# Automated Verification Support in Producible Adaptive Model-based Software


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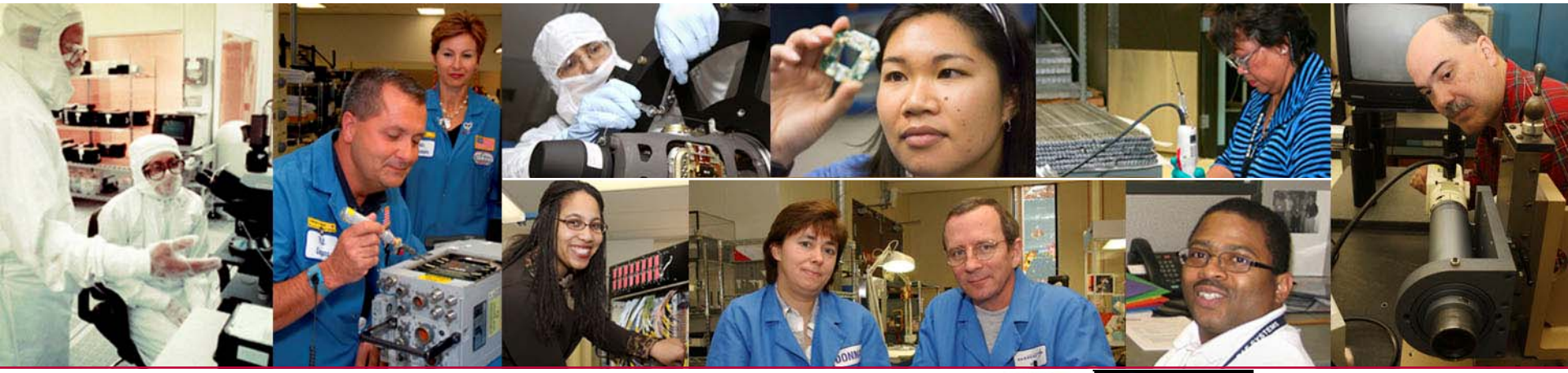


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# Agenda

- Overview of Producible, Adaptive Model-Based Software (PAMS) / Disruptive Manufacturing Technology (DMT) DARPA program
  - Motivation, approach and goal
- PAMS model-driven technologies developed to address the producibility problem
- Addressing the verification problem using PAMS technologies



# Overview of DMT PAMS

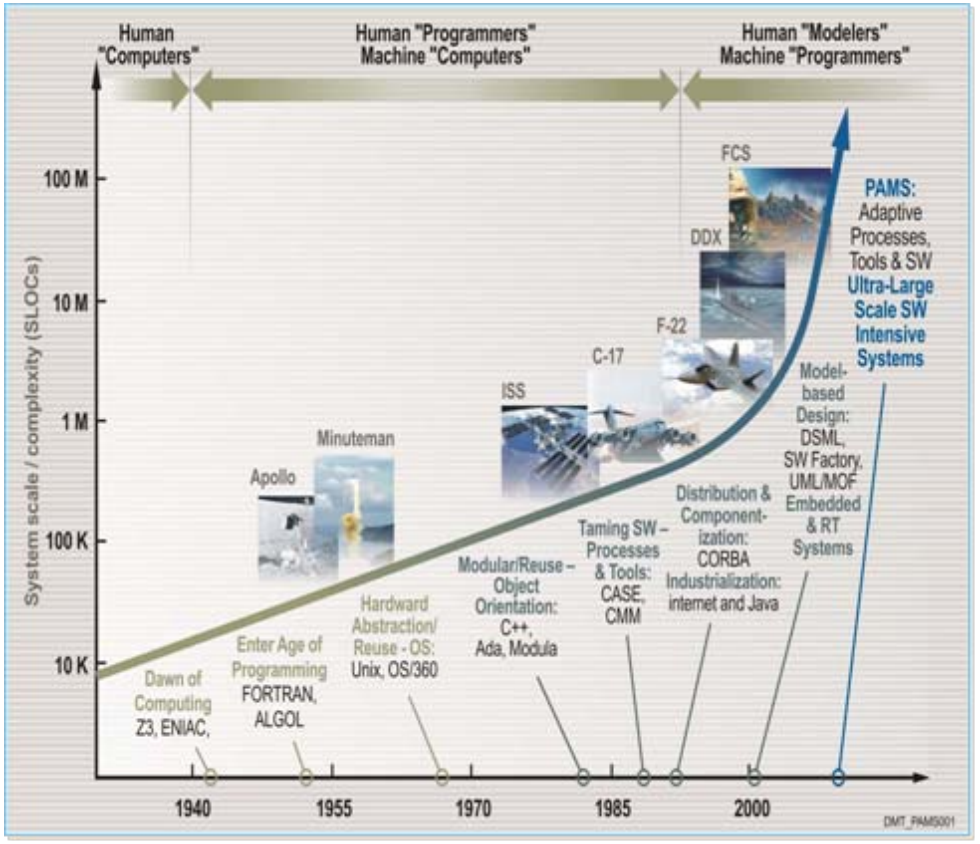
***Initiative: Disruptive Manufacturing Technologies (DMT)***

***Program: Producible, Adaptive Model -based Software (PAMS)***

- DARPA sponsored program
  - 3-Year program starting in 2007
  - PAMS is the sole software program in the DMT initiative
- Program Team
  - BAE Systems (Prime), Vanderbilt University Institute for Software Intensive Systems (ISIS) and MIT Computer Science and Artificial Intelligence Laboratory (CSAIL)
- Program goal is to reduce development time by 70% and cost by 90% for software changes to long-lived platforms

# Overview of DMT PAMS technology

- **Problem:** *In danger of reaching the* **producibility limit** *given the dramatic increase in complexity, size and adaptivity required for modern software intensive systems*
  - Rapidly shifting requirements result in disillusionment with and abandonment of inadequate software methodologies
  - Software not easily configured for purpose and not adaptable to changing conditions
- **PAMS Strategy:** *Adapt to changing requirements throughout the s/w lifecycle*
  - **At design time** to evolving requirements as well as to evolving domain concepts
  - **At load time** to mission, context, resources
  - **At runtime** to mission changes and unforeseen conditions



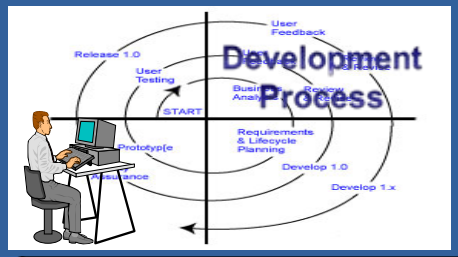

**PAMS Approach:** Develop an innovative *methodology* and a *suite of tools* that enable rapid, **model supported adaptation**

# Program Approach

## Three new software producibility techniques

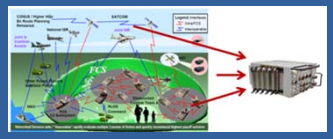
July 2007 — September 2010

### Design Time Adaptation (DTA)




**Tooling:** Support the spiral development process with tools that **adapt** while carrying forward existing engineering products (models, designs, etc.)

### Load Time Adaptation (LTA)



**Configuration:** Enable rapid adaptation of system to new platforms or mission **profiles**

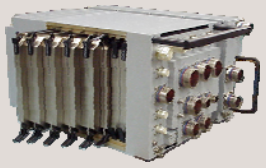
### Run Time Adaptation (RTA)

**Control:** Create system software that can rapidly **adapt** to changing mission requirements, environmental events, and faults in the system

**Goal: Reduce Development Time By 70% And Cost By 90%**

Diverse Experimental Domains

**Electronic Flight Control System (FCVMS)**



**Software Defined Radio**

Team: BAE Systems (Prime); Vanderbilt University (ISIS); MIT (CSAIL)

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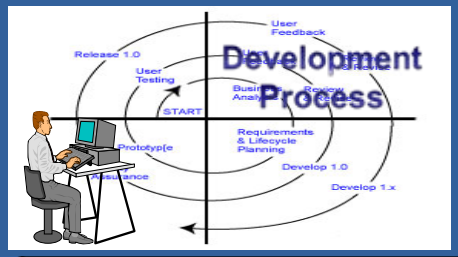


**Tooling:** Support the spiral development process with tools that **adapt** while carrying forward existing engineering products (models, designs, etc.)

**Focus of this presentation**

### Load Time Adaptation (LTA)

Enable rapid adaptation of system to new platforms or mission profiles.

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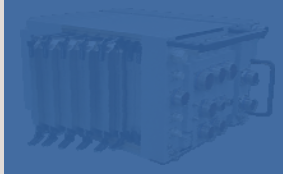

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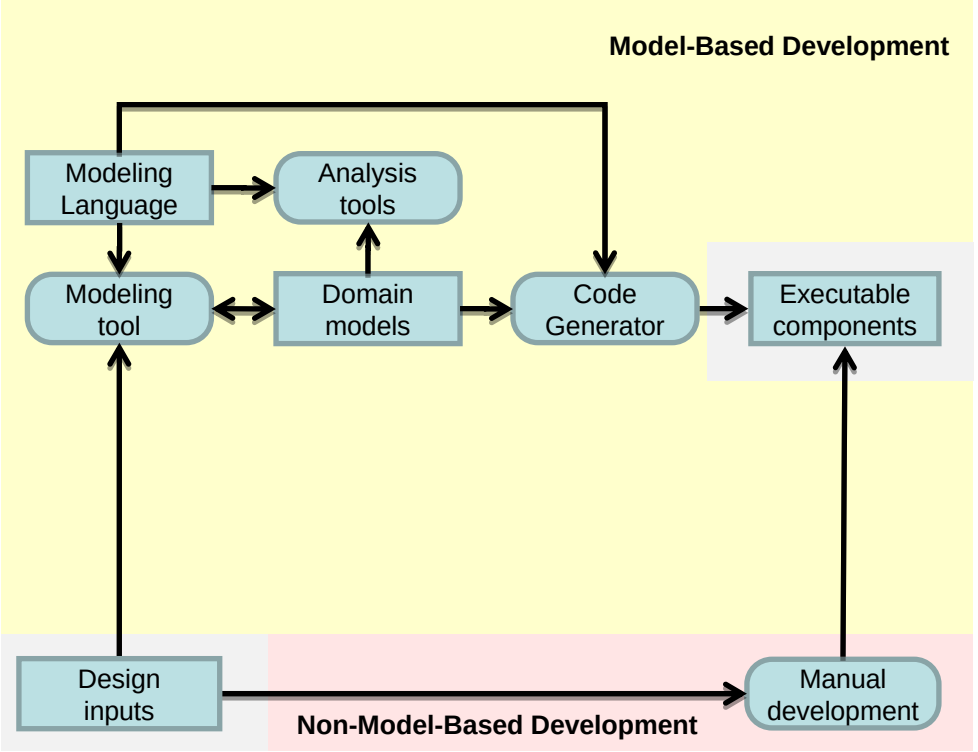
# Design-Time Adaptation Producibility Problem

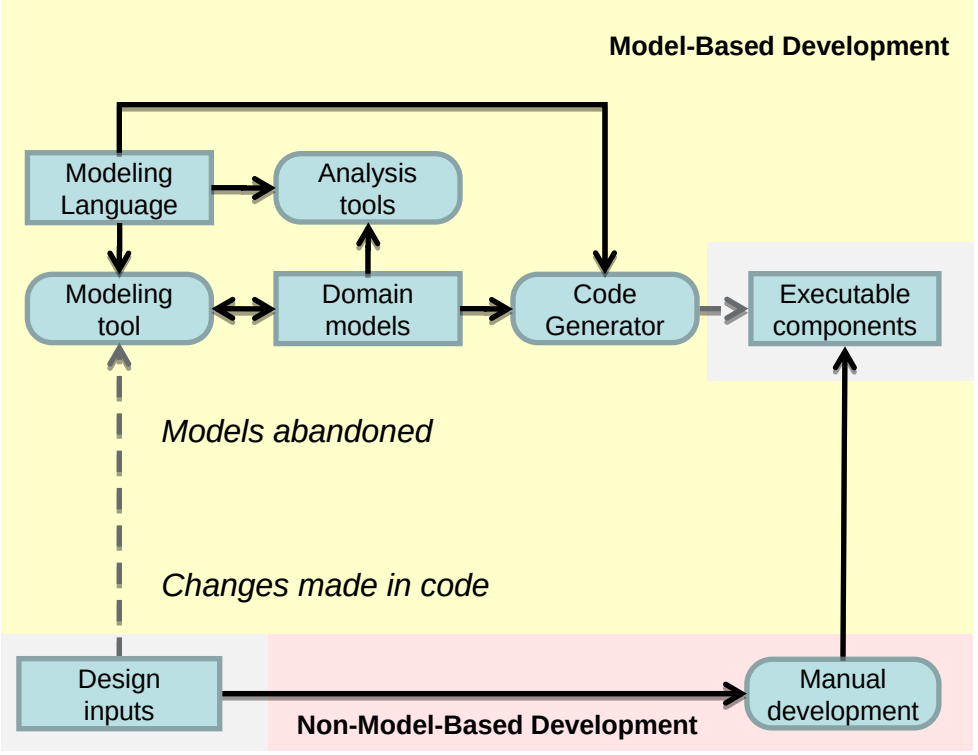
- **Typical model-based environment for software development:**
  - Modeling environments are used to design, analyze, and automatically generate code and executables




**Initial Phase of Software Development**

# Design-Time Adaptation Producibility Problem

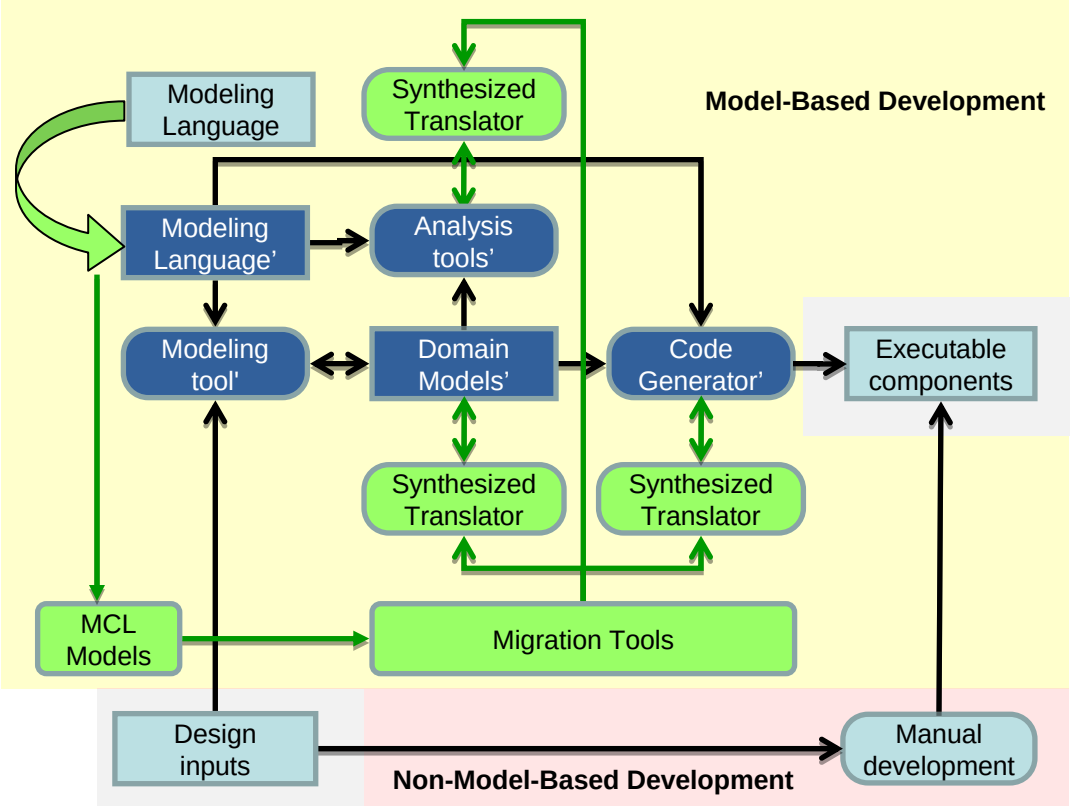
- **Problem:**
  - After significant modeling, an aspect of the application arises that cannot be adequately modeled
- **Underlying reasons:**
  - Modeling languages have limited expressivity
  - Long-running software projects do not adequately prepare for the evolution of the problem domain, tools, and processes
  - Very difficult to adapt languages & development tools or to integrate new tools
- **End results:**
  - Models are abandoned; developers move to handwritten code modification
  - Significant cost increase relative to full lifecycle use of model-based development
  - Alternatively, expensive rework is required to reproduce what has already been done once




**Continued Development with Model Abandonment**

# PAMS Approach to the Producibility Problem

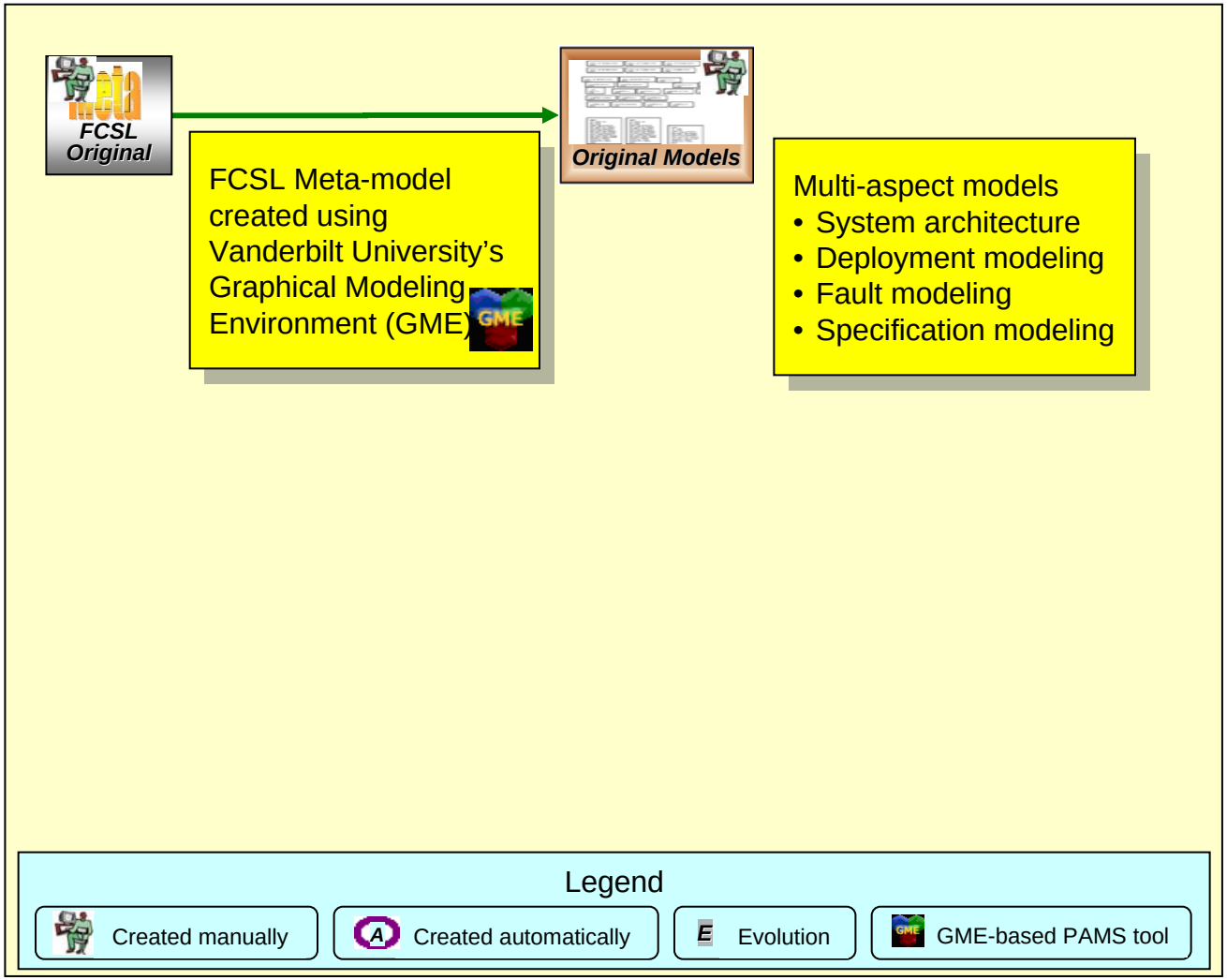
- **PAMS Solution:**
  - Co-evolve modeling language and model-based development tools
  - Result: Enable use of model-based development throughout lifecycle
- **PAMS Approach:**
  - Develop model change language (MCL) to specify modeling language changes
  - Develop migration tools that use these change models to synthesize software that automatically transform the existing engineering artifacts (models), and tools
- **Result: Significantly reduced lifecycle costs**




**Continued Development with PAMS**

# PAMS Tools for the Producibility Problem

- Flight-control domain specific meta-model / language (FCSL) is a multi-aspect modeling environment



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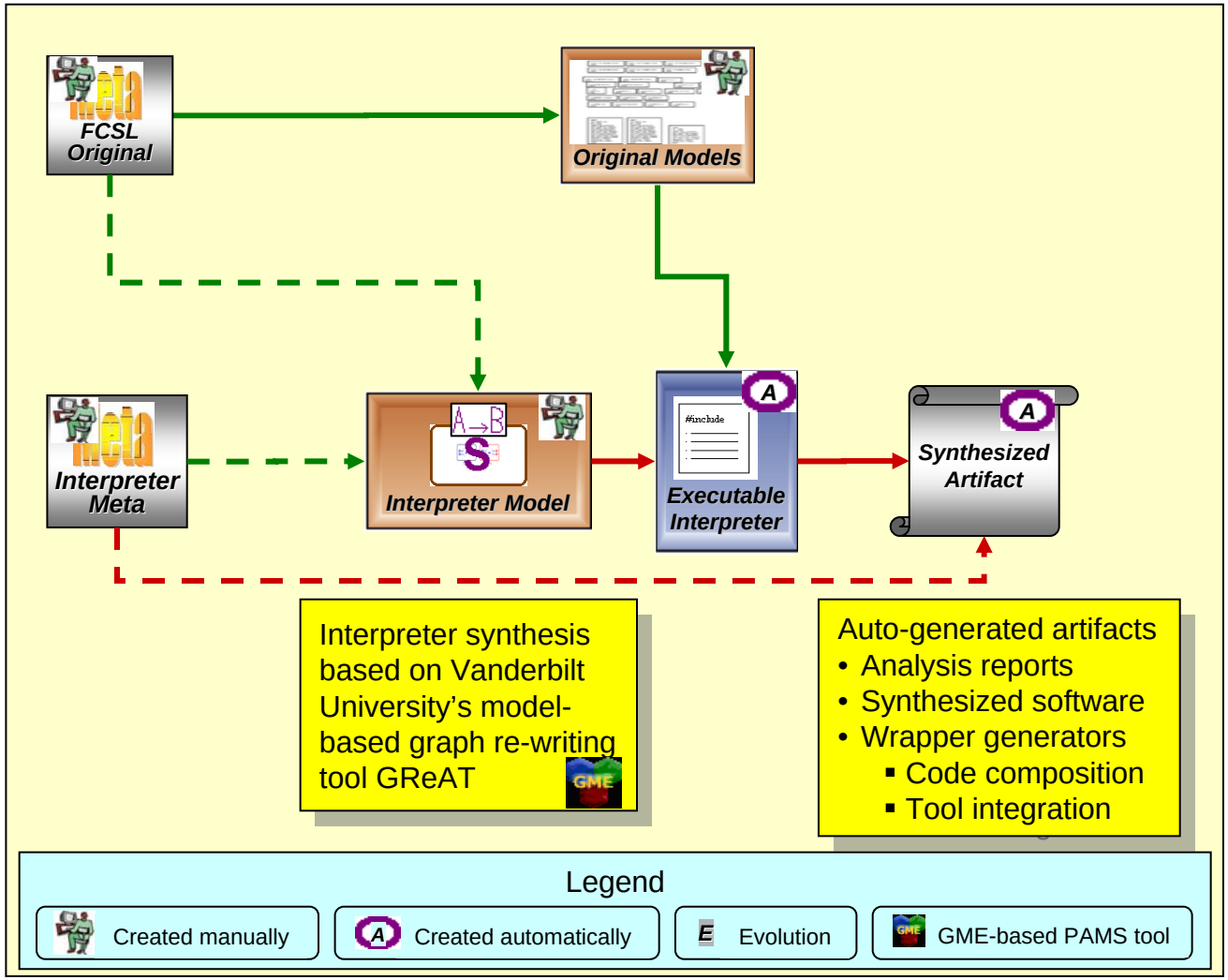
- Model-based interpreters graphically describe usage of information encoded in models



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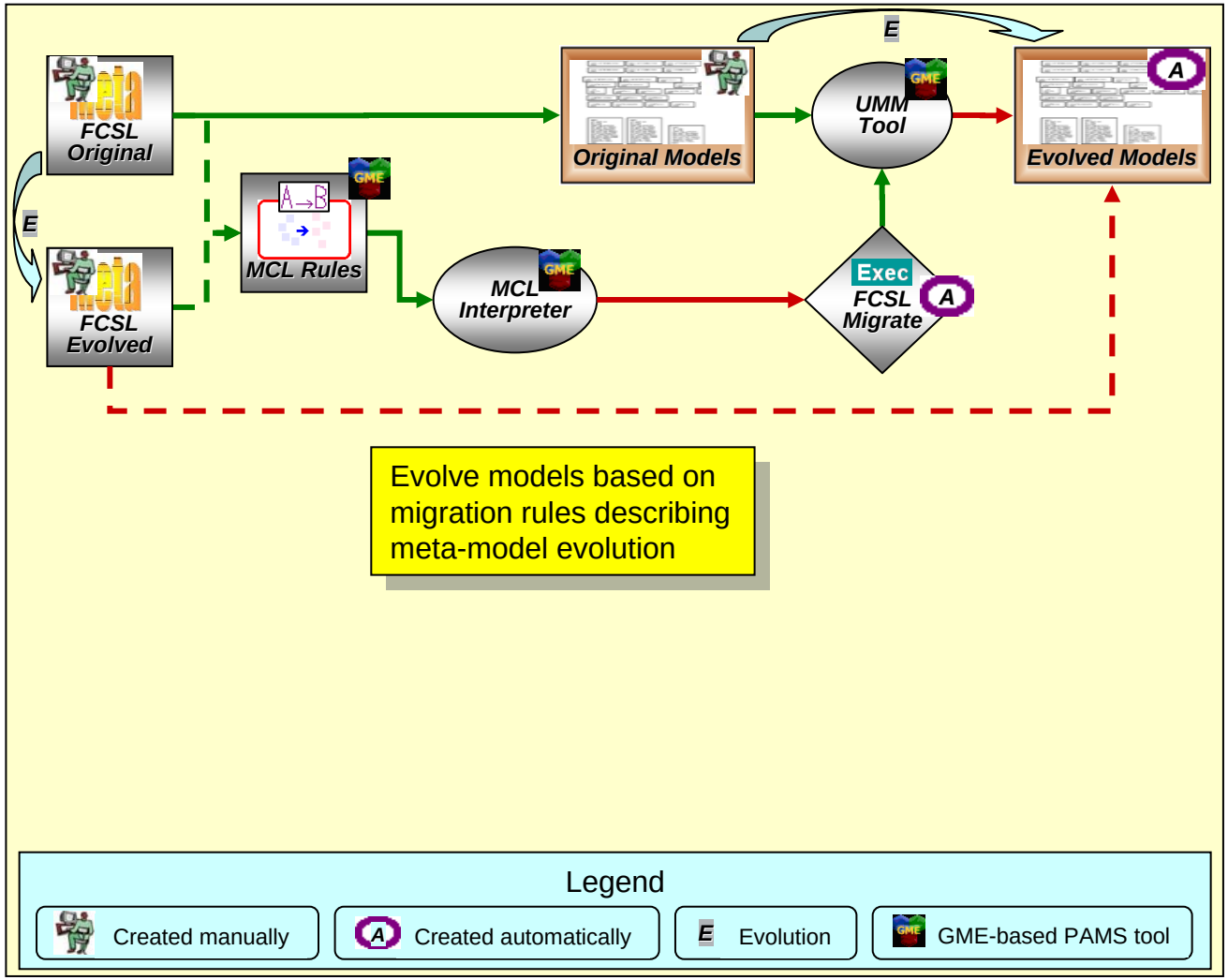
- **PAMS tools:**
  - MCL is a simple but expressive modeling language to specify migration rules describing meta-model evolution
  - MCL interpreters synthesize software to automate model evolution based on MCL rules
  - Universal Model Migrator (UMM) is a GUI-based model evolution engine



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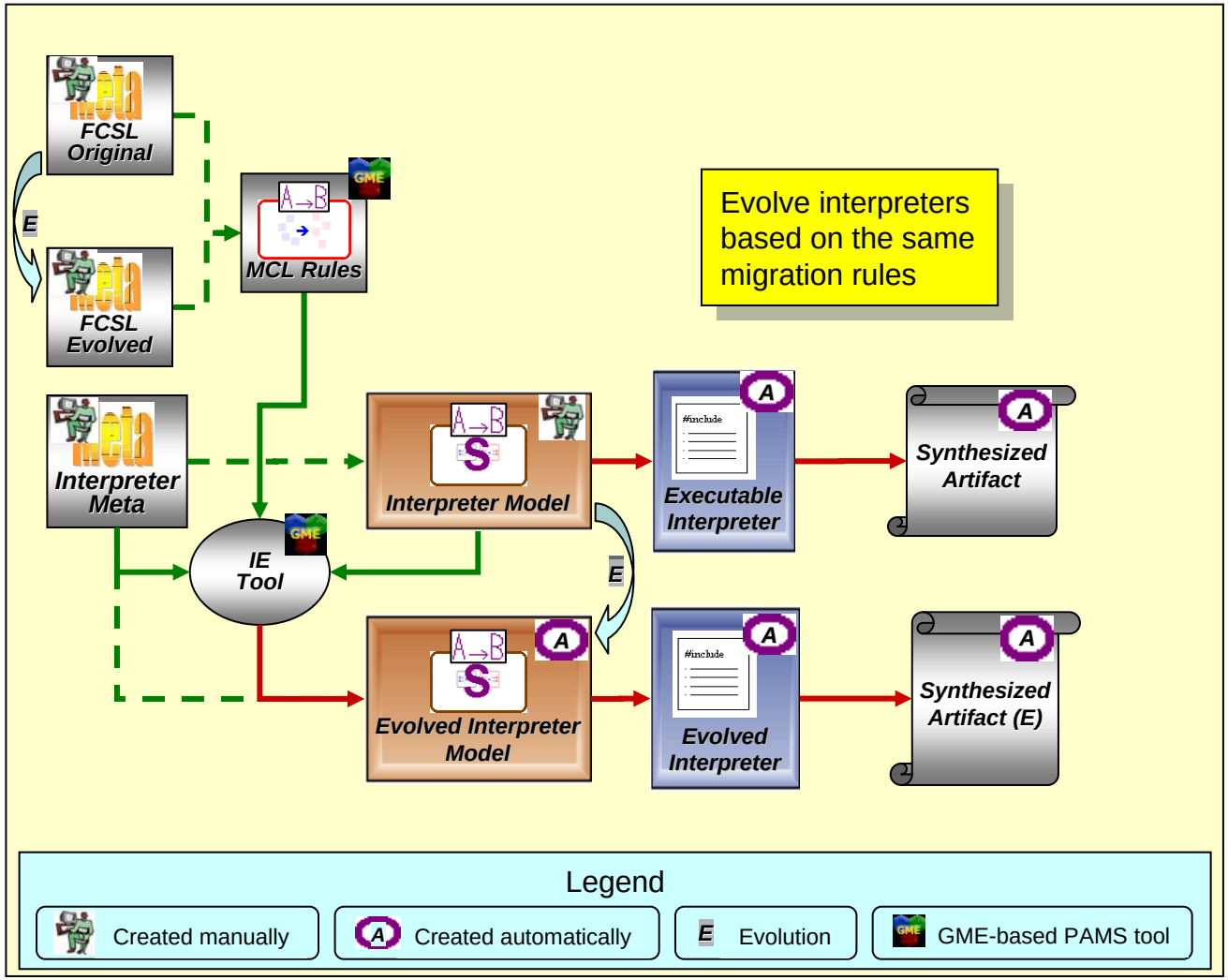

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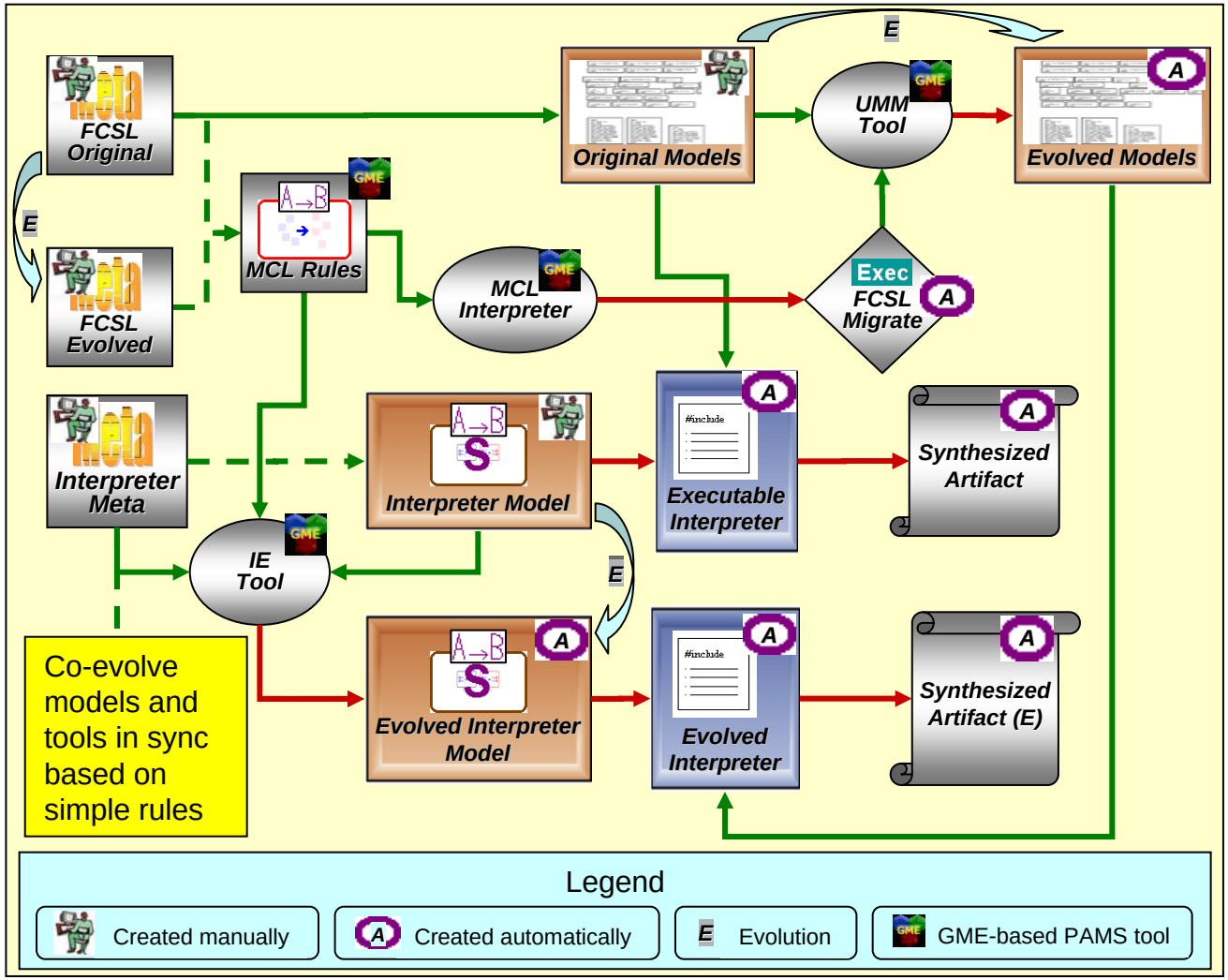
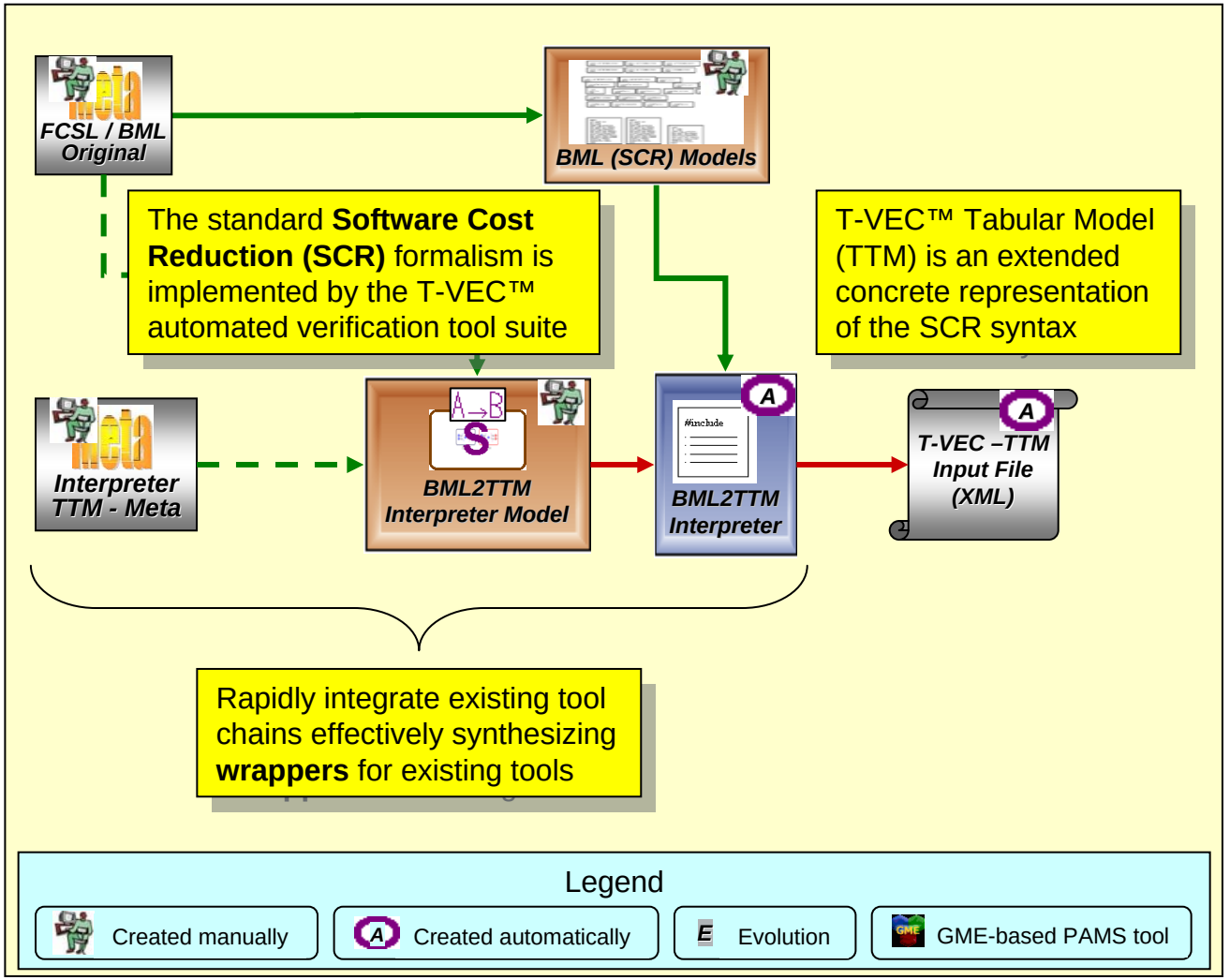


# PAMS Tools Applied to the Verification Problem

- **Software verification problem:**
  - Largest cost and schedule driver for high-confidence software development programs
  - Powerful, state-of-the-art software verification tool chains and methodologies exist but have not been fully embraced by industry
- **Underlying reasons:**
  - Modeling the software abstraction for verification is an “additional / overhead” activity that typically require highly trained specialists
  - Automated verification tools generate an overwhelming volume of artifacts that are difficult to review, maintain and evolve
- **Result:**
  - Modeling, review and configuration management overheads may overwhelm automation benefit

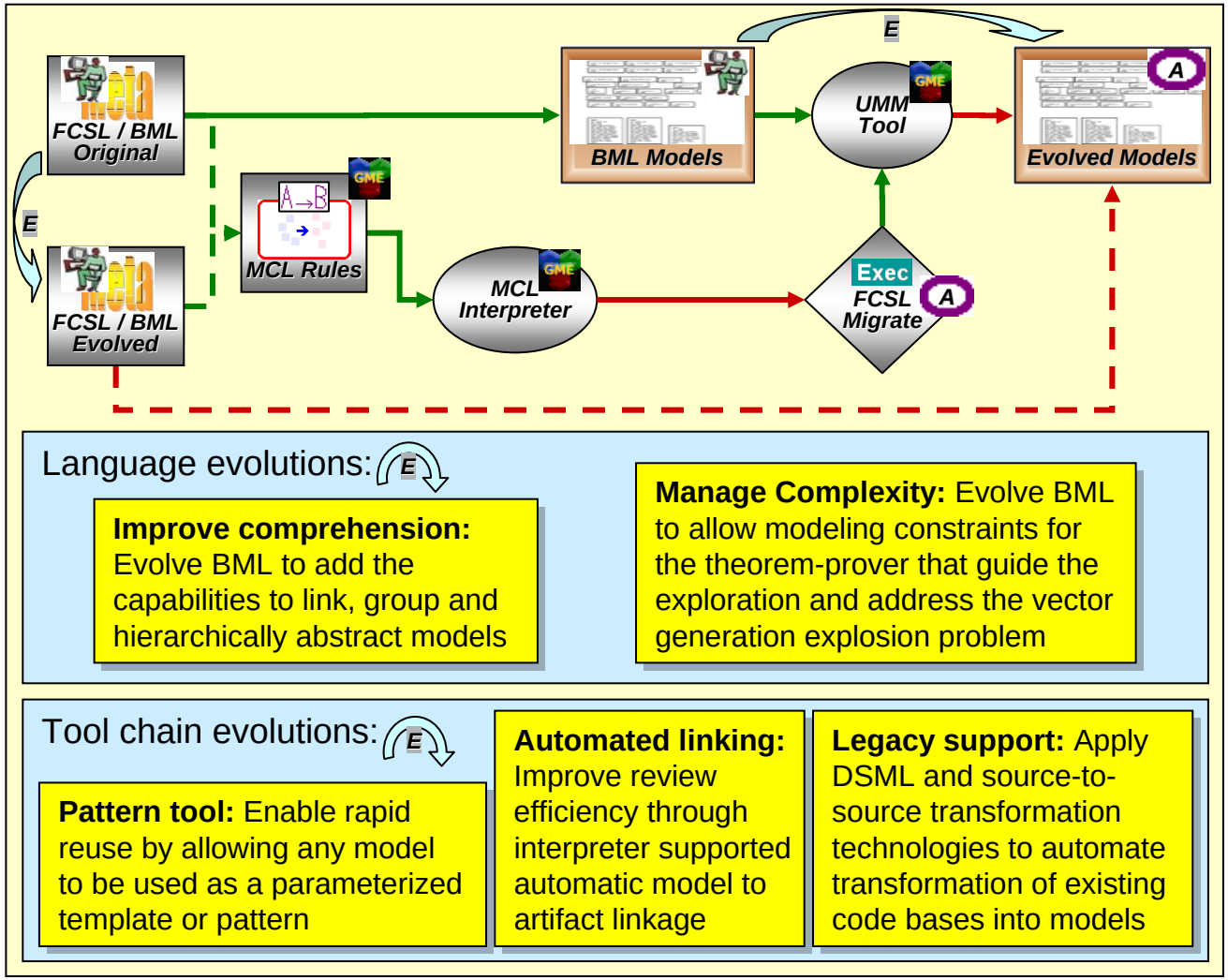
# PAMS Tools Applied to the Verification Problem

- **PAMS approach:**
  - Develop the behavior modeling language (BML) aspect of FCSL to model system specifications in the SCR formalism
  - Apply BML to create our behavior models
  - Develop the interpreter modeling language (TTM-meta) targeting the T-VEC wrapper representation
  - Model the rules to create the BML2TTM interpreter that ingests BML models and produces T-VEC input files
- **Result:**
  - Tool chain that ingests SCR behavior specification models and then drives the T-VEC theorem-provers to automate test vector generation



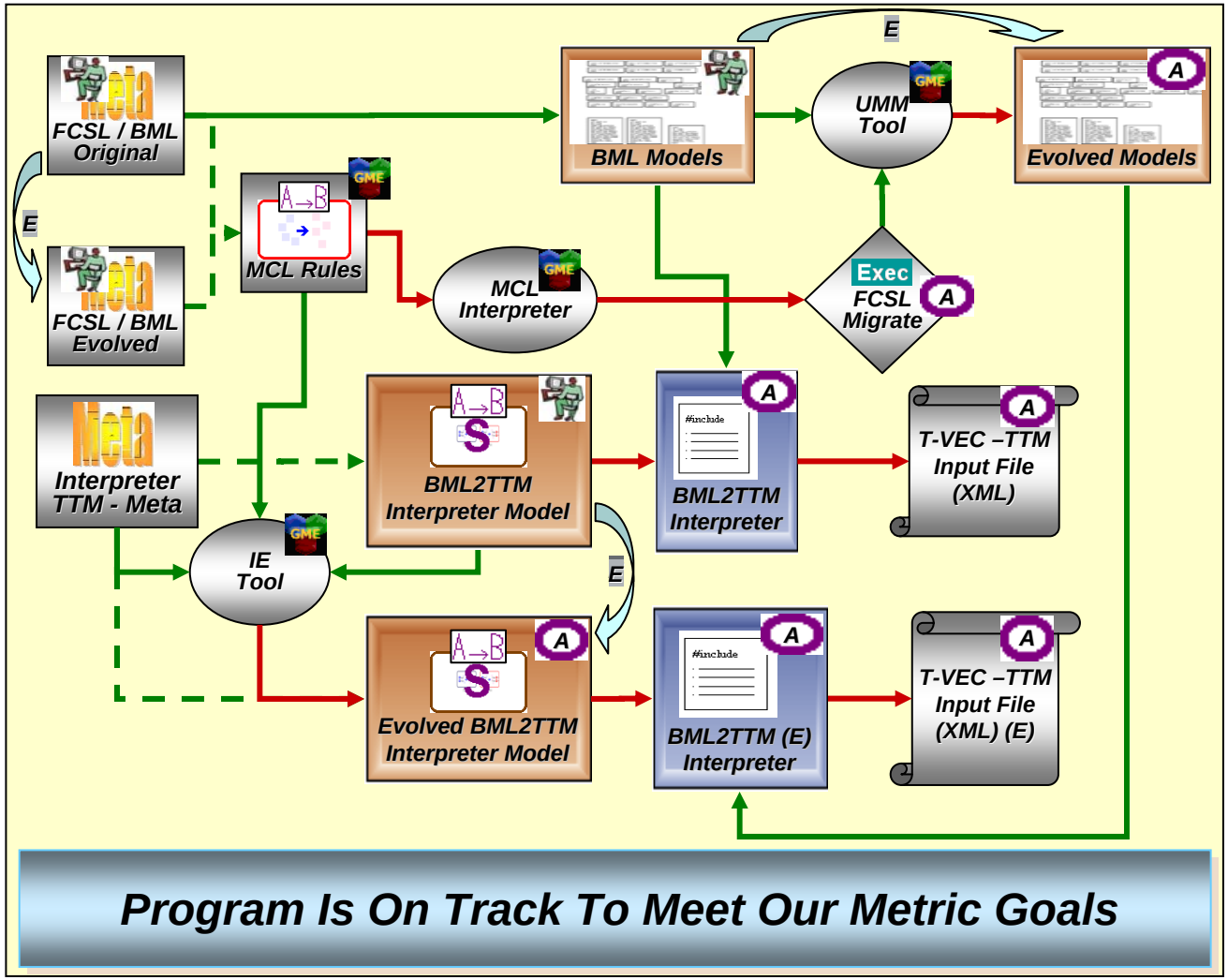
# PAMS Tools Applied to the Verification Problem

- **PAMS evolutions:**
  - Language evolutions to
    - Improve comprehension
    - Manage complexity
  - Tool chain evolution to reduce modeling effort
    - Introducing the active pattern technology
    - Automating generation of model to artifact links
    - Supporting legacy code bases (in progress)
    - Developing generalized evolution technology by synchronously evolving related meta-models (in progress)



# Conclusion

- **PAMS success:**
  - Using the evolved tool chain develop reviewable verification artifacts automatically and efficiently
  - The tool chain and models remain flexible to continuous evolution
- **Next steps:**
  - Better support for evolving legacy code bases
  - Maturing the tool chains to improve understanding of the evolution impacts



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