# GMPT Future Control Software Requirements

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# *Outline*

- Manufacturing User Requirements
- Control Software Requirements
- Technical Elements
- Research Agenda
- Summary

# “Lean” Manufacturing Objectives

- Reduce Costs
- Increase Responsiveness
- Improve Quality

**Lean** = **Responsiveness** + **Cost** + **Quality**

**Responsiveness**
- System Flexibility
- Adoption of new Technologies

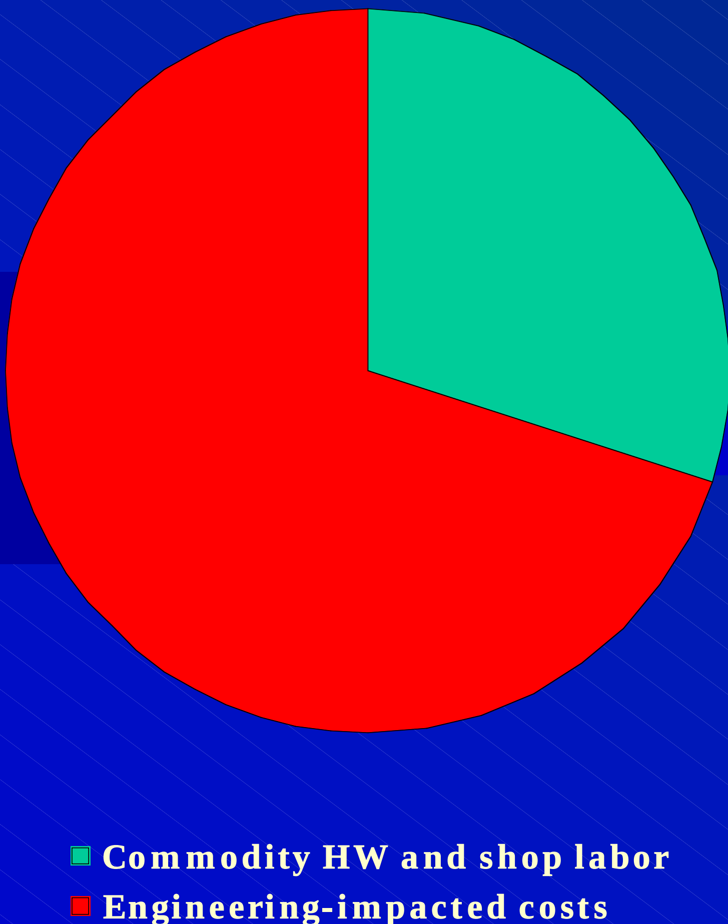
**Quality**
- Design & Engineering
- Manufacturing & Production

**Cost**

**Investment**
- Equipment Procurement
- Stability of Technology

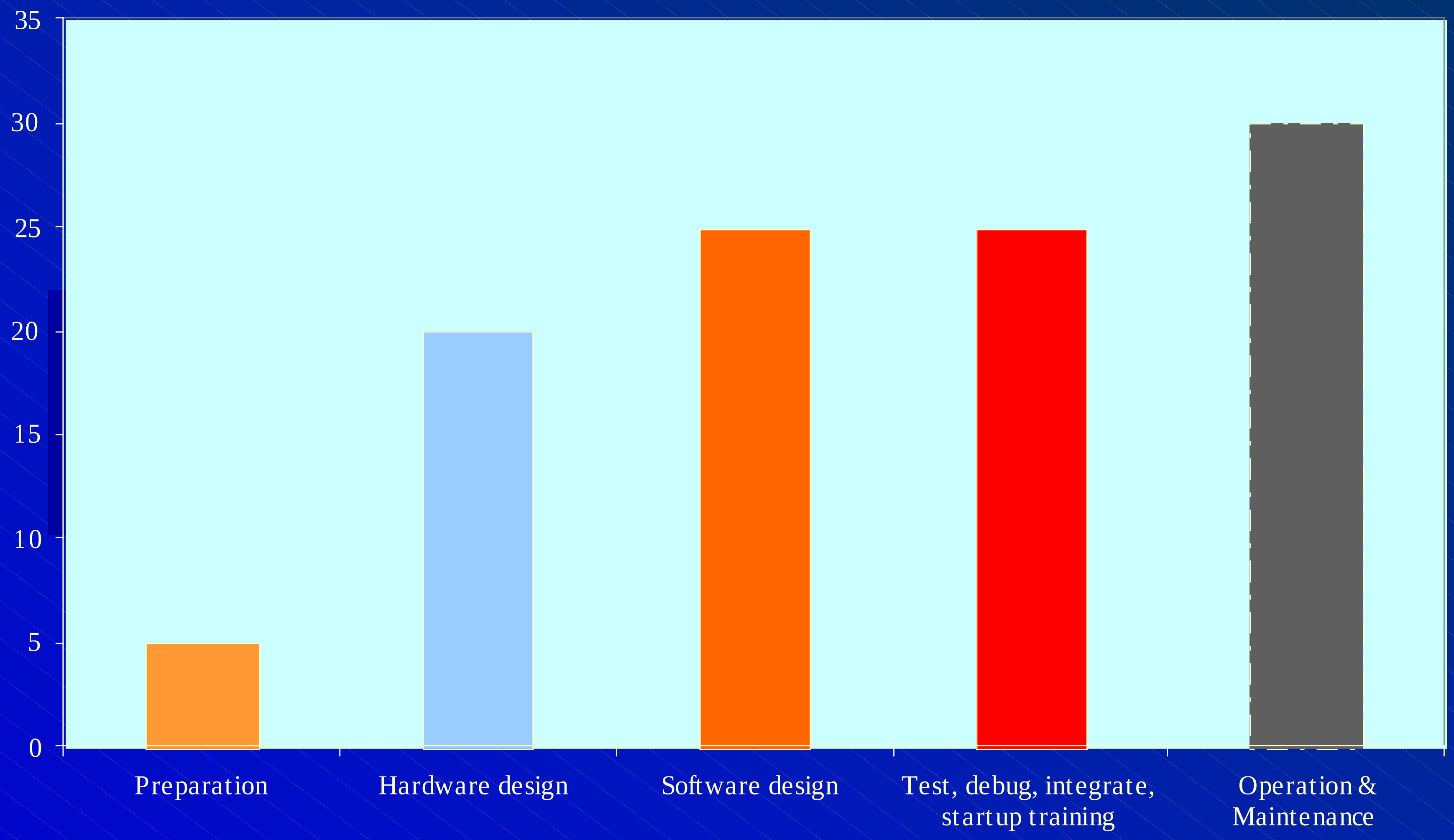
**Operating**
- Reliability & Maintainability
- Capability
- Usability

# *Cost Areas*




- Focus on costs that can be impacted with engineering.
- Need a more efficient engineering & maintenance process

# *Engineering-impacted lifecycle cost profile*



# *Engineering & Maintenance Needs*

- Efficient Engineering
  - New applications
  - Retrofits
- Efficient Start-up
  - Easy, safe learning curve at start-up
  - Efficient, safe debugging
- Efficient, Safe Operation and Maintenance

## *Assuring Correctness of Programs*

- Support to capture process specs (sequence of operations) correctly
- Validation of process specs, e.g.,
  - Check for inconsistencies
  - Support for simulation with manufacturing process in the loop
- Efficient transformation from process specs to executable programs
- Ability to debug on shop floor at high level program/spec

# Reducing Design Time/Cost

- Support for efficient reuse of library components
- Support for efficient maintenance of reusable libraries
- Platform independence
- Export/import in vendor-neutral, tool-neutral form

# *Making Programs Easier to Understand*

- Proper modularization, e.g., IEC 61499 function block types
- Reuse of software
  - Standard library elements
- Standards for module interconnection & interaction
- Consistent control structure that is not error-prone
- Eliminate need for changes in low level code
  - Change at high level only

# *Supporting Operation & Maintenance (1/2)*

- Minimize time cost to locate cause of interruption in production
  - Eliminate need to browse “raw” control logic
  - Support operator in correcting manufacturing problems
    - Reduce avoidable calls to skilled trades
  - Isolate condition not fulfilled
  - Indicate specific fault point
  - Provide online help & documentation
    - Support adding helpful hints from experience

# *Supporting Operation & Maintenance (2/2)*

- Minimize engineering effort in providing troubleshooting help
  - Integrate diagnostics with control logic
  - Reuse & integrate data from multiple sources, e.g., IO devices database
- Integrate subsystem status & diagnostics info, e.g., servos
- Safe recovery procedures when out of sequence

# *Existing Deficiencies*

- The lack of Open Modular Architecture Controls has been a significant impediment during the debug and ramp-up phase of a manufacturing system
  - Can not support proper reconfiguration of manufacturing systems
- The lack of portability and reusability application software imposes significant avoidable costs and delays in creating new manufacturing system configurations
- There is a lack of organized, systematized knowledge to specify, apply, integrate, use, test and evaluate an OMAC-based system correctly and efficiently

## General Control Software Requirements

- Control logic software shall be modular, portable, and composed of reusable library components
- The definition of all language elements shall be publicly published, supplier-neutral, and independent of any graphical presentation form or language
- Application control logic shall be accessible in a view-independent form for portability
- Software organization shall be consistent with the model described in IEC 61499

# *Reuse - Standard Library Elements*

**Automation domain Function Block types**
Examples:
AxisSupervisor, Servo-axis of motion
2PositionMotionDevice, IOdevice

Integral diagnostics

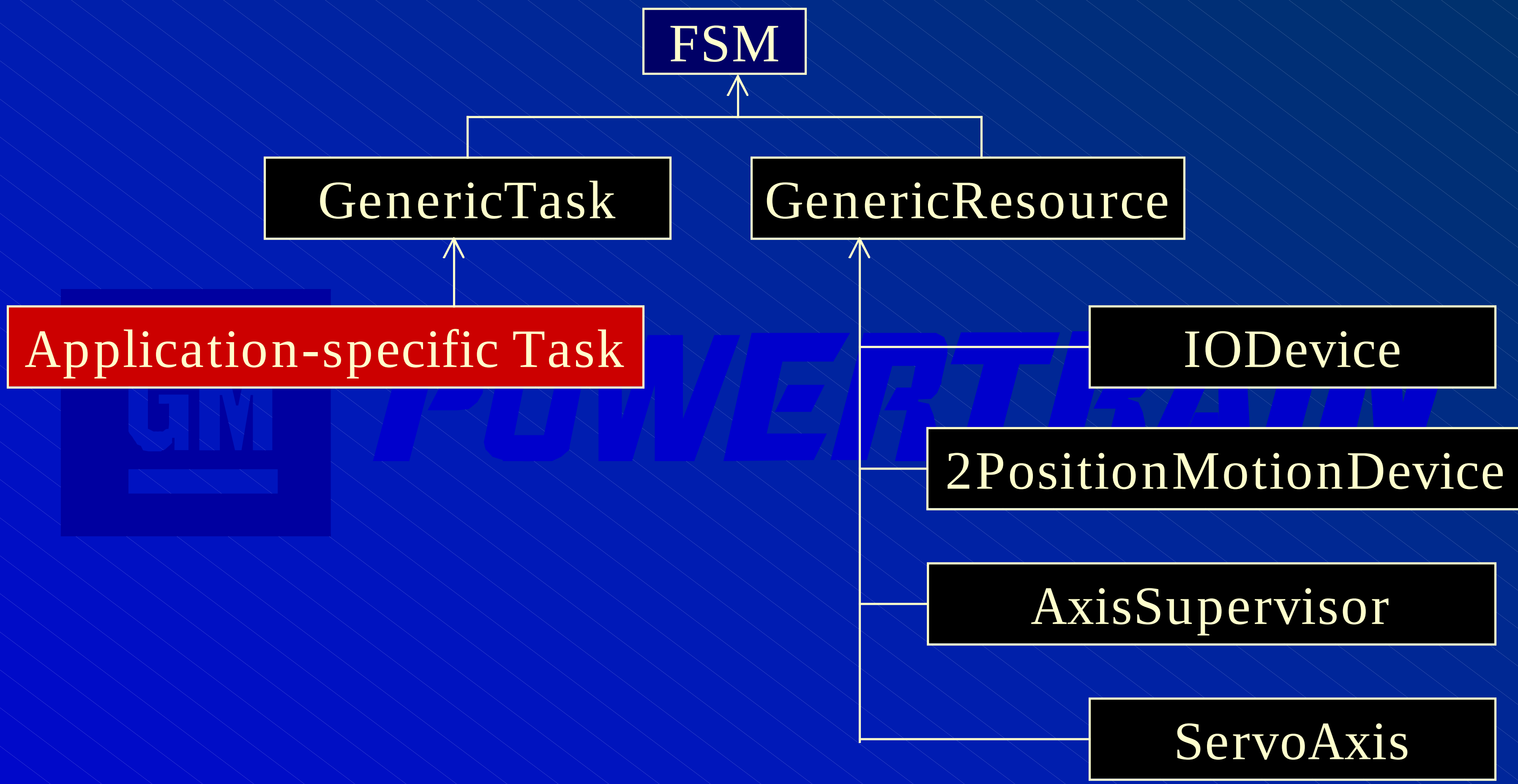
**General Function Block (FB) types**
Examples:
counter/timer
character-string

**Common elements**
(ref IEC 61499)
Identifiers, literals, data types, variables
Function block type structure

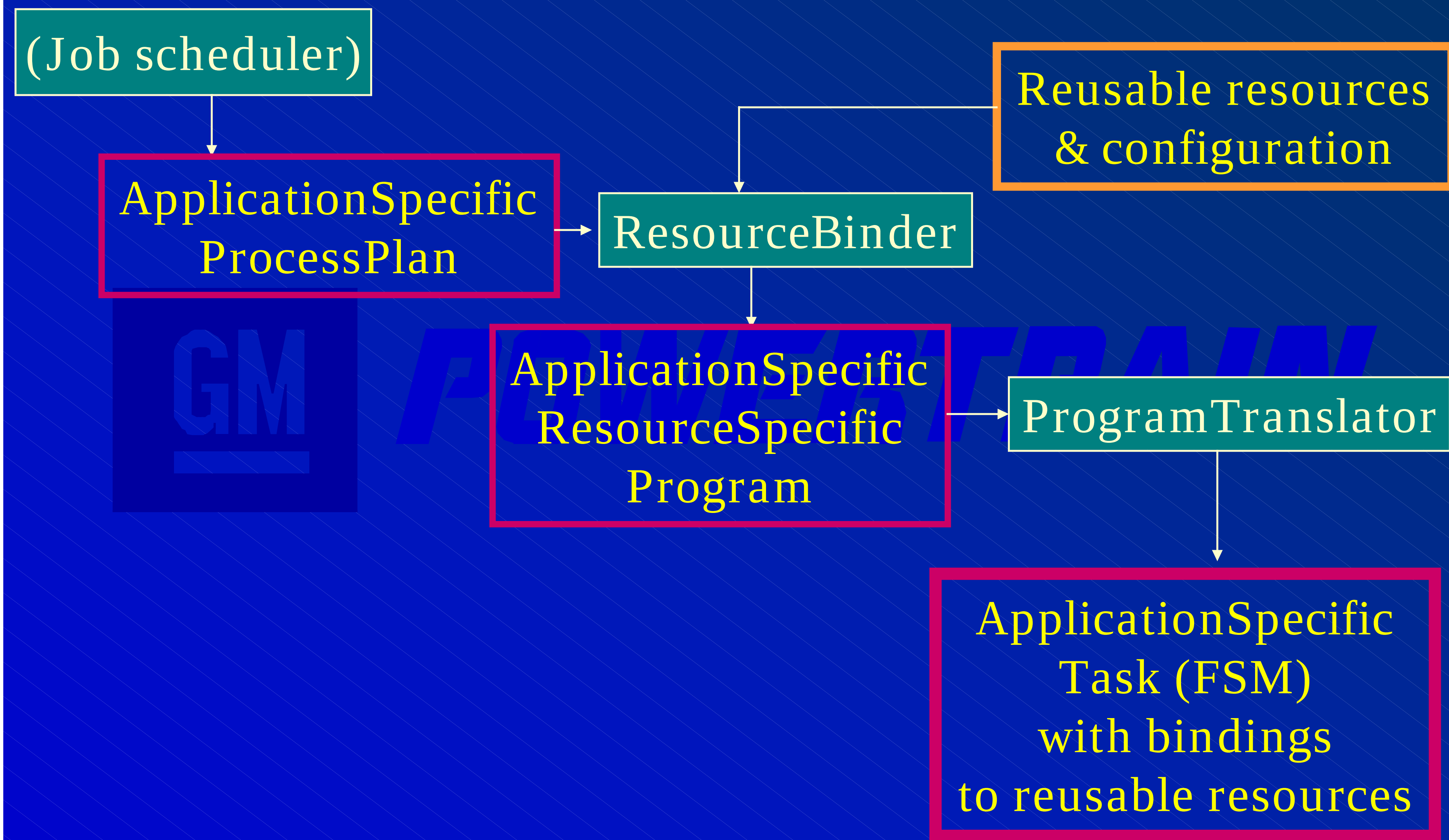
# Language Elements

- In cases where no IEC standard is sufficiently defined
  - specified through or mappable into XML Schema, utilizing the most expressive elements

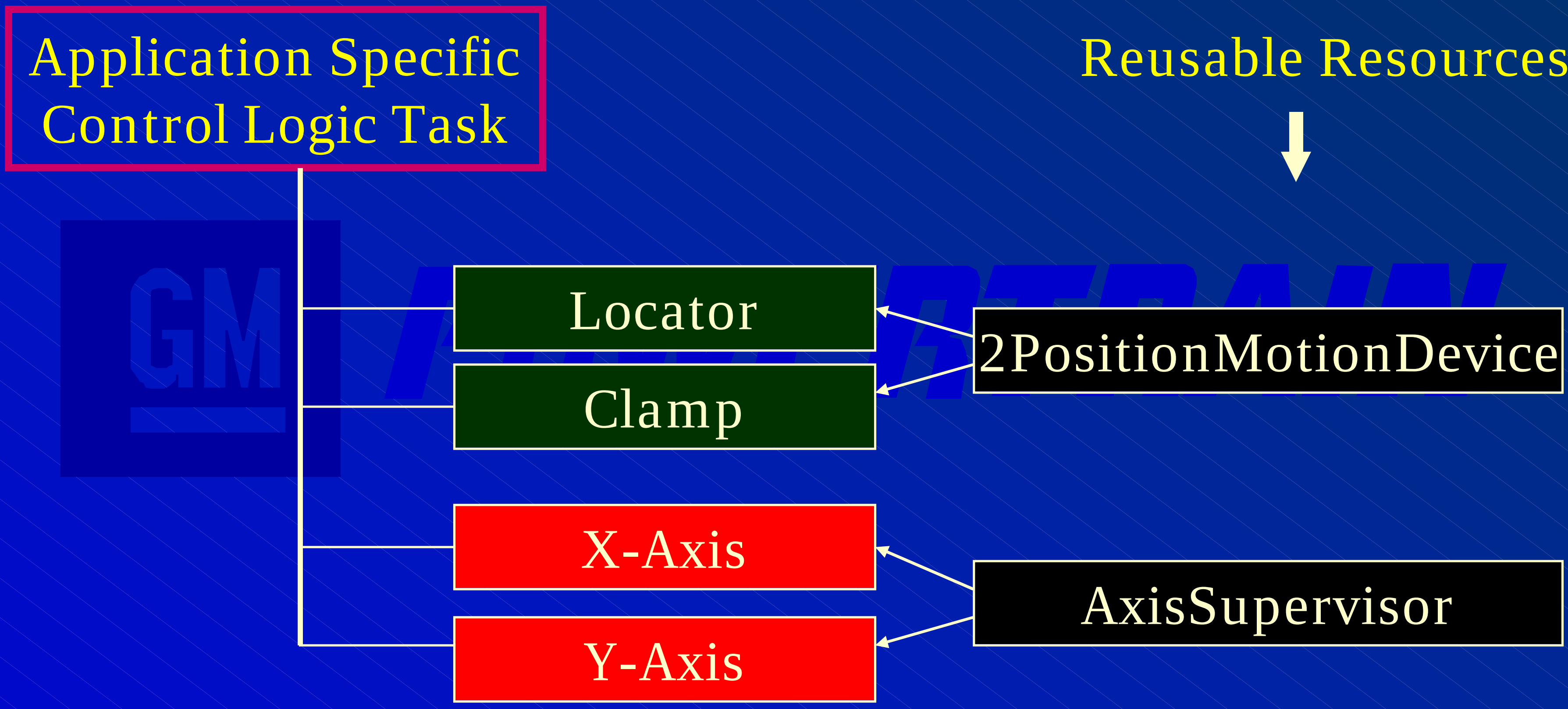
# Reusable generic interfaces



# *Process Plan-to-Task Transformation*

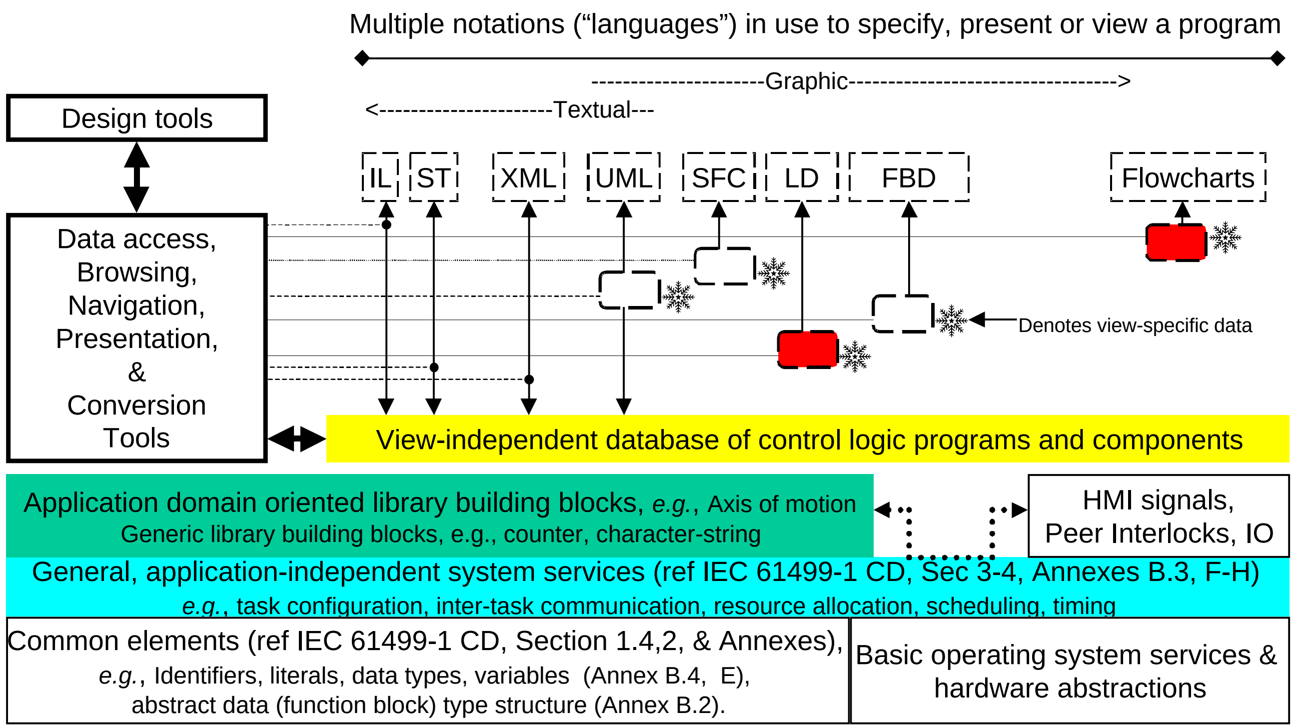


# *From Application Specific Task to Reusable Resources*



# Control Logic Design Structure

Modularization of programming software and resources



# *Software Engineering Research (1/2)*

- Compare various architectural alternatives
  - Reduction in learning time
  - Reduction in debug time
  - Reduction in integration time
  - Reduction in machine control application development time
- Develop the metrics to compare various architectural alternatives

## *Software Engineering Research (2/2)*

- Test methods & procedures to assure “plug and play” integration of software components for the machine control application domain
  - including conformance to timing requirements

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# *Software engineering research issue (3)*

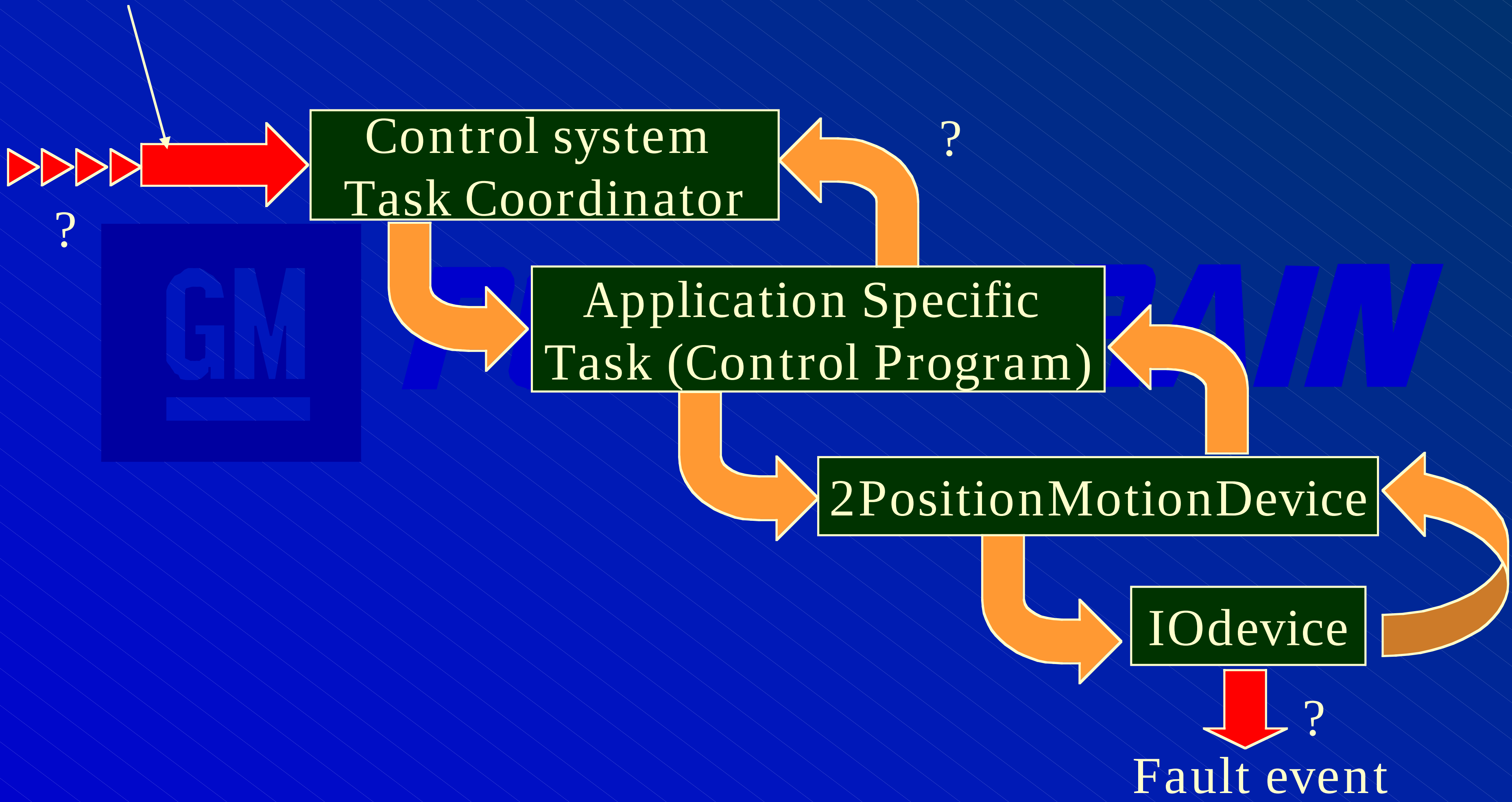
- Which FSM Model? ?
  - Controversy in FSM model - action on transition or in state?

# *Event management research issue (1/2)*

- Abnormality events
  - An abnormality event can occur in any state, e.g., some emergency.
  - Should its transition be explicitly specified in every state?
  - Or, can there be a shortcut without affecting verifiability?

# *Event management research issue (2/2)*

External event flow in hierarchical FSM: inside->out, outside->in, ...?



## *Summary*

- OMAC User Requirements given in terms of impact on the overall engineering & maintenance process lifecycle.
- No new inventions / paradigms needed.
- R&D needed in software engineering to compare alternatives with respect to
  - Ease of learning
  - Reduction of debug, integration & startup time
  - Ease of maintenance
  - Reuse

***http://isd.mel.nist.gov/projects/omacapi/ReferenceDocumentation/***