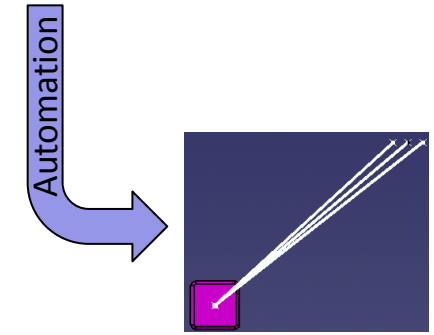
- Increasing no of PCs increases the file size and degrades the performance.
- Users complain slow system response, which affects speed of work.

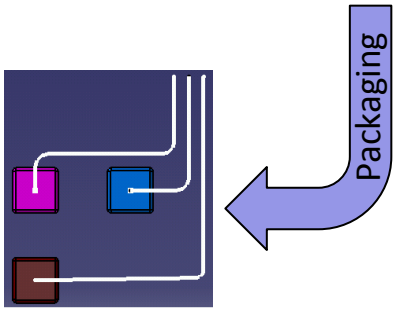
Various Solutions

- Reduce features in PowerCopy
  - Reduce grouping of different configurations into single PC
  - Automation utility to remove extra flexibility in the PCs after instantiation
- Use of rules instead of Generative Shape Design (GSD) features

Further Enhancements

Name	Start	End	Size
Connection.1	Key.1	Bus.1	2
Connection.2	Key.2	Bus.1	3
Connection.3	Key.3	Bus.1	2





- Startup Utility
  - Key / Connection info loaded from MS-Excel
  - All components positioned at origin with appropriate connections
- Edit Support
  - Edit key instances (not available with PC)
  - Insert points in connections to create chain of connections
- Packaging Validation
  - Check intersection between 3D Solids and Envelope
  - Violations provide ‘immersive feedback’

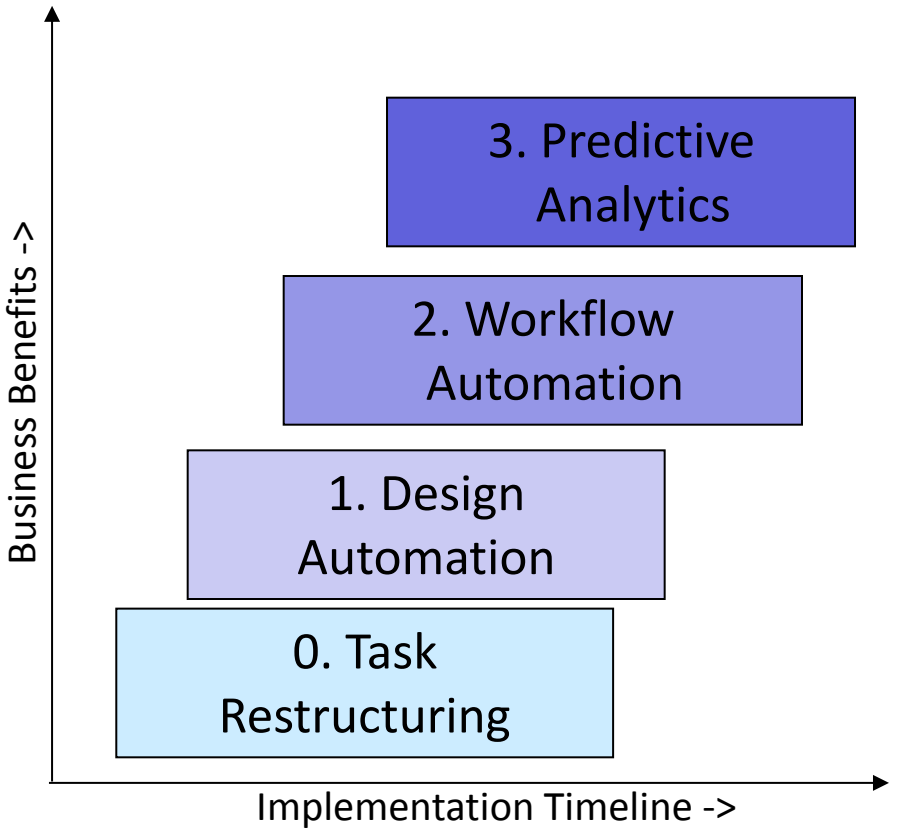
Implementation & Results

Implementation Plan

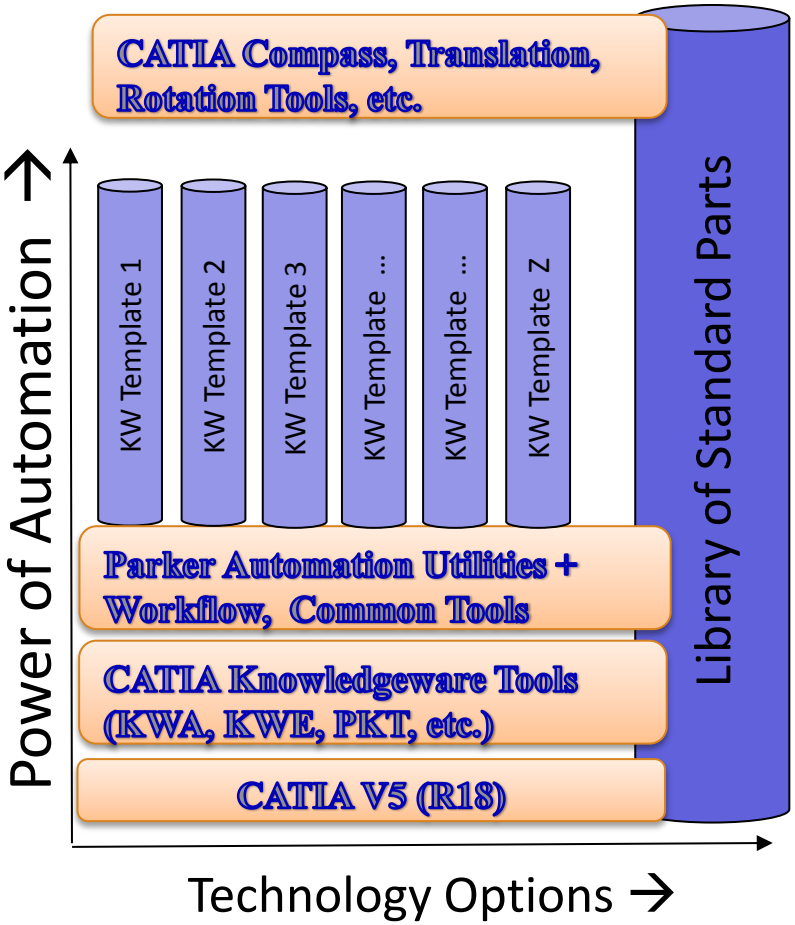
- Duration - 12-14 months
- Incremental implementation across multiple deployments
- Each phase signed-off by users, after a mockup / presentation.

Results

- Packaging effort reduced by ~50%
- Lead time reduced by ~40%
- Eases modifications & reuse due to better & uniform structure
- Rework due to clearance violations reduced significantly



Conclusion



- Generic architecture, extendable to a multidisciplinary control system
- OGS allowed managing a complex PC with various type of entities and multiple output as single unit
- Scalability issues can be tackled by optimizing no of features & use of rules
- Synergy of KW Templates with Automation Utilities enhances power of automation
- Incremental implementation approach achieved results with lower risk

Questions?

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