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The SAE AADL Standard - An Architecture Analysis & Design Language for Embedded Real-Time Systems

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Tutorial Objectives

- *Provide* an overview of the SAE AADL Standard
- *Introduce* architecture-based development concepts
- *Provide* a summary of AADL notation capabilities
- *Give* an overview of AADL tools

Outline: An Introduction & Overview

- Overview of SAE AADL Standard
- Model-Based Architecture-Driven System Engineering
- AADL-Based Development Environment
- Case Studies
- AADL Language Concepts
- Open Source AADL Tool Environment
- UML Profile of AADL
- Summary

SAE Architecture Analysis & Design Language (AADL)

- Specification of
  - Real-time
  - Embedded
  - Fault-tolerant
  - Securely partitioned
  - Dynamically configurable
- Software task and communication architectures
- Bound to
  - Distributed multiple processor hardware architectures
- Fields of application
  - Avionics, Automotive, Aerospace, Autonomous systems, …

An SAE Standard

- Based on 15 Years of DARPA funded technologies
- Core language standard has been approved
- Sponsored by
  - SAE International
  - Avionics Systems Division (ASD)
  - Embedded Systems (AS2)
  - AADL Subcommittee (AS-2C)
- Contact
  - Bruce Lewis AS-2C chair, bruce.a.lewis@us.army.mil
  - http://www.aadl.info
  - For Information email to info@aadl.info

SAE AS-2C AADL Subcommittee

- Bruce Lewis (US Army AMRDEC): Chair
- Peter Feiler (SEI): technical lead, author & editor
- Steve Vestal (Honeywell): co-author
- Ed Colbert (USC): UML Profile of AADL
- Joyce Tokar (Pyrrhus Software): Ada & C Annex

Other Voting Members

- Boeing, Rockwell, Honeywell, Lockheed Martin, Raytheon, Smith Industries, General Dynamics, Airbus, Axlog, European Space Agency, TNI, Dassault, EADS, High Integrity Solutions

Coordination with

- NATO Aviation, NATO Plug and Play, French Government COTRE, SAE AS-1 Weapons Plug and Play, OMG UML & SysML

Potential Users

- Airbus
  - New System Engineering Approach incorporates AADL
- European Space Agency
  - Modeling of Satellite Systems, Architecture Verification - ASSERT
- Rockwell Collins
  - Modeling of Avionics Computer System
- Lockheed Martin
- Smith Industries
  - Embedded System Engineering & AADL
- Raytheon
- Boeing FCS
- Common Missile
  - Apply AADL for systems integration modeling & analysis
- System Plug and Play
  - NATO/SAE AS1 Weapon System Integration

AADL Status

- Requirements document SAE ARD 5296
  - Input from aerospace industry
  - Balloted and approved in 2000
- SAE AADL document SAE AS 5506
  - Core language approved by SAE Sept 2004
- In review to be balloted Fall 2004
  - Graphical AADL notation
  - UML profile of AADL for UML1.4 and UML 2.0
  - XMI domain model, XML schema
  - Ada and C Annex
- In development
  - Error Model Annex
  - ARINC 653 Annex

MetaH: Proof of Concepts for AADL

1991 DARPA DSSA program begins
1992 Partitioned PFP target (Tartan MAR/i960MC)
1994 Multi-processor target (VME i960MC)
1995 Slack stealing scheduler
1998 Portable Ada 95 and POSIX middleware configurations
1998 Extensibility through MetaH-ACME Mapping
1998 Reliability modeling extension
1999 Hybrid automata verification of core middleware modules

Numerous evaluation and demonstration projects, e.g.

- Missile G&C reference architecture, demos, others (AMCOM SED)
- Hybrid automata formal verification (AFOSR, Honeywell)
- Missile defense (Boeing)
- Fighter guidance SW fault tolerance (DARPA, CMU, Lockheed-Martin)
- Incremental Upgrade of Legacy Systems (AFRL, Boeing, Honeywell)
- Comanche study (AMCOM, Comanche PO, Boeing, Honeywell)
- Tactical Mobile Robotics (DARPA, Honeywell, Georgia Tech)
- Advanced Intercept Technology CWE (BMDO, MaxTech)
- Adaptive Computer Systems (DARPA, Honeywell)
- Avionics System Performance Management (AFRL, Honeywell)
- Ada Software Integrated Development/Verification (AFRL, Honeywell)
- FMS reference architecture (Honeywell)
- JSF vehicle control (Honeywell)
- IFMU reengineering (Honeywell)

AADL in Context

Research ADLs

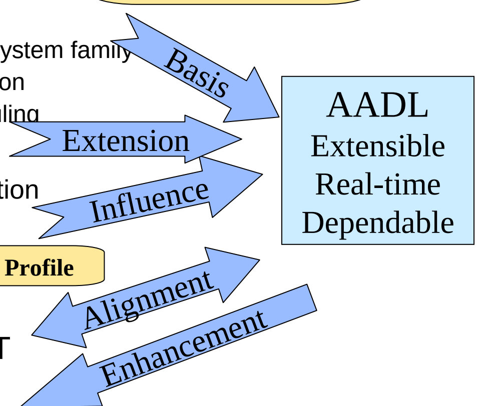
DARPA Funded Research since 1990

- MetaH
  - Real-time, modal, system family
  - Analysis & generation
  - RMA based scheduling
- Rapide, Wright, ..
  - Behavioral validation
- ADL Interchange
  - ACME

UML Profile

Industrial Strength

- UML 2.0, UML-RT
- HOOD/STOOD
- SDL



Airbus & ESA

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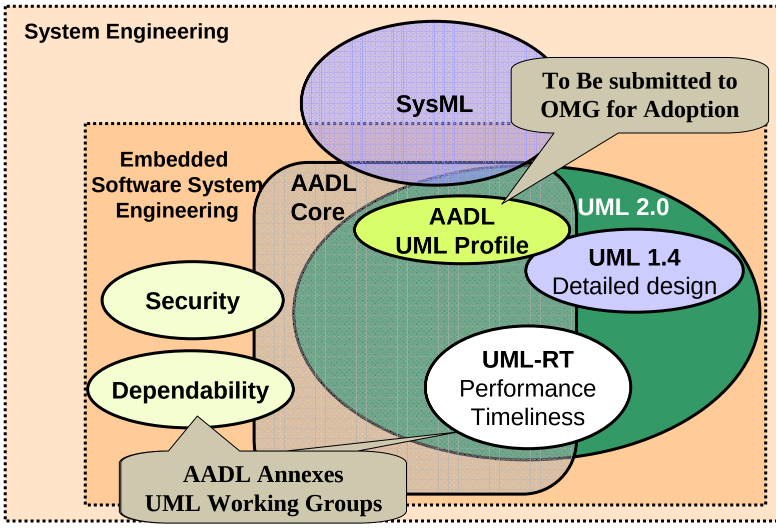
AADL/UML Relationship



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Outline: An Introduction & Overview

- Overview of SAE AADL Standard
- ➡ Model-Based Architecture-Driven System Engineering
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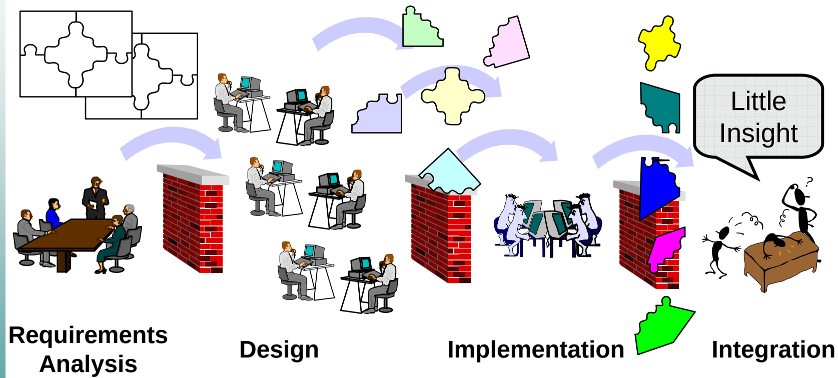
Typical Software Development Process

Manual, Paper Intensive, Error Prone, Resistant to Change



High Development & Maintenance Cost

High Risk System Integration

Embedded Systems Development Concerns

- Incomplete capture of specification and design
- Little insight into non-functional system properties until system integration & test
  - Performance (e.g., Throughput, Quality of Service)
  - Safety - Reliability
  - Time Critical - Security
  - Schedulability - Fault Tolerance
- System Integration - high risk
- Evolvability – very expensive
- Life Cycle Support – very expensive
- Leads to rapidly outdated components

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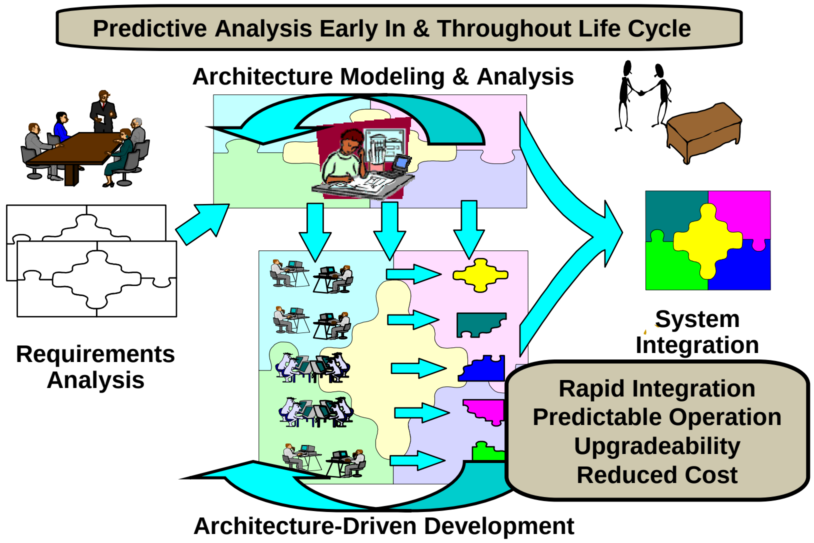
Model-Based System Engineering



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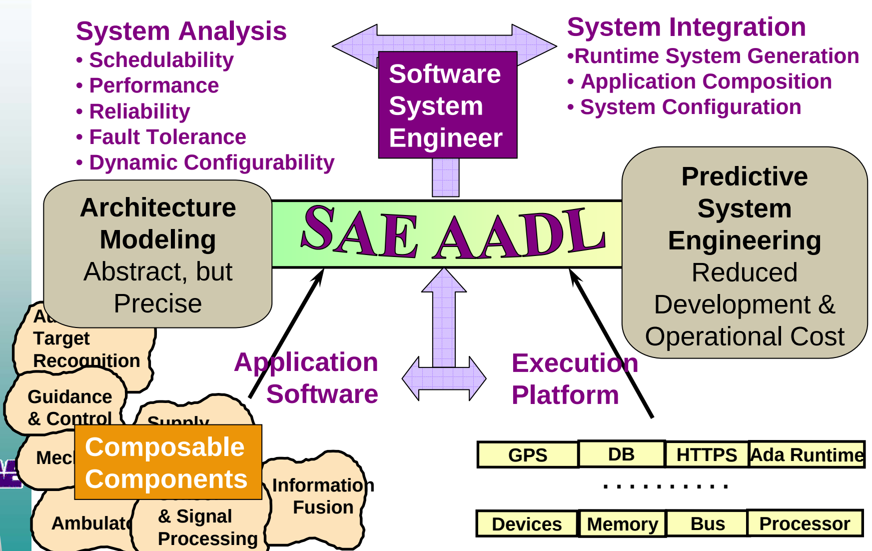
AADL-Based System Engineering



Focus Of SAE AADL

- Component View
  - Model of system composition & hierarchy
  - Well-defined component interfaces
- Concurrency & Interaction View
  - Time ordering of data, messages, and events
  - Dynamic operational behavior
  - Explicit interaction paths & protocols
- Execution view
  - Execution platform as resources
  - Binding of application software
  - Specification & analysis of runtime properties
    - timeliness, throughput, reliability, graceful degradation, …

What Is Involved In Using The AADL?

- Specify software & hardware system architectures
- Specify component interfaces and implementation properties
- Analyze system timing, reliability, partition isolation
- Tool-supported system integration
- Verify source code compliance & middleware behavior

Model and analyze early and throughout product life cycle

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Evolutionary Development

- A control systems simulation perspective
- A model-based architecture perspective
- An integrated perspective

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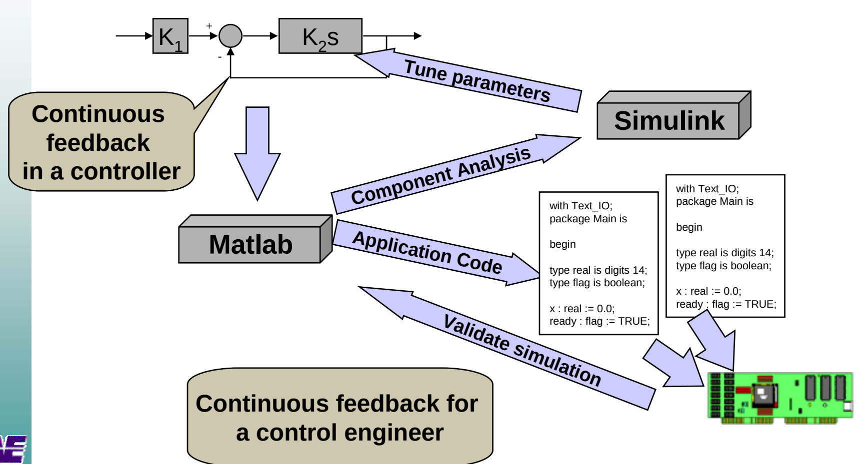
A Control Engineer Perspective



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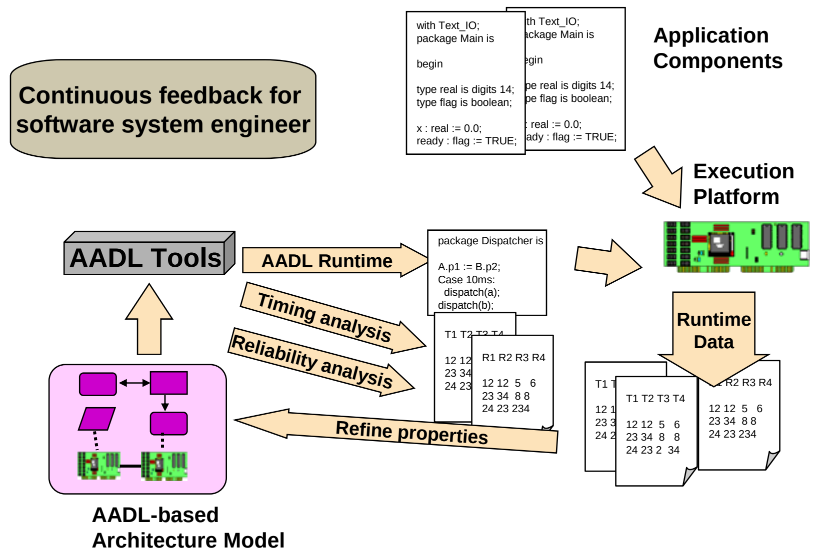
A Software System Engineer Perspective



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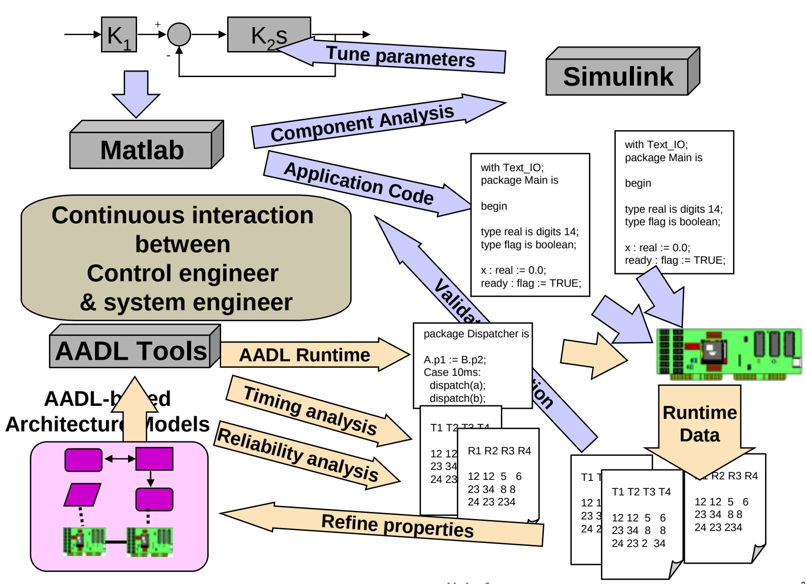
A Combined Perspective



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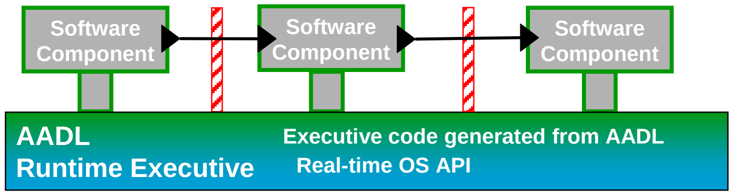
Partitioning of Responsibilities: The Application Engineer

Application design perspective

Data content properties
Stream completeness characteristics
Phase delay & timeliness



Application implementation perspective

Ports accessible as variables
Port variable values not overwritten during execution
Control flow via events & messages
Initialize, activate, deactivate, compute, recover, finalize entrypoints

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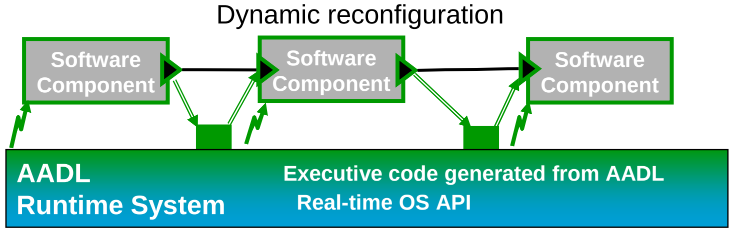
Partitioning of Responsibilities: The Software System Engineer

Task & Communication Perspective

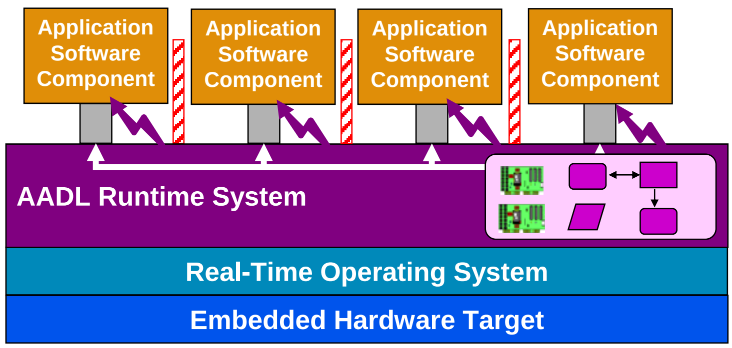
Task dispatch & deadlines
Timely & deterministic communication
Dynamic reconfiguration



Runtime System perspective

Rate groups, priorities & dispatch order
Coordinated dispatch & communication
Double buffering where necessary
Shared variables where appropriate

A Partitioned Portable Architecture



Strong Partitioning

- Timing Protection
- OS Call Restrictions
- Memory Protection

Interoperability/Portability

- Tailored Runtime Executive
- Standard RTOS API
- Application Components

Predictable System Integration

- Requirements, predicted, and actual properties
- Application components designed against functional and non-functional properties
- Application code separated from task dispatch & communication code
- Consistency between task & communication model and implementation through generation
- Feedback into model parameters: refinement of estimated performance values

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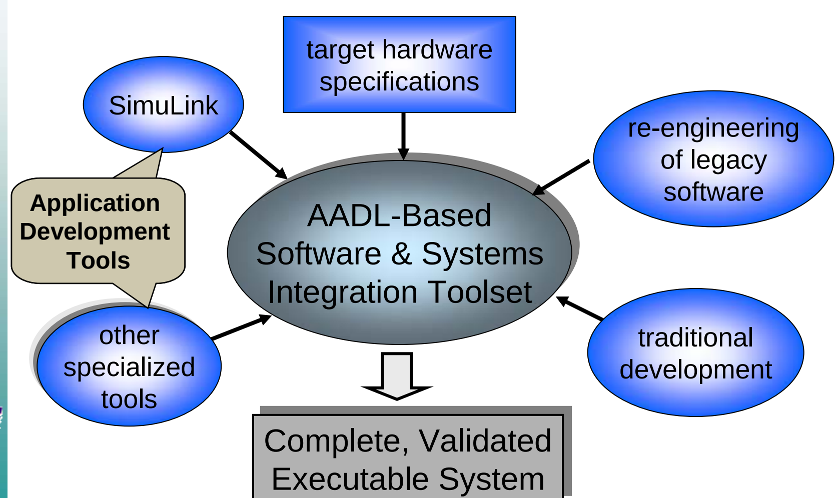
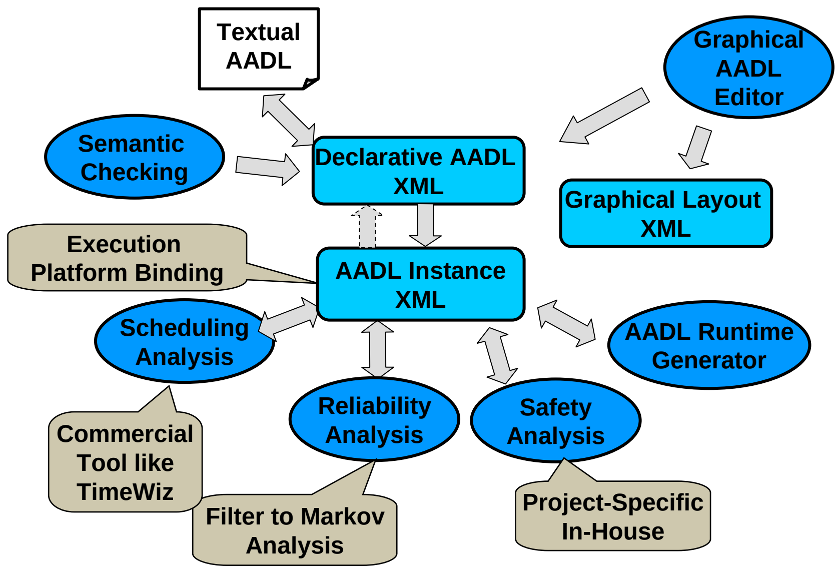
Application Development Environment



An XML-Based AADL Tool Strategy



Two-Tier Tool Strategy

- Open Source AADL Tool Environment (OSATE)
  - Developed by SEI
  - Low entry cost solution (no cost GPL)
  - Multi-platform based on Eclipse
  - Prototyping environment for project-specific analysis
  - Architecture research platform
- Commercial Tool Support
  - UML tool environment extension based on UML profile
  - Extension to existing modeling environment with AADL export/import
  - Analysis tools interfacing via XML or XML to native filter
  - Runtime system generation tools

Open Source AADL Tool Environment

- OSATE is
  - Developed by the Software Engineering Institute
  - Available at under a no cost General Purpose License (GPL)
  - Implemented on top of Eclipse Release 3 (www.eclipse.org)
  - Generated from an AADL meta model
  - A textual & graphical AADL front-end with semantic & XML/XMI support
  - Extensible through architecture analysis & generation plug-ins
- OSATE offers
  - Low cost entrypoint to the use of SAE AADL
  - Platform for in-house prototyping of project specific architecture analysis
  - Platform for architecture research with access to industrial models & industry exposure to research results

Potential Tool Support Areas

- Architecture extraction/import from existing representations
  - UML designs, Simulink models, application code
- Requirements tracing to the AADL design
- Non-functional properties analysis
  - Scheduling, Real-time Simulation, Throughput, Latency, Concurrency, Reliability, Security, Safety, …
- AADL Architecture consistency analysis
  - High/low risk patterns and properties
- AADL Design Risk Assessment
- AADL Architectural Design Optimizer and Quality Metrics
- Auto-document Generation
- Runtime system generation & optimization

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Two Case Studies

- Pattern-based analysis of systemic issues
  – Modernized avionics system architecture
  – Change in real-time architecture concepts
- Full-scale analysis & integration
  – Port of missile guidance system
  – Tool-supported analysis & generation

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AADL-Based Pattern Analysis

- SAE AADL employs
  - Components with precisely defined execution semantics
  - Explicit component interactions
  - Separation of concerns
- Pattern-based architecture analysis approach
  - Uses design patterns in analysis
  - Identifies systemic problems early
  - Enables the right choices with confidence
  - Provides analysis-based decisions

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An Avionics System Case Study

- Migration from static timeline to preemptive scheduling
  - Identified issues with shared variable communication
  - Migration potential from polling tasks to event-driven tasks
- Flexibility, predictability & efficiency of port-based communication
  - Support for deterministic transfer & optimized buffers
- Effectiveness of connection & flow semantics
  - Bridge to control engineers
  - Insulate from partition scheduling decisions
  - Support end-to-end latency analysis
- Analyzable fault-tolerant redundancy patterns
  - Orthogonal architecture view without model clutter

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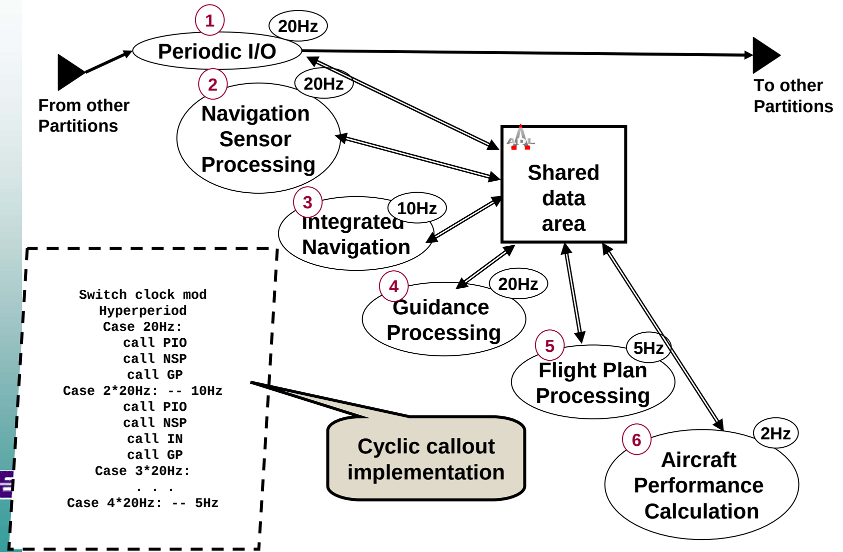
A Cyclic Executive Implementation



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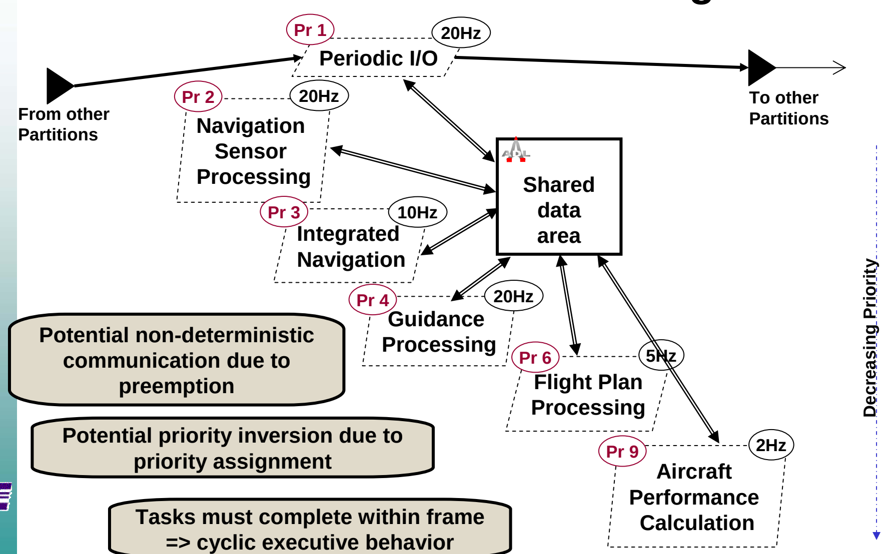
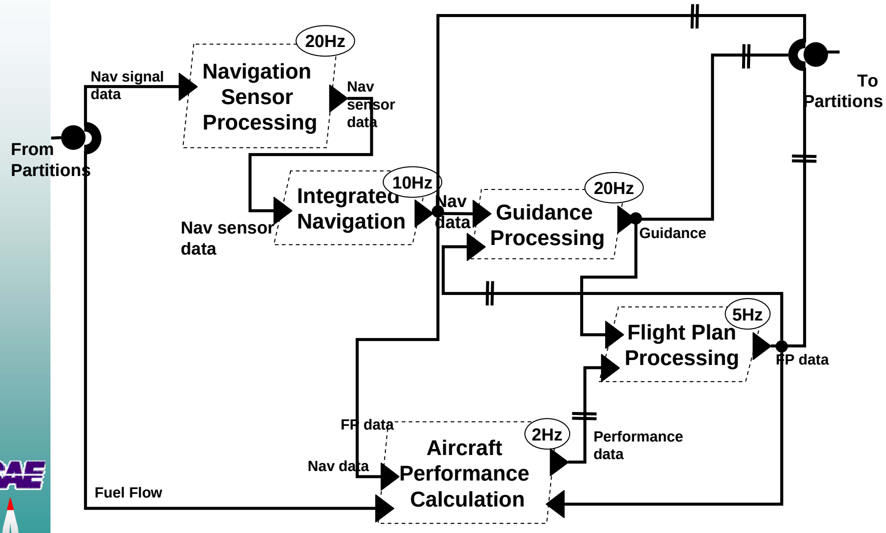
A Naïve Thread-based Design



Flight Manager in AADL



MetaH Case Study at AMCOM

- Reengineered Missile Application
  - Missile on-board software and 6DOF environment simulation originally in Jovial
  - Ported to Ada83, executing on dual i80960MC, Tartan Ada, VME Boards
  - Built to Generic Missile Reference Architecture
  - Specified in MetaH, 12 to 16 concurrent processes
  - Timing analysis early in reengineering effort
  - Runtime executive generated by MetaH toolset
  - MetaH reduced total re-engineering cost 40% on first project it was used on. Missile prime estimated savings at 66%.

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MetaH Case Study at AMCOM - 2

- Missile Application ported to a new execution environment
  - Multiple ports to single and dual processor implementations
  - New processors (Pentium and PowerPC), compilers, O/S
  - First time executable, flew correctly on each target environment
  - Execution platform description and binding specification in MetaH model
  - Port of runtime executive virtual machine to new processor & O/S
  - Ports took a few weeks rather than 10 months

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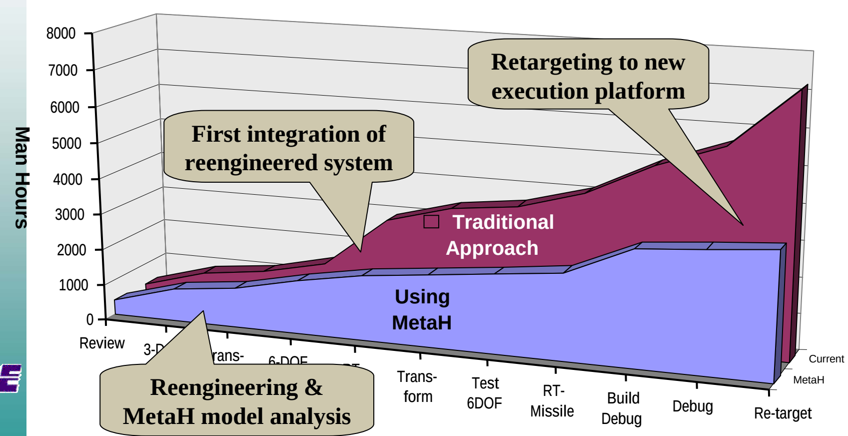
AMCOM Effort Saved Using MetaH

Total project savings 50%, re-target savings 90%



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  - Component interaction & flows
  - Faults & modes
  - Large-scale development & extensions
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AADL: The Language

Components with precise semantics
- Thread, thread group, process, system, processor, device, memory, bus, data, subprogram

Completely defined interfaces & interactions
- Data & event flow, synchronous call/return, shared access
- End-to-End flow specifications

Real-time Task Scheduling
- Supports different scheduling protocols incl. GRMA, EDF
- Defines scheduling properties and execution semantics

Modal, configurable systems
- Modes to model transition between statically known states & configurations

Component evolution & large scale development support

AADL language extensibility

Component-Based Architecture

- Specifies a well-formed interface
- All external interaction points defined as features
- Multiple implementations per component type
- Properties to specify component characteristics
- Components organized into system hierarchy
- Component interaction declarations must follow system hierarchy

System Type

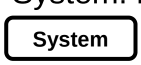
```
system GPS
features
  speed_data: in data port metric_speed
     {sei::miss_rate => 0.001 mps;};
  geo_db: requires data access real_time_geoDB;
  s_control_data: out data port state_control;
flows
  speed_control: flow path
       speed_data -> s_control_data
properties sei::redundancy => 2 X;
end GPS;
```

System Implementation

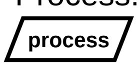
```
system implementation GPS.secure
subcomponents
  decoder: system PGP_decoder.basic;
  encoder: system PGP_encoder.basic;
  receiver: system GPS_receiver.basic;
connections
  c1: data port speed_data -> decoder.in;
  c2: data port decoder.out -> receiver.in;
  c3: data port receiver.out -> encoder.in;
  c4: data port encoder.out -> s_control_data;
flows
 speed_control: flow path speed_data -> c1 -> decoder.fs1
             -> c2 -> receiver.fs1 -> c3 -> decoder.fs1
             -> c4 -> s_control_data;
modes none;
properties sei::redundancy_scheme => Primary_Backup;
end GPS;
```


Application Components

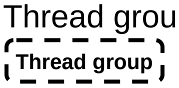
- System: hierarchical organization of components



- Process: protected virtual address space



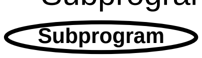
- Thread group: organization of threads in processes



- Thread: a schedulable unit of concurrent execution

- Data: potentially sharable data

- Subprogram: Callable unit of sequential code



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Thread Dispatch Protocols

5ms Periodic thread

– represents periodic dispatch of threads with typically hard deadlines.

Aperiodic thread

– represents event-triggered dispatch of threads with typically hard deadlines.

5ms Sporadic thread

– represents dispatching of threads with minimum dispatch separation and typically hard deadlines.

B Background thread

– represents threads that are dispatched once and execute until completion.

Additional protocols can be introduced

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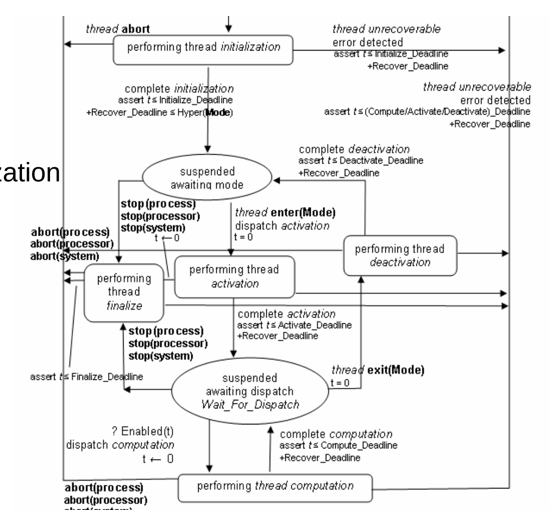
Thread Execution Semantics

- Nominal & recovery
- Fault handling
- Resource locking
- Mode switching
- Initialization & finalization



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Some Thread Properties

```
Dispatch_Protocol => Periodic;
Period => 100 ms;
Compute_Deadline => value(Period);
Compute_Execution_Time => 20 ms;
Initialize_Deadline => 10 ms;
Initialize_Execution_Time => 1 ms;
Compute_Entrypoint => “speed_control”;
Initialize_Entrypoint => “speed_control_init”;
Source_Text => “waypoint.java”;
Source_Code_Size => 12 KB;
Source_Data_Size => 5 KB;
```

Dispatch execution properties

Code function to be executed on dispatch

File containing the application code

Data Component

- Data component type represents data type
  - Used for typing ports
  - Optional modeling of operations
- Data component implementation
  - Substructure modeling
- Data component
  - Sharable between threads through data access connections
  - Access properties
  - Concurrency control protocol property

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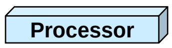
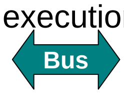
Execution Platform Components

- Processor – Provides thread scheduling and execution services



- Memory – provides storage for data and source code

- Bus – provides physical connectivity between execution platform components



- Device – interface to external environment

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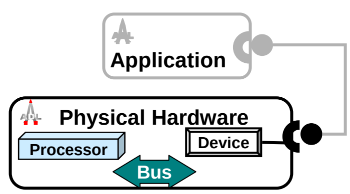
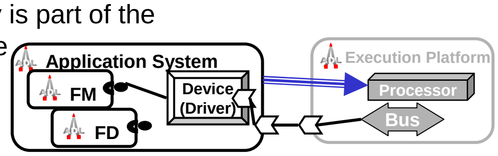
Perspectives on Devices

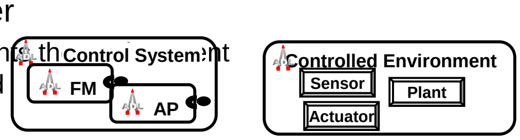
- Hardware Engineer
  - Device is part of physical system



- Application developer
  - Device functionality is part of the application software



- Control Engineer
  - Device represents the plant being controlled



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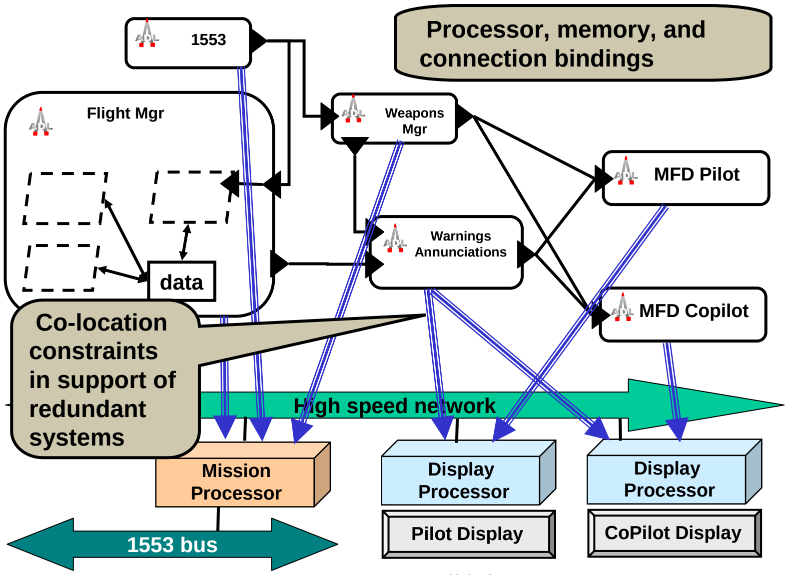
Execution Platform Bindings



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Ports & Connections

Ports: directional transfer of data & control

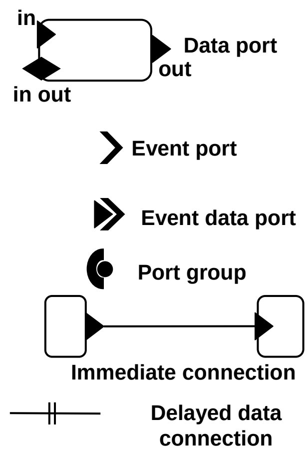
Data port: state, sampled data streams

Event port: Queued, thread dispatch & mode switch trigger

Event data port: queued messages

Port group: aggregation of ports into single connection point

Immediate & delayed data connection: deterministic data transfer semantics



Deterministic Communication Issues

Fixed-priority preemptive scheduling

- Better resource utilization

Efficient data stream communiation

- Shared variable communication within a processor
  - Preemptive scheduling introduces non-deterministic read-write order
- Single buffer send/receive communication within and across processors
  - Preemption and concurrency of threads result in non-deterministic application level send/receive call ordering

The consequence

- Non-deterministic variation in latency & phase delay
- Appearance of noisy data to controllers

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Deterministic Communication in AADL

- Data ports represent unqueued communication of data streams
- Immediate & delayed connection timing semantics assure deterministic data stream transfer
- Immediate connections constrain thread execution order
- Delayed connections increase concurrency
- Implementation considerations
  - Mutual exclusive port variable access
  - Double buffering as appropriate
  - AADL runtime system responsible for dispatch & communication

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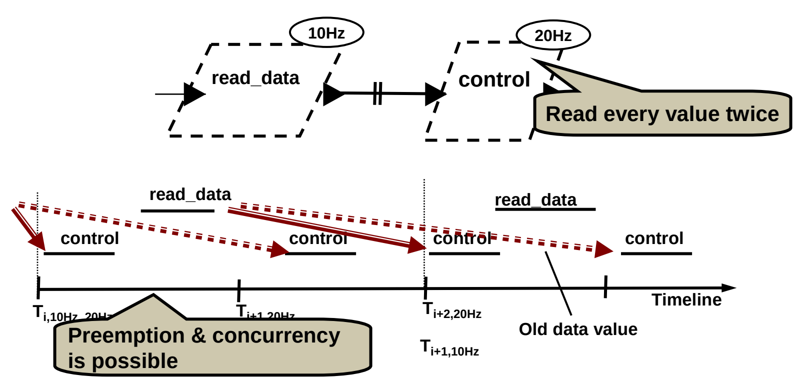
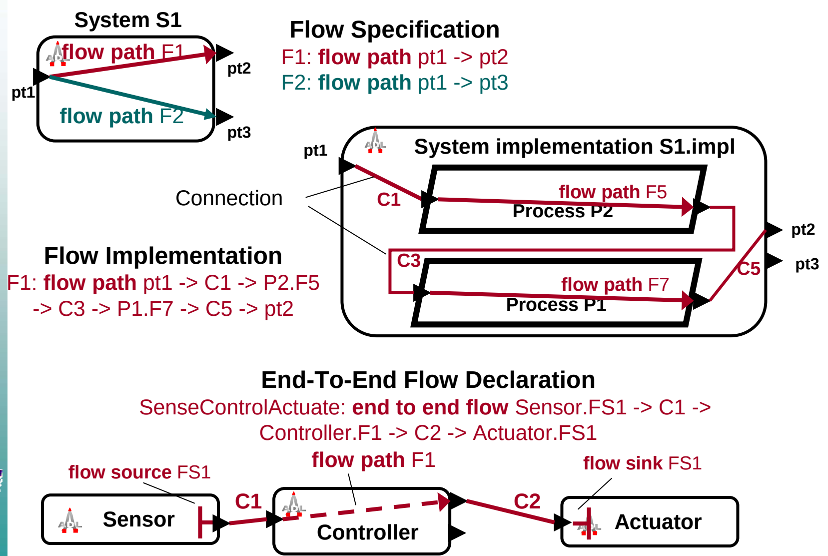
Sampling & Delayed Connections

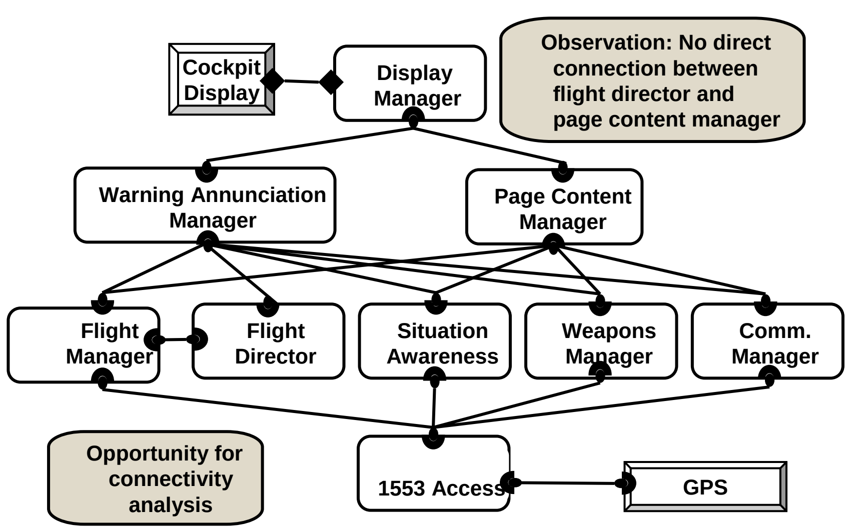


AADL assures
- **Deterministic sampling & phase delay**
- **Requires double buffering as necessary**

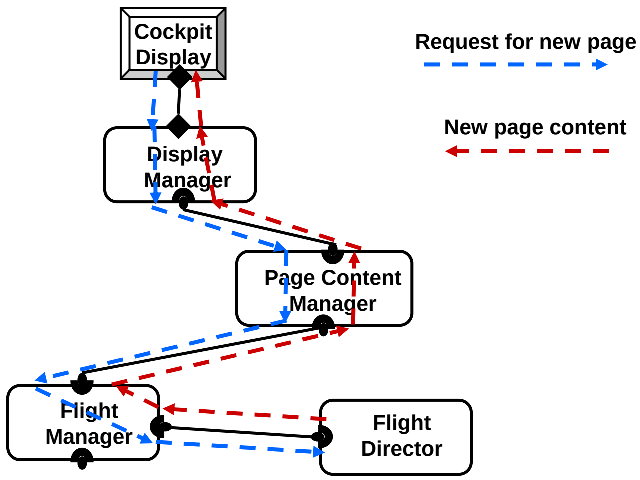
Flows in AADL



Avionics Subsystem Architecture



Flight Director Command Flow



Response Time Analysis

- Worst-case scenario
  - Period delay per partition communication
    - DM sampling latency (max. = partition period)
    - Six periods of partition communication latency
    - DM execution latency (max. = partition period)
    - 0.4 seconds worst case response time
    - 0.3 seconds best case response time
- Single processor static timeline
  - One direction immediate, opposite direction phase delayed
  - Reduces partition communication latency to three periods
- Multiple processor synchronous system
  - Take into consideration bus/network latency
- Multiple processor asynchronous system
  - Asynchronous sampling with max. sampling latency = period

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Data Stream Latency Analysis

- Flow specifications in AADL
  - Properties on flows: expected & actual end-to-end latency
  - Properties on ports: expected incoming & end latency
- End-to-end latency contributors
  - Delayed connections result in sampling latency
  - Immediate periodic & aperiodic sequences result in cumulative execution time latency
- Phase delay shift & oscillation
  - Noticeable at flow merge points
  - Variation interpreted as noisy signal to controller
  - Analyzable in AADL

Potential hazard

Latency calculation & jitter accumulation

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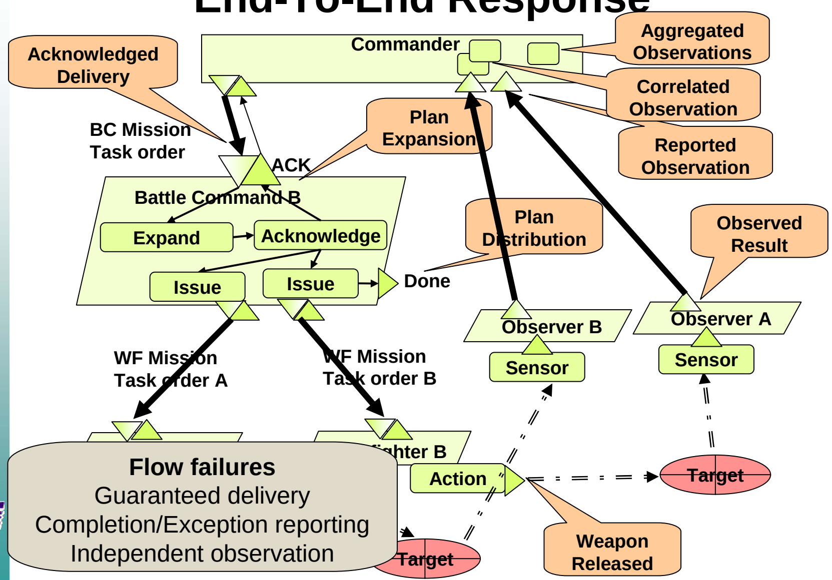
Insights into Flow Characteristics

- Miss rate of data stream
  - Accommodates incomplete sensor readings
  - Allows for controlled deadline misses
- State vs. state delta communication
  - Data reduction technique
  - Events as state transitions
  - Requirement for guaranteed delivery
- Data accuracy
  - Reading accuracy
  - Computational error accumulation
- Acknowledgement semantics in terms of flows

End-To-End Response



Flow failures
Guaranteed delivery
Completion/Exception reporting
Independent observation

Outline: An Introduction & Overview

- Overview of SAE AADL Standard
- Model-Based Architecture-Driven System Engineering
- AADL-Based Development Environment
- Case Studies
- AADL Language Concepts
  - Components
  - Component interaction & flows
  - Faults & modes
  - Large-scale development & extensions
- Open Source AADL Tool Environment
- Summary

Faults and Modes

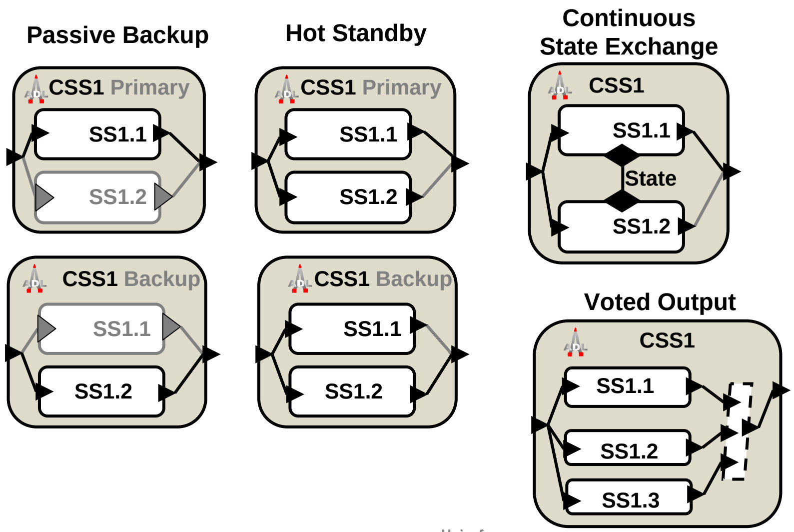
- AADL provides a fault handling framework with precisely defined actions
- AADL supports runtime changes to task & communication configurations
- AADL defines timing semantics for task coordination on mode switching
- AADL supports specification of mode transition actions
- System initialization & termination are explicitly modeled

Fault Management

- Fault containment
  - Process as a runtime protected address space
- Fault recovery
  - Within application code & thread local
  - Error propagation
- Propagated error management
  - Propagation through event connections
  - Trigger reconfiguration through mode switching
  - Monitoring & decision making through health monitor

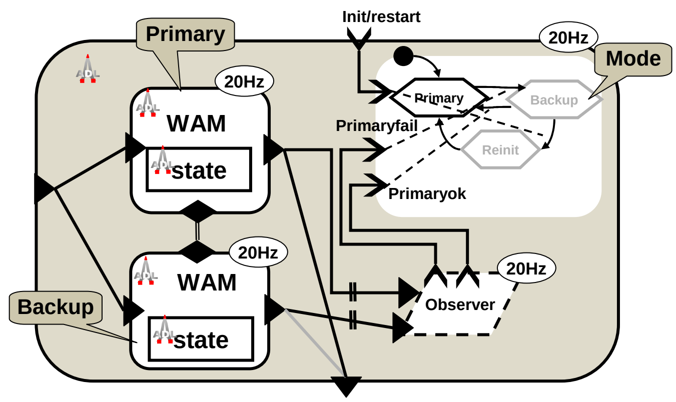
Event queue processing by aperiodic & periodic threads

Primary/Backup Configurations



Primary Backup Synchronization

- External and internal mode control
- Errors reported as events
- Supports reasoning about Primary/Backup logic



Dual Redundancy Pattern

```
system PrimaryBackupPattern
features
   insignal: data port;
   outsignal: data port;
end PrimaryBackupPattern;

system implementation PrimaryBackupPattern.impl
subcomponents
   Primary: system sys;
   Backup: system sys;
connections
   inPrimary: data port insignal -> Primary.insignal;
   inBackup: data port insignal -> Backup.insignal;
   outPrimary: data port Primary.outsignal -> outsignal;
   outBackup: data port Backup.outsignal -> outsignal;
modes
   Primarymode: initial mode;
   Backupmode: mode;
   Reinitmode: mode;
   Backupmode –[restart]-> Reinitmode;
   Reinitmode –[Primary.Complete]-> Primarymode;
end PrimaryBackupPattern.impl;
```

Defines a dual redundant pattern

Refined Dual Redundancy Pattern

```
system PassivePrimaryBackup extends PrimaryBackupPattern
features
   restart: in event port;
end PassivePrimaryBackup;


system implementation PassivePrimaryBackup.impl extends
   PrimaryBackupPattern.impl
subcomponents
   Primary: refined to system in modes ( Primarymode );
   Backup: refined to system in modes ( Backupmode );
   Reinit: system reloadsys in modes ( Reinitmode );
connections
   inPrimary: refined to data port in modes ( Primarymode );
   inBackup: refined to data port in modes ( Backupmode );
   outPrimary: refined to data port in modes ( Primarymode );
   outBackup: refined to data port in modes ( Backupmode );
modes
   Reinitmode: mode;
   Backupmode –[restart]-> Reinitmode;
   Reinitmode –[Reinit.Complete]-> Primarymode;
end PassivePrimaryBackup.impl;
```

Provides externally restart control

Defines who is active when

Defines restart logic

Modal Systems

- Operational modes
  - Alternate task and communication configurations
  - Reflect system operation
- Modal subsystems
  - Internal mode control to model autonomous subsystems
  - External mode control to model coordinated operational modes
- Alternate system configurations
  - Reachability of mode combinations
- Reduced analysis space
  - Less conservative analysis results
- Management of consistent configuration
  - Inconsistency identification through analysis
  - Inconsistency repair through selective reconfiguration

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Component Evolution

- Partially complete component type and implementation
- Multiple implementations for a component type
- Extension & refinement
  - Component templates to be completed
  - Variations and extensions in interface (component type)
  - Variations and extensions in implementations

Example of Dual Redundancy pattern

Large-Scale Development

- Component type and implementation declarations in *packages*
  - Name scope for component types
  - Public and private package sections
  - Grouping into manageable units
  - Nested package naming
  - Qualified naming to manage name conflicts
- Supports independent development of subsystems
- Supports large-scale system of system development

AADL Language Extensions

- New properties through property sets
- Sublanguage extension
  - Annex subclauses expressed in an annex-specific sublanguage
- Project-specific language extensions
- Language extensions as approved SAE AADL standard annexes
- Examples
  - Error Model
  - ARINC 653
  - Behavior
  - Constraint sublanguage

Example Annex Extension

```
THREAD t
  FEATURES
    sem1 : DATA ACCESS semaphore;
    sem2 : DATA ACCESS semaphore;
END t;

THREAD IMPLEMENTATION t.t1
  PROPERTIES
    Period => 13.96ms;
    cotre::Priority => 1;
    cotre::Phase => 0.0ms;
    Dispatch_Protocol => Periodic;
```

```
ANNEX cotre.behavior {**
   STATES
     s0, s1, s2, s3, s4, s5, s6, s7, s8 : STATE;
     s0 : INITIAL STATE;
   TRANSITIONS
     s0 -[ ]-> s1 { PERIODIC_WAIT };
     s1 -[ ]-> s2 { COMPUTATION(1.9ms, 1.9ms) };
     s2 -[ sem1.wait ! (-1.0ms) ]-> s3;
     s3 -[ ]-> s4 { COMPUTATION(0.1ms, 0.1ms) };
     s4 -[ sem2.wait ! (-1.0ms) ]-> s5;
     s5 -[ ]-> s6 { COMPUTATION(2.5ms, 2.5ms) };
     s6 -[ sem2.release ! ]-> s7;
     s7 -[ ]-> s8 { COMPUTATION(1.5ms, 1.5ms) };
     s8 -[ sem1.release !]-> s0;
  **);
END t.t1;
```

COTRE thread properties

COTRE behavioral annex

Courtesy of cotre

System Safety Engineering

Capture the results of
- *hazard analysis*
- *component failure modes & effects analysis*

Specify and analyze
- *fault trees*
- Markov models
- partition isolation/event independence

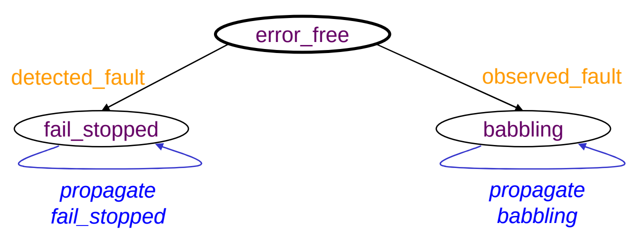
Supported by Error Model Annex

Integration of system safety with architectural design
- enables cross-checking between models
- insures safety models and design architecture are consistent
- reduces specification and verification effort

Error Modeling Approach

Error model annex clauses declare
- Error states and transitions
- Fault events & occurrence rates
- Error propagation & occurrence rates
- Masking of subcomponent and propagation errors

Architecture model provides
- Dependency information
- Basis for isolation analysis



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Open Source AADL Tool Environment

- Developed by the SEI
- No cost CPL license
- OSATE Release 0.3.0 based on Eclipse Release 3
- Parsing & semantic checking of approved AADL
- Text to XML & XML to text
- Syntax-sensitive text editor
- Syntax-Sensitive AADL Object Editor
- AADL property viewer
- AADL to MetaH translator
- Online help
- Model instantiation
- First analysis plug-ins

Processed 21000 line AADL model

Next release Nov 2004
Graphical editor
Multi-file support
Analysis plug-in development

AADL Meta Model

- Defined in Eclipse Modeling Framework (EMF)
  - Collection of packages with multiple graphical views
  - Separate from, but close to UML profile of AADL
- XML as persistent storage
  - XMI specification from Ecore meta model
  - Generated XML schema
- In-core AADL model
  - Generated methods for AADL model manipulation
  - Edit history, deep copy, object editor, graphical editor
  - Methods to support
    - AADL extends hierarchy
    - feature “inheritance”
    - property value “inheritance”

OSATE Plug-in Extensions

OSATE
Textual AADL, Graphical AADL
XML/XMI AADL, AADL object model API
AADL extension support

EMF
XML/XMI, Metamodel
Change notification
Multi-file support

Eclipse
Platform independence
Extensible help
Task & Problem Mgt
Team support
Plug-in development

AADL Front-end
Text editor
Object editor
Graphical editor
Text<->XML
Semantics

OSATE Extensions
Analysis template
Generation template
AADL Semantic API

External Models
<See later>

Model Transformation
Timing analysis (RMA)

Architecture Import
Simulink/Matlab model
Extraction via SVM

Architecture Export
MetaH

Architecture Analysis
Security level
Data stream miss rate
Latency

Architecture Consistency
Required connectivity
Model completeness profiles
Connectivity cycles

Architecture Transform
Conceptual architecture ->
Runtime architecture
Rate group optimization
Port group identification

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Tool Plug-in Example

```
public Object caseConnection(Connection conn)  {
    if ( conn instanceof DataAccessConnection || conn instanceof BusAccessConnection)
        return DONE;
    PropertyHolder scxt = (PropertyHolder) conn.getSrcContext();
    PropertyHolder dcxt = (PropertyHolder) conn.getDstContext();
    if ( scxt == null || dcxt == null) return DONE;
    if (scxt instanceof PortGroup)
        scxt = conn.getContainingComponentImpl();
    if (dcxt instanceof PortGroup)
        dcxt = conn.getContainingComponentImpl();
    IntegerValue spv = scxt.getSimplePropertyValue(“SEI","SecurityLevel");
    IntegerValue dpv = dcxt.getSimplePropertyValue(“SEI","SecurityLevel");
    if (spv == null || dpv == null) {
        ErrorHandling.userError(conn,"Security level specification missing");
        return DONE;
    }
    if (spv.getValue() > dpv.getValue())
        ErrorHandling.userError(conn,"Security level violation");
    return DONE;
}
```


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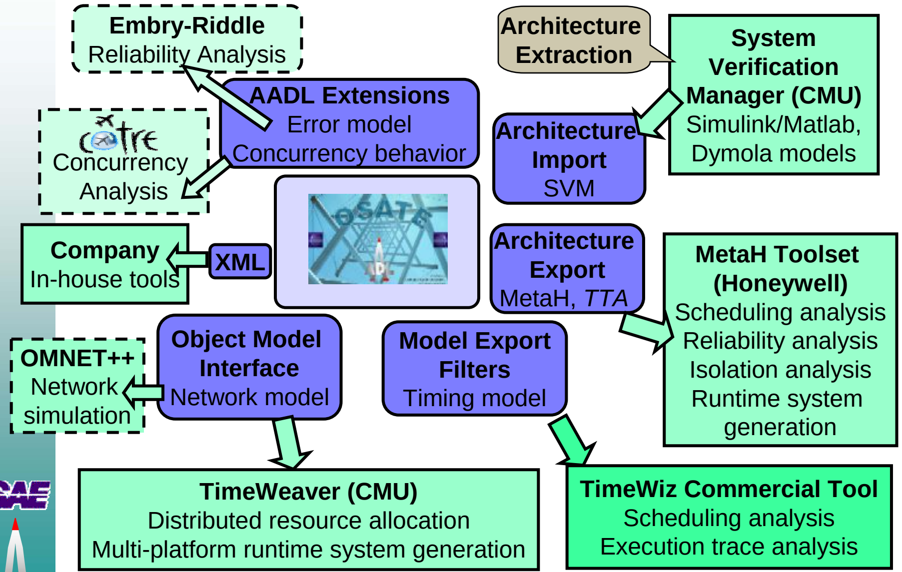
Security Level Example

```
property set SEI is
SecurityLevel    : aadlinteger
    applies to (thread, thread group, process,
    system);
end SEI;

data signal
end signal;

thread peter
features
    pe: in event port;
    pd: out data port signal;
properties
    SEI::SecurityLevel => 2;
end peter;

thread implementation peter.default
end peter.default;

thread pierre
features
    pd: in data port signal;
    pe: out event port;
properties
    SEI::SecurityLevel => 1;
end pierre;

thread implementation pierre.default
end pierre.default;

process sys
end sys;

process implementation sys.impl
subcomponents
    T1: thread peter.default;
    T2: thread pierre.default;
connections
    data port T1.pd -> T2.pd;
    event port T2.pe -> T1.pe;
end sys.impl;
```

OSATE and External Tools



OSATE Community Development

- www.aadl.info website
- OSATE Plug-in update site
- Bugzilla error reporting
- SEI-Hosted CVS Development Server
- Availability of Source Code (CPL)
- Plug-in contributions
  - Syntax-sensitive text editor by York U.
  - Graphical layout editor by USC
  - AADL to MetaH translator by SEI
  - Error modeling support by Embry-Riddle

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UML Profile of AADL

- The UML 1.4 and 2.0 profiles of AADL
- Example

<placeholder for Ed Colbert material>

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Summary of AADL Capabilities

- AADL abstractions separate application architecture concerns from runtime architecture concerns
- AADL incorporates a run-time architecture perspective through application system and execution platform
- AADL is effective for specialized views of embedded, real-time, high-dependability, software-intensive application systems
- AADL supports predictable system integration and deployment through model-based system engineering
- AADL component semantics facilitate the dialogue between application and software experts

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Value of AADL-Based Development

- Early Prediction and Verification (Tool-Supported)
  - performance
  - reliability
  - system safety
- Component Compliance Verification (Tool-Supported)
  - functional interface
  - resource requirements
  - system safety
- System Integration and Verification (Tool-Supported)
  - workstation testing
  - system performance
  - system safety verification

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SAE AADL: An Enabler for Predictable Embedded Systems Engineering

- Industry standard architecture modeling notation & model interchange format facilitates
  - Interchange of architecture models between contractors & subcontractors
  - Integration of architecture models for system of systems analysis
  - Common architecture model for non-functional system property analysis from different perspectives
  - Interoperability of modeling, analysis, and generation tools
- Open Source AADL Tool Environment offers
  - Low cost entrypoint to the use of SAE AADL
  - Platform for in-house prototyping of project specific architecture analysis
  - Platform for architecture research with access to industrial models & industry exposure to research results

Benefits

- Model-based system engineering benefits

Predictable runtime characteristics addressed early and throughout life cycle greatly reduces integration and maintenance effort

- Benefits of AADL as SAE standard

AADL as standard provides confidence in language stability, broad adoption, and strong tool support

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The End

- For information go to www.aadl.info