Model-Based Integration of Reusable Component-Based Avionics Systems

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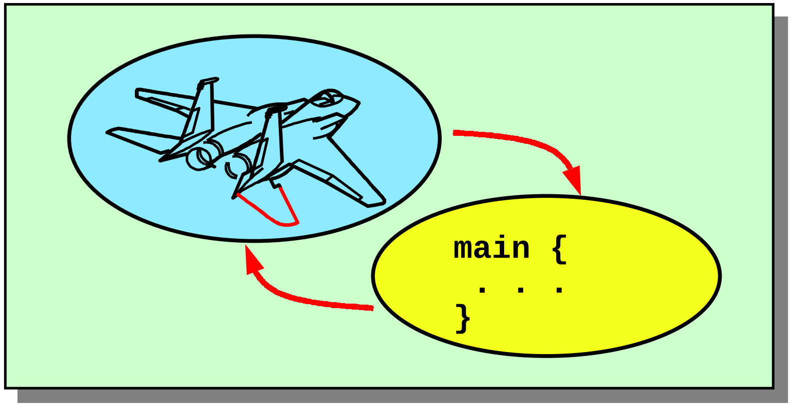
Outline

- DARPA Model-Based Integration of Embedded Software Program Introduction
- Boeing Open Experimental Platform Overview
- Model-Based Integration Vision
  - Context
  - Multi-view Modeling
  - Model-based Analysis
  - Model-based Composition
  - Resultant Process
- Experimentation
- Conclusion

MoBIES Objectives

"The objective of MoBIES is to develop the technology to flexibly integrate the physics of the underlying domain with the embedded software design tools in order to custom-tailor the software process to the application"

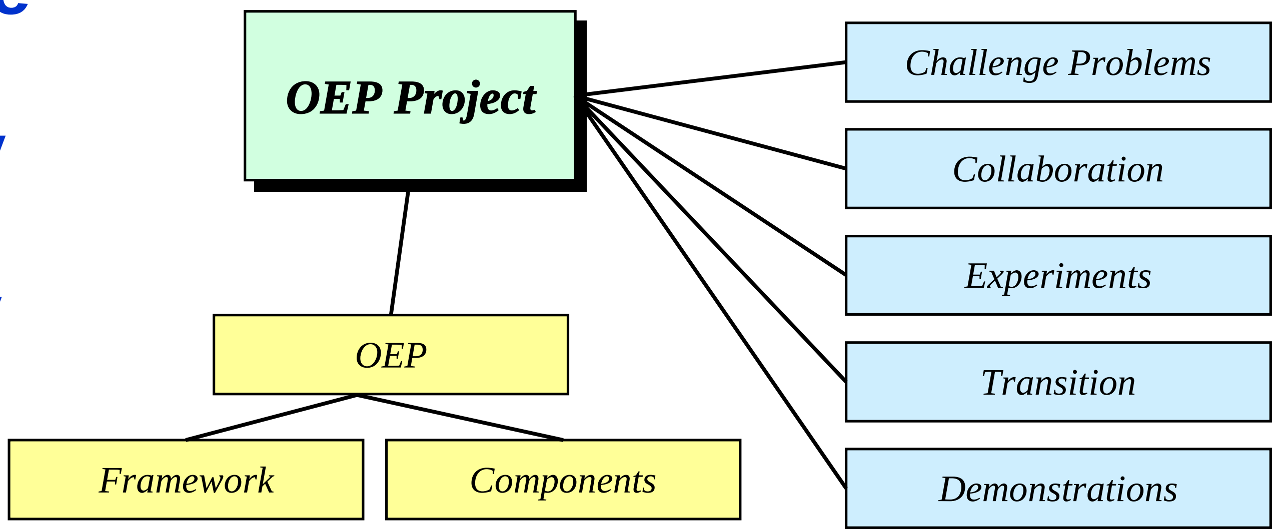


Impact if the Program is Successful:

MoBIES Technology Advance	*Impact for Department of Defense Systems*
Software design tools will be tailored to the application domain	• ***Physical constraints will be automatically integrated: less after-the-fact testing necessary*** • ***Designers can program in their own languages: fewer potential errors*** • ***Fewer bugs due to implementation issues: timing, resources, failures***
Multiple design tools can be integrated in customized, application-specific suites	• ***Commercial tool vendors can provide modular, customized components: COTS tools will be more available and suitable*** • ***Multiple design views can accommodate software collaboration with automated configuration control: fewer errors and reduced integration time.***
Code can be automatically produced with correct-by-construction generators	• ***Larger, more complex programs can be written without the verification and validation (V&V) roadblock*** • ***Reduced time to produce executable code***

Boeing OEP Project Summary

- Develop Open Experimental Platform (OEP)
- Define transitionable challenge problems
- Collaborate with integration technology researchers
- Experiment with and evaluate integration technologies for embedded weapon systems
- Demonstrate technology applicability and affordability



The Avionics Software Integration Challenge

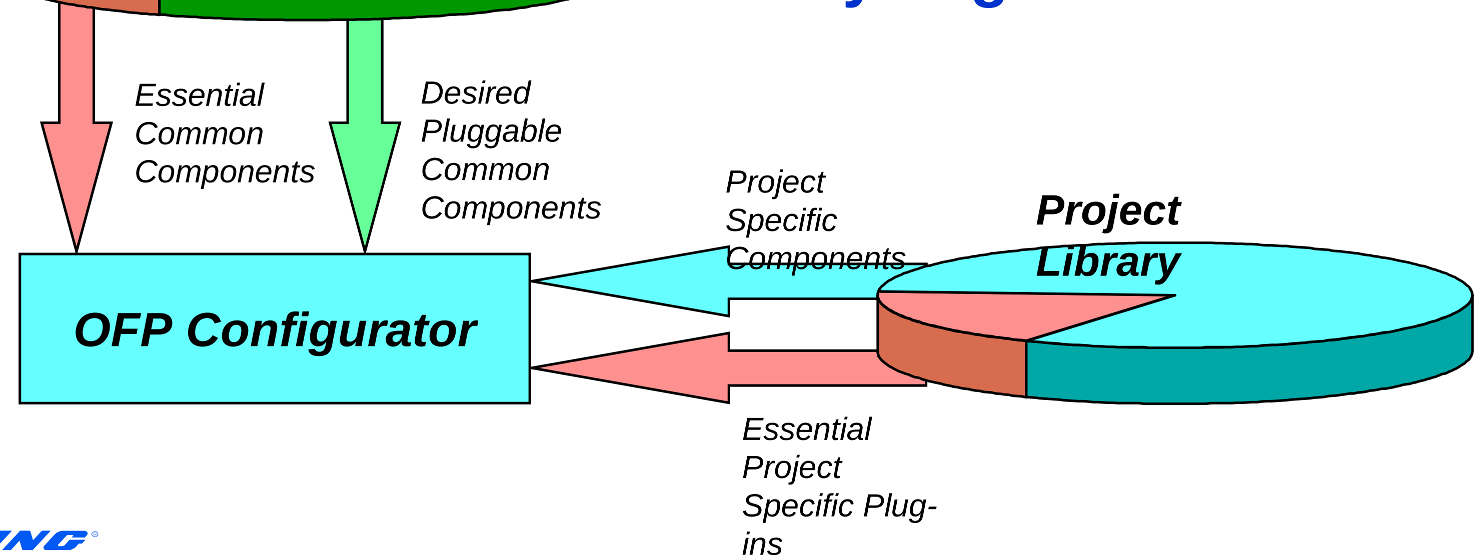
- Reuse-based development approaches can dramatically improve cost, quality and cycle time
- Cross-cutting extra-functional properties are endemic to embedded real-time systems and hinder reuse

How do we compose systems from reusable components while satisfying large-scale embedded system requirements?

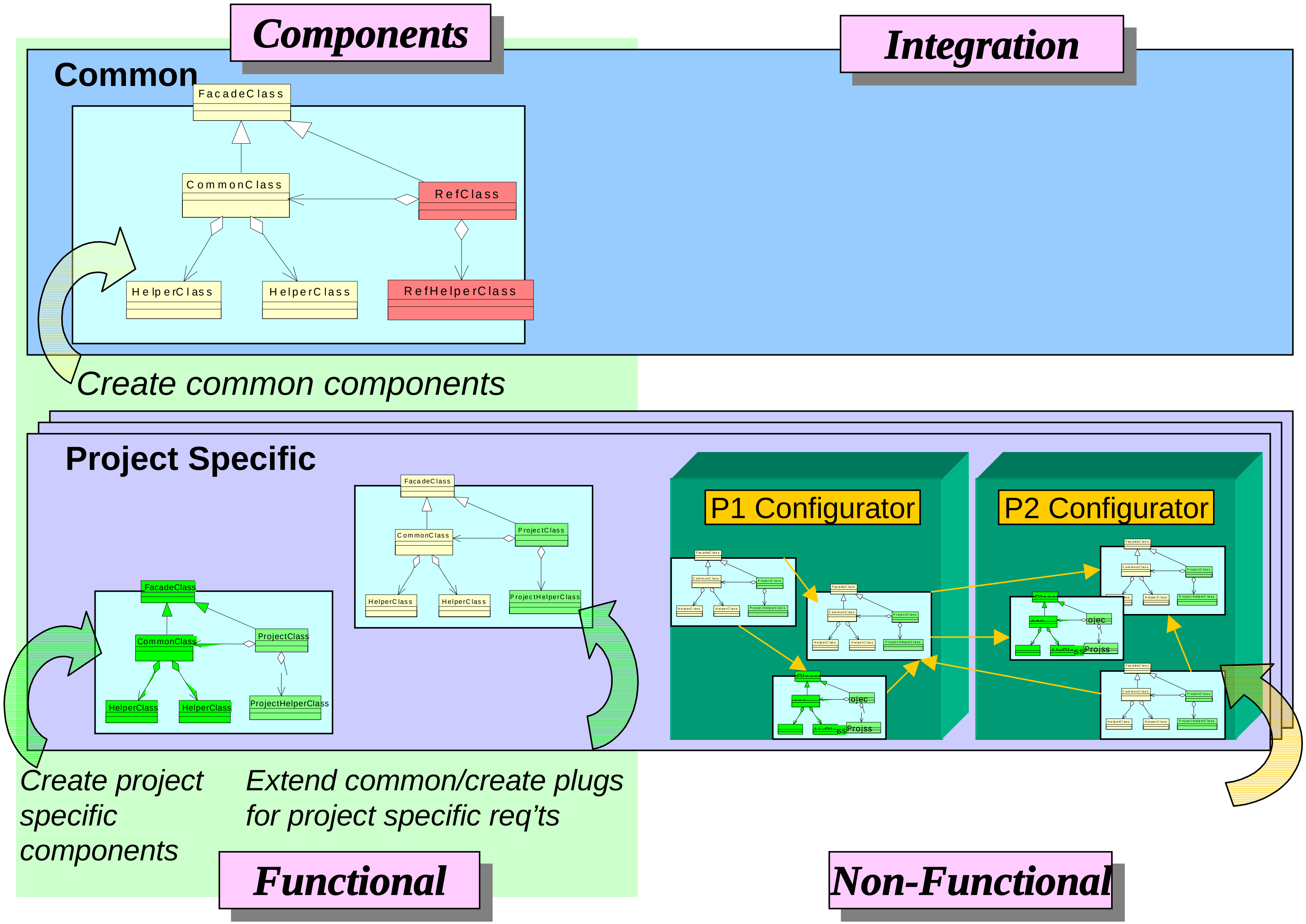
- Including
  - –Hard and soft real-time deadlines
  - –Fault tolerance
  - –Distribution…

Context

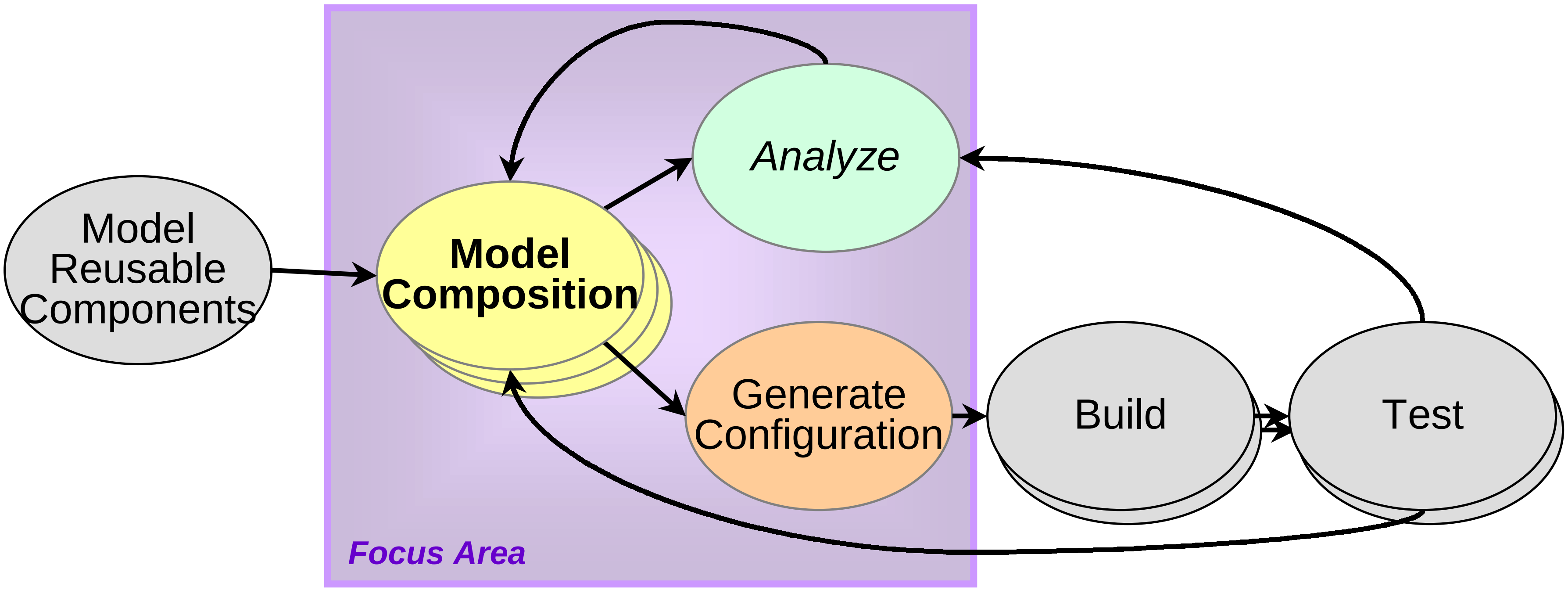
- **Successful transition requires insertion of technology into existing process**
  - **Extend existing tools**
  - **Add new tools where needed**
- **Boeing Bold Stroke initiative**
  - **Existing open systems architecture based product line for avionics systems**
  - **Reusable components**
- **UML/Rational Rose**
- **Leverage existing work by engineers**



Product Line Development



Model-Based Component Integration Approach

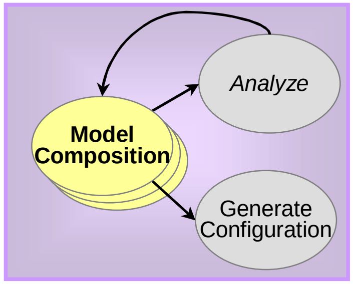


Challenges for Model-Based Component Integration

- **Multi-view modeling**
  - Represent system features that impact cross cutting constraints in feature-appropriate models
    - Process view models
    - Deployment view models
  - Integrate multiple views
- **Model-based analysis**
  - Apply analytic methods to the design models to ensure satisfaction of cross cutting embedded constraints
- **Model-based system configuration**
  - Use system models to generate integration code needed to assemble a system from components

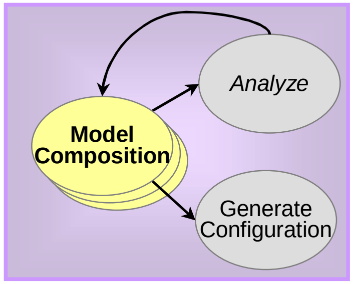
Process Related Views

- Logical fault management
  - Operational and backup modes and components
  - Components that need replicated backups
- Execution dependencies
  - Triggers and trigger types
  - Trigger based dependency graphs
  - Execution rates for the roots of dependencies
- Threads
  - Threads and their associated rates and priorities



Deployment Related Views

- Physical fault management
  - Relationships between fault modes and physical resources
- Component quality of service
  - Execution rates
  - Importance
  - Resources requirements

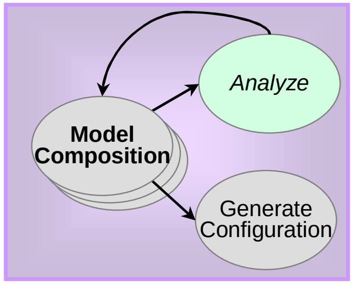


- Process
  - System physical resources
  - Allocation of threads to processes
- Component allocation
  - Components that are strongly coupled
  - Allocation of components to processors and processes
  - Parameters for automatic generation of integration code
    - Identify and generate CORBA stubs and skeletons as needed

Model-Based Analysis

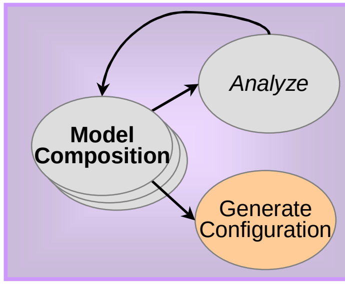
Having models that capture cross-cutting aspects of a system is the basis for analysis

- **Fault-tolerance**
  - **Determine status of components in various fault scenarios**
  - **Support allocation of backup components to processors to meet fault-tolerance goals**
- **Execution dependencies**
  - **Identifying cyclic dependencies**
  - **Ensuring consistency of dependency graphs**
  - **Using dependency graphs to identify execution requirements for timing analysis**
- **Timing analysis**
  - **Schedulability**
  - **Utilization**

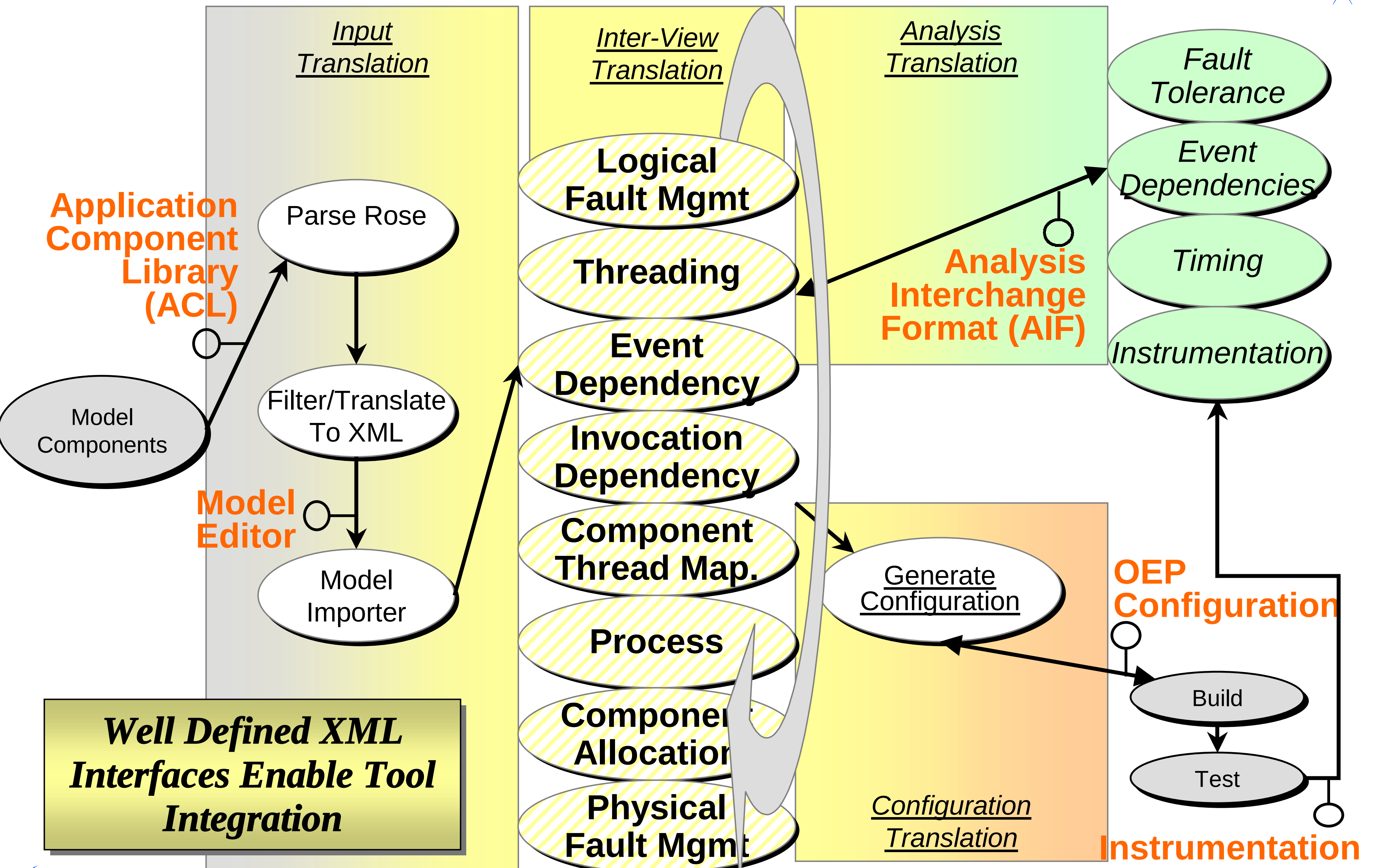


Model-Based Configuration

- **Automatic generation of configuration code based on models can yield increased speed and quality and reduced cost**
  - **Manual creation of integration code is time consuming, tedious and error prone**
  - **Much integration code is fully determined by a model of the system configuration**
  - **Tools already exist that generate much similar code**
    - **CORBA IDL compilers, etc.**



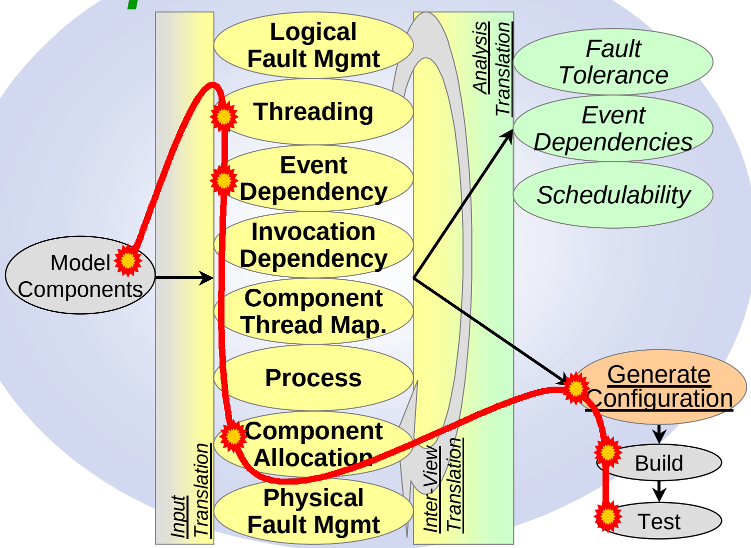
Resultant Process



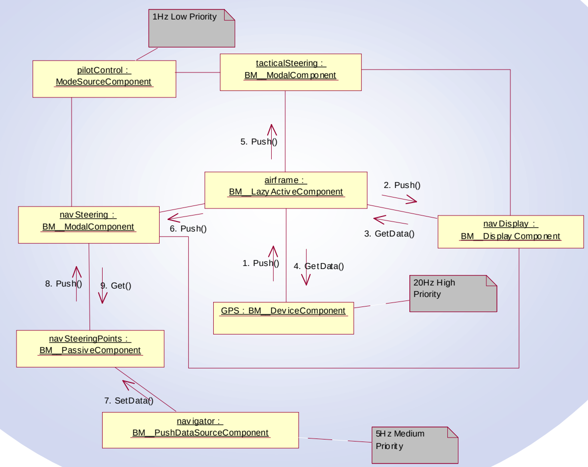
Well Defined XML Interfaces Enable Tool Integration

Experimentation Approach

Development Scenarios and …



Product Scenarios…

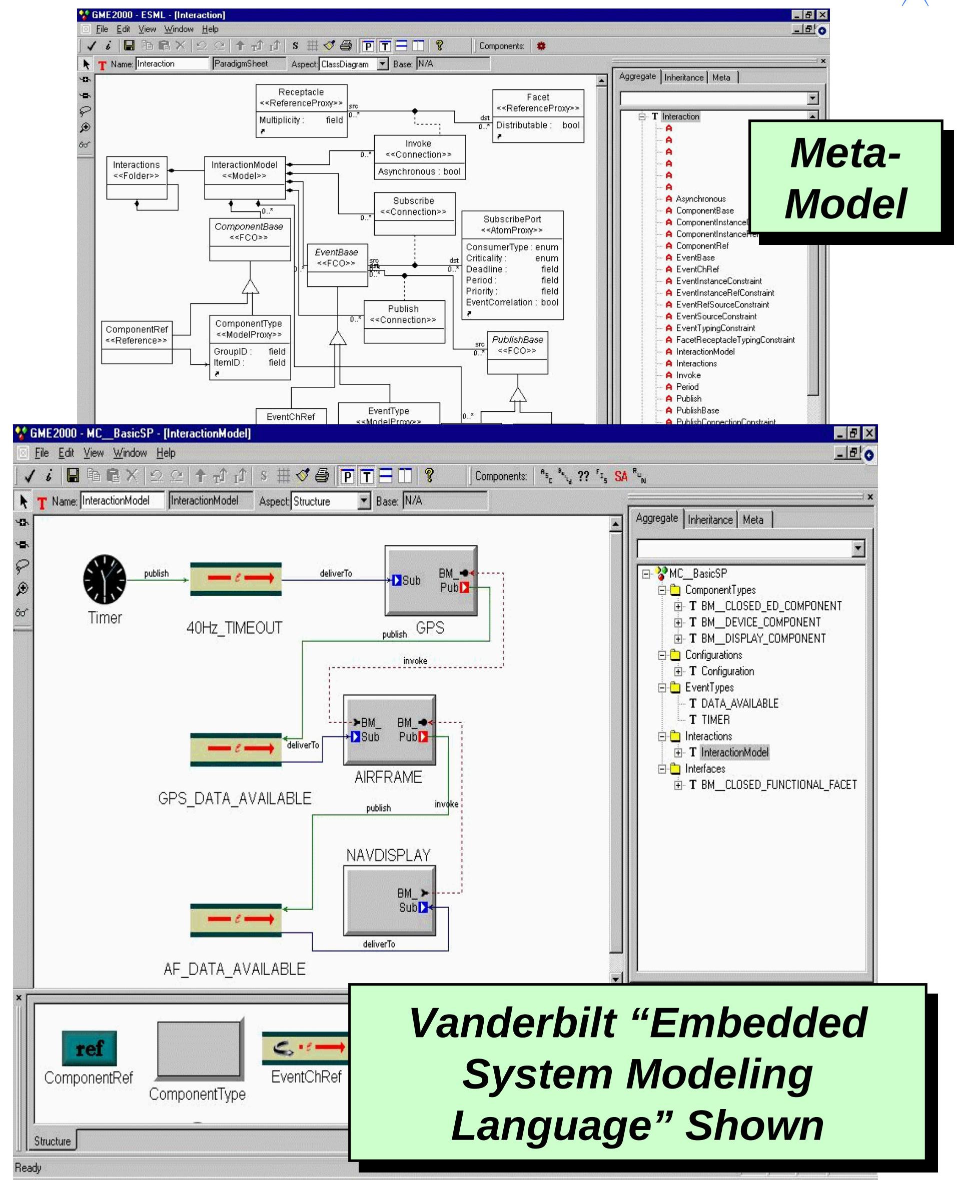


…Comprise Experiments

	PS 1 *Basic Single*	**PS 2** *Rep. Single*	**PS 3** *Basic Dist.*	**PS 4** *Rep. Dist.*
DS 1 *Basic*	**Exp 1-1**			
DS 2 *Evt Analysis*	**Exp 2-1**	**Exp 2-2**	**Exp 2-3**	**Exp 2-4**
DS 3 *Scheduling*	**Exp 3-1**	**Exp 3-2**	**Exp 3-3**	**Exp 3-4**
DS 4 *Fault Toler.*			**Exp 4-3**	**Exp 4-4**
DS 5 *Full*			**Exp 5-3**	**Exp 5-4**

Experimentation Results

- **Demonstrated capability to:**
  - Model multiple views
  - Perform timing analysis
  - Generate configuration code
  - Initialize and run configured system
- **… Using an integrated set of tools from multiple researchers**

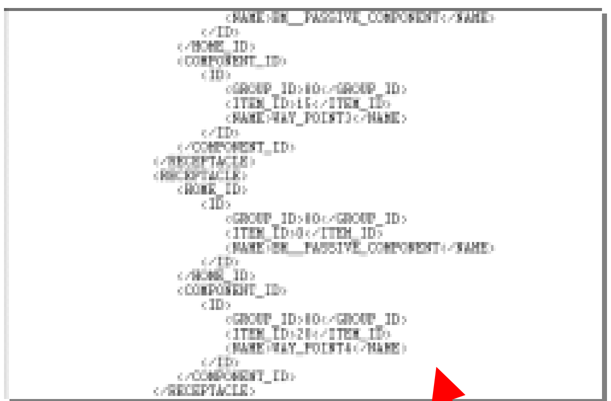


Current Status

- **Heavy Focus Now On Preparing For Transition Of *Component-Oriented Programming***
  - **Filling in capability gaps**
  - **Increasing scalability, usability…**
  - **Optimizing run-time performance**
- **Realistic evaluation of**
  - **Overall approach**
  - **Integrated tool sets**
  - **Individual tools**

Conclusions

- **Model-based integration technologies promise dramatic advances in component-based system quality, affordability, and timeliness**
  - **Integrated tool support**
  - **…for component-based product line development**
  - **…satisfying cross-cutting constraints**
- **…And address unmet needs of product integrators**
  - **Automates many manual steps**
  - **Predicts system correctness prior to construction**

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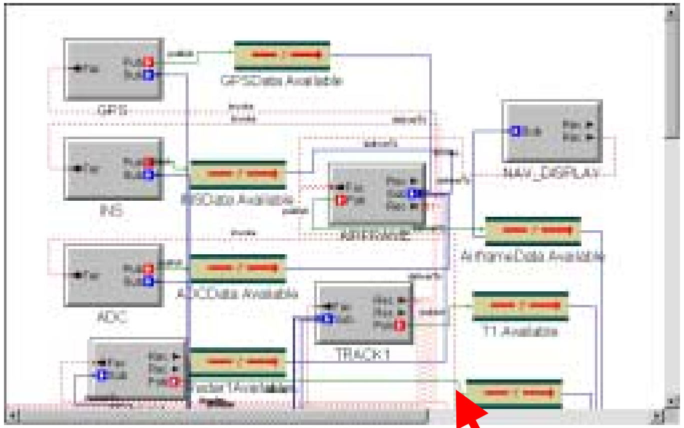

Medium scenario, 3000+ lines **Medium scenario, 2 interaction diagrams in ESML**