AutomationML Logic Description

<AutomationML/>

The Glue for Seamless Automation Engineering
Overview about AutomationML

CAEX IEC 62424
Top level format

- Plant topology information
  - Plants
  - Cells
  - Components
  - Attributes
  - Interfaces
  - Relations
  - References

Object A

Object A₁

Object A₂

Object Aₙ

AutomationML
Engineering data

COLLADA
Geometry
Kinematics

PLCopen XML
Behaviour
Sequencing

Further XML Standard format
Further aspects of engineering information

Further aspects of engineering information
Logic information covered by AutomationML

- Distinction between three types of information
  - „Sequencing“ of automation systems
  - „Behaviour“ of components
  - „Interlocking“ as description of necessary safety related conditions
- One system component may contain each type of information
Logic Information covered by AutomationML

- **Representative selection of model types**
  - Behaviour: e.g. State Charts, Sequence Function Charts
  - Sequencing: e.g. Gantt, Impulse Diagrams, Sequence Function Charts
  - Interlocking: e.g. Logic Networks

- **Storage of logical information based on PLCopen XML**
  - Usage of PLCopen XML Version 2
  - Sequencial Function Charts (SFC) for Sequencing and Behaviour
  - Function Block Diagrams (FBD) for Behaviour and Interlocking

- **Seamless integration into AutomationML top level format by**
  - Referencing of PLCopen XML documents
  - Referencing of PLCopen XML variables
## Logic models covered by AutomationML 1/2

<table>
<thead>
<tr>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
</table>
| ![Sequence diagram - Transport 2](image1.png) | **Gantt Charts**  
  - „straight-forward“ sequencing on higher level  
  - Used within early phases of system engineering  
  - First input for system simulation and control programming |
| ![Sequence diagram - Transport 2](image2.png) | **Impulse Diagrams**  
  - Describe sequencing on device level  
  - Exploits and describes ramps of signals  
  - Input for system simulation and control programming |
| ![Sequence diagram - Transport 2](image3.png) | **PERT Charts**  
  - Describe complex sequencing on higher level  
  - Describe complex timing information  
  - Input for system simulation and control programming |

### Operation

<table>
<thead>
<tr>
<th>Number</th>
<th>Action</th>
<th>Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lower skid</td>
<td>4,0</td>
</tr>
<tr>
<td>2</td>
<td>Stop Lift</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Unlock Skid</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Move to end of 110H TR 002</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Handover to 120R F_002 over 120R FB001</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Move on 110H TR 002</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Move on 120R F_002</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Move on 120R FB001</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>Move over to 120R F_003</td>
<td>5,7</td>
</tr>
</tbody>
</table>
## Logic models covered by AutomationML 2/2

<table>
<thead>
<tr>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
</table>
| ![Sequence Function Charts (SFCs)](image) | ▪ **Sequence Function Charts (SFCs)**  
▪ Describes sequencing and control implementations  
▪ Executable description  
▪ Near to PLC implementation |
| ![State Charts](image) | ▪ **State Charts**  
▪ Describes complex behaviour of mechatronical units  
▪ Not executable at PLC  
▪ required for virtual commissioning |
| ![Logic Networks](image) | ▪ **Logic Networks**  
▪ Describes interlocking information  
▪ Provides structures for state description  
▪ Near to PLC implementation |
Challenge transformation of different logic models

Logic Models
- PERT
- Impulse
- Gantt
- ...

Transformation to AutomationML
History of PLCopen XML

- **1992 PLCopen was founded**
  - One main activity is to develop and promote the IEC 61131-3 standard
  - Other activities in the scope of function block technologies, motion and safety

- **2002 Work of TC6 PLCopen XML started**
  - Aim is the definition of a data exchange format for PLC programs
  - Uses XML as basis for the data format

- **2005 First Version of PLCopen XML was published**

- **2008 Version V2.0 of PLCopen XML Specification**
  - GlobalID Concept
  - Extension with user defined data possible
The logic part of AutomationML covers all engineering phases

- **Planning**
  - Product Design
  - Plant Planning
  - Electr. Constr.
  - PLC Progr.
  - Robot Progr.
  - HMI Progr.
  - Virtual Comm.
  - Gantt Chart
  - Pert Chart

- **Control System Behavior**
  - Impulse diagram

- **Interlocking**
  - Logical Networks

- **Control System Implementation**
  - SFC

- **Component Behavior**
  - State Charts
  - SFC
The Intermediate Modeling Layer

- Reduction of translation efforts by defining of a common intermediate format
- Enabling of two step approach for data translation
- Decouples the target format PLCopen XML from various input and output data formats

Gantt chart
PERT chart
Impulse diagram
State chart
...

Intermediate Modeling Layer (IML)

PLCopen XML

```xml
<PLCopen>
<XML>
...</XML>
</PLCopen>
```
AutomationML enables transformation between models

\[
\text{Signal}_{\text{Motor1}}_1 = \text{TRUE}
\]

\[
\text{Signal}_{\text{Time}}_0 = \text{TRUE}
\]

\[
\text{Signal}_{\text{Time}}_1 = \text{TRUE}
\]

\[
\text{Signal}_{\text{Time}}_0 = \text{TRUE}
\]

\[
\text{Signal}_{\text{Time}}_1 = \text{TRUE}
\]

\[
\text{Signal}_{\text{Drive1}}_0 = \text{FALSE}
\]

\[
\text{Signal}_{\text{Drive1}}_1 = \text{FALSE}
\]

\[
\text{Signal}_{\text{Drive1}}_2 = \text{FALSE}
\]

\[
\text{Signal}_{\text{Drive1}}_3 = \text{FALSE}
\]

\[
\text{Signal}_{\text{Drive1}}_{\text{Slow to Fast}} = \text{TRUE}
\]

\[
\text{Signal}_{\text{Drive1}}_{\text{Fast}} = \text{TRUE}
\]

\[
\text{Signal}_{\text{End}} = \text{TRUE}
\]

\[
\text{Terminal Step}
\]

\[
\text{Initial Step}
\]
AutomationML enables exchange within the engineering process
Interlocking with AutomationML

- Interlocking information is used to describe states which:
  - Are prerequisite for special actions
  - Must not be violated during special actions
  - Require a stop of running actions

- The interlocking description can be used for:
  - Safety information
  - Behaviour information of components
  - In combination with Sequencing and Behaviour information
Three levels of interlocking description

Level 1: Signal and component groups
- Signal group:
  - Emergency stop 1
  - Emergency stop 2
  - Light guard 1
- Component group:
  - Welding tool 1
  - Gate 1
  - Robot 2

Level 2: Boolean logic networks for signal groups
- POU 3:
  - Var1
  - Var2
  - Var3
  - AND
  - interlockingSignal

Level 3: Complex logic network elements
- POU1
- POU2
- LIMIT_INT
- IN
- MN
- INT_TO_BOOL
- OUT_POU2
- Min
- Temp
- Max
Example: Sequence Planning for a Daimler real life cell (1/3)

Microsoft Excel, Logic CPF
Example: Sequence Planning for a Daimler real life cell (2/3)
AutomationML Logic Viewer
Example: Sequence Planning for a Daimler real life cell (3/3) jPlan, Logic CPF
The logic description is an integrated part of AutomationML

- Supports most used graphical models
- Enables transformation of models from early Gantt charts to SFCs close to PLC code
- The storage of logic information is based on PLCopen XML 2.0
Join AutomationML!

http://www.automationml.org