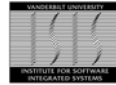


# Institute for Software-Integrated Systems (ISIS)

Dr. Janos Sztipanovits

Janos Sztipanovits



## ISIS Parameters

- Established by the School of Engineering at Vanderbilt University in 1998
- Academic/professional research organization
- Composition:
  - 29 Research Scientists & Engineers
  - 5 Faculty
  - 3 Admin Staff
  - 27 Graduate students

Janos Sztipanovits

2



## Research Thrusts

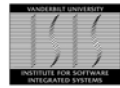
### Core technology



- **Model-Integrated Computing**  
Meta-programmable modeling tools, model-synthesis tools, generators, and open tool integration platform for model-based design
- **Distributed Object Computing**  
Open source RT CORBA, model-based integration technology above the CORBA Component Model
- **Model-Based Design**  
Diagnosis, fault-adaptive systems, structurally adaptive systems



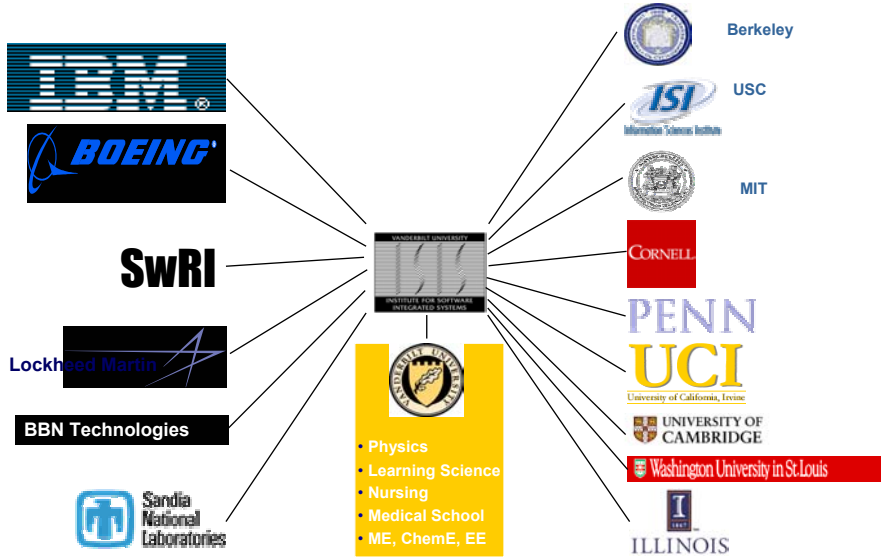
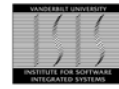
## Sponsors



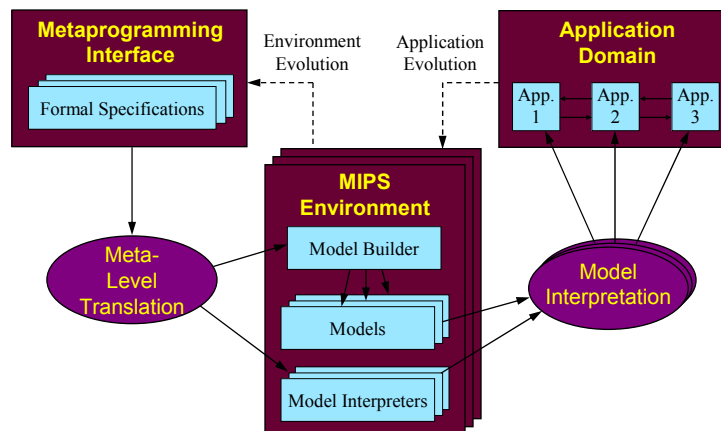
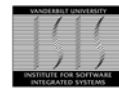
- NSF
- DARPA/DoD
- NASA
- Sandia Nat. Labs
- USAF
- DoD/ACTD
- ONR
- Saturn/GM
- Boeing
- DuPont
- Motorola
- IBM
- others...



# Partners

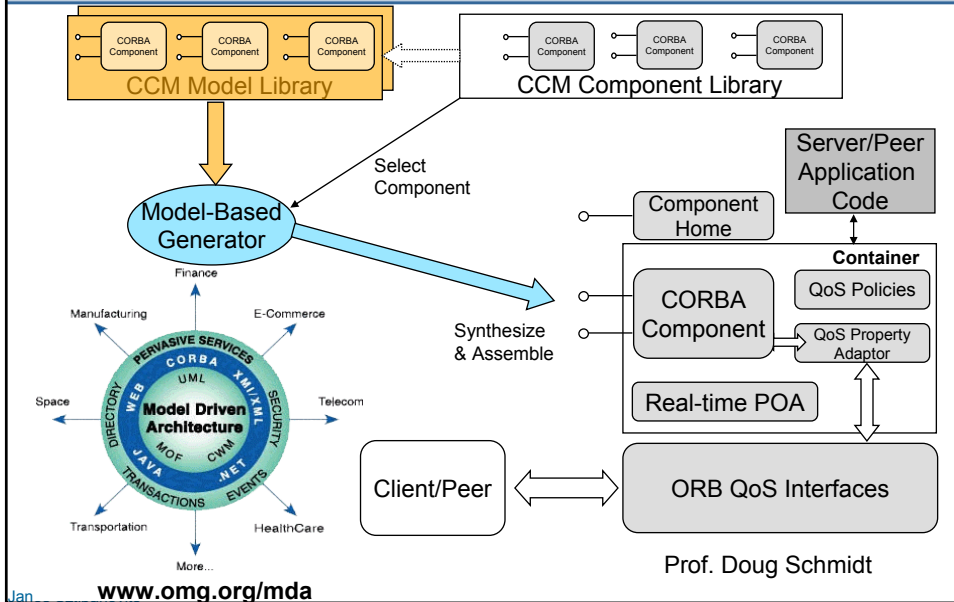
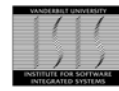


# Model-Integrated Computing Process and Architecture

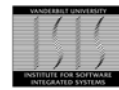




# New Direction: Combining MIC & Component Middleware



# ISIS at Vanderbilt



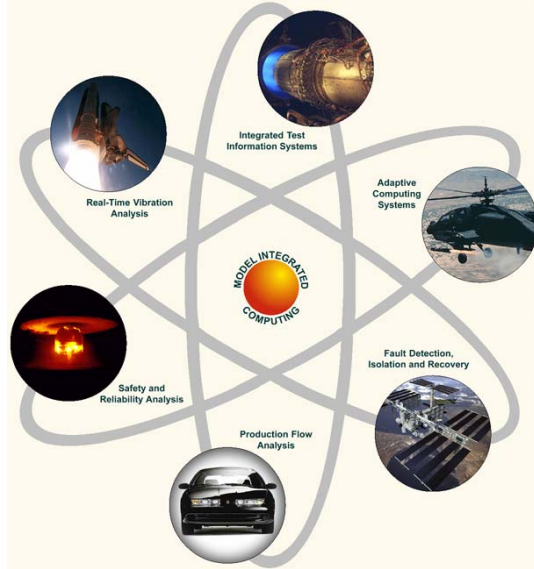
## Leads or partners in interdisciplinary teams:

- ❑ Physics Department (Prof. Paul Sheldon)  
BTeV Fault-tolerant RT Computer (NSF)  
(ISIS builds the tools and experimental computer platforms for the high-performance computer system of BTeV.)
- ❑ Physics Department (Prof. John Wikswo)  
Instrumenting the Cell (DARPA)  
(ISIS contributed to proposal development – pending option)
- ❑ BME ERC (Prof. Tom Harris)  
VaNTH (NSF-ERC)  
(ISIS develops the Learning Technology Infrastructure for VaNTH.)
- ❑ CEE Department (Prof. Mahadevan)  
Reliability and Risk Engineering (NSF-IGERT)  
(ISIS contributes to model-integrated reliability toolsets)
- ❑ ME Department (Prof. Ken Frampton)  
Smart Structure (DARPA; NSF)





# Applications

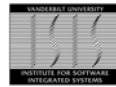


*Defense*  
*Manufacturing*  
*Space*  
*Scientific Computing*

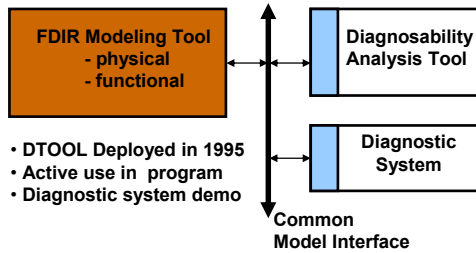
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# Fault Detection, Isolation, and Recovery



International Space Station



- ◆ **Domain-Specific Models of Space Station**
  - Mechanical, Electrical, Failure Modes, Instrumentation
- ◆ **Analyze System for Diagnosibility**
  - Sensor Location
  - Fault Mode Distinguishability
- ◆ **Synthesize Embedded, Real-Time Diagnostics Engine**
  - Multiple/Temporal Faults, using Timed Failure Propagation Graphs

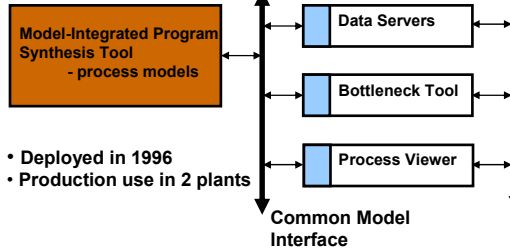
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# Saturn Site Production Flow



GM-Saturn

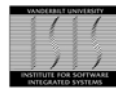


SSPF Model-Integrated Tools

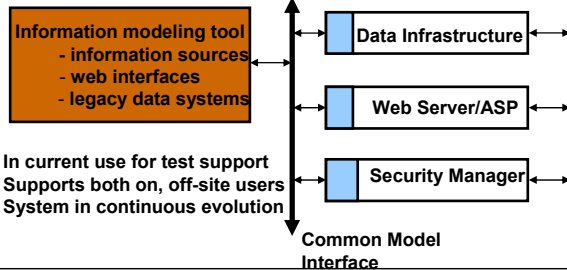
- ◆ **Domain-Specific Models of Automobile Production Plant**
  - Processes, Conveyors, Starving/Blocking, Throughput, Biz Procs, UI
- ◆ **Generate Site-Wide Data Integration System**
  - Real-Time Production History Database
  - Real-Time Client-Server Visualization Across Entire Plant
- ◆ **Productivity Enhancement Tools (+10% achieved)**
  - Bottleneck Analysis



# Integrated Test Information System



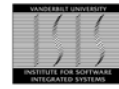
Arnold Engineering Development Center/Sverdrup Tech.



- ◆ **Domain-Specific Models of AEDC Distributed Data Systems**
  - Computers, Formats, Access Mechanisms, Security, UI, Web
- ◆ **Generate Test Information System**
  - Integrate Legacy Computers into a Real-Time, Distributed Database
  - Web-enabled secure access to real-time test data
  - Manage User Security/Permissions
- ◆ **Rapid System Specification and Evolution**



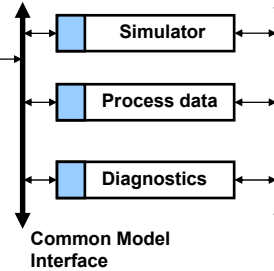
# On-line Problem Solving Environment for Plant Operations



DuPont Chemical/Osaka Gas

**Activity Modeling Tool**  
- process models  
- activity models

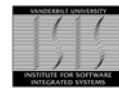
- Deployed in 1994
- Used in Control Room



- ◆ **Domain-Specific Models of Chemical Processing Plant**
  - Process, Equipment, Math Models, Fault Propagation
- ◆ **Generate Integrated Monitoring/Control/Simulation System**
  - Real-Time Database
  - Integrated Chemical Plant Simulator (ASPEN)
  - On-Line Diagnostics
- ◆ **Rapid System Specification and Evolution**

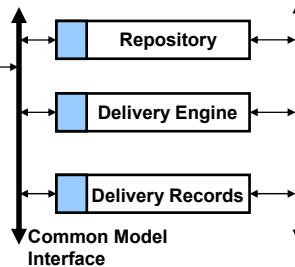


# Learning Technology



**Courseware authoring environment**  
- delivery models  
- learning objectives  
- metadata

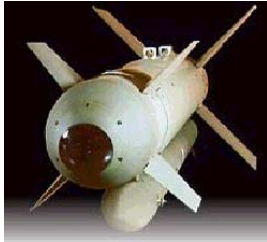
- 2000-2004
- NSF VaNTH ERC



- ◆ **Visual language for courseware authoring**
  - Authoring from re-purposable learning resources (learning objects)
  - Instructional design patterns guided by learning science
  - Adaptive sequencing for individual learners
- ◆ **Repository-based content management (eLCMS)**
  - Web-based shareable resources for courseware authoring
- ◆ **Model-based courseware delivery (eLMS)**
  - Adaptable web-based delivery engine
  - Persistent records of learner experience

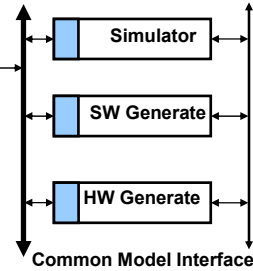


# DARPA: Adaptive Computing



**Reconfigurable Systems Tool**  
 - Data Flow  
 - Hardware Resources  
 - Behavior

- Developed: 1997-2000
- Target ARMY/AMCOM



- ◆ **Domain-Specific Models of Reconfigurable Embedded App.**

- Algorithms, Resources, Dynamic Behavior

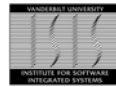
- ◆ **Generate Simulations & Dynamic Embedded Systems**

- Discrete Event Simulation
- Custom Hardware Implementation
- Heterogeneous, Parallel Real-Time Systems

- ◆ **Rapid System Specification and Evolution**

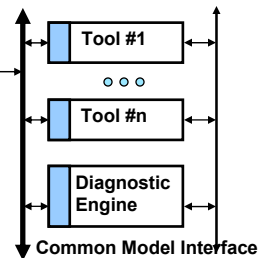


# Boeing Aircraft Diagnostics



**Diagnostics Tool Integration**  
 Onboard Diagnostics/  
 Prognostics

- Developed: 1997-2000



- ◆ **Domain-Specific Models of Tool Data**

- Syntax & Semantics

- ◆ **Generate Simulations & Dynamic Embedded Systems**

- Tool Adapters
- Semantic Mapping Engines
- Common Model Database

- ◆ **Generation of Embedded Diagnostics**

- Diagnosis & Prognostics, Integrate Diverse Techniques





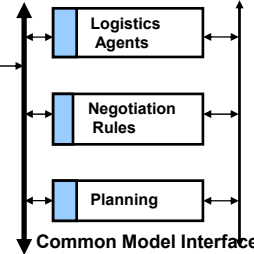
# DARPA: Distributed Logistics/ANTS



**Aircraft Maintenance Management**  
**Autonomous Negotiating Agents**

• Development: 1999-2003

Funding Source: DARPA, DoD/ACTD; Subcontractors: Boeing/MIT



## ◆ Domain-Specific Models of Logistics Process

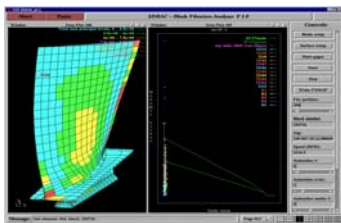
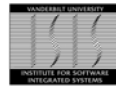
- Suppliers, Consumers, Negotiating Strategies

## ◆ Generate Dynamic Negotiating System

- Depot Agent/Negotiation Rules
- Consumer Agent/Negotiation Rules

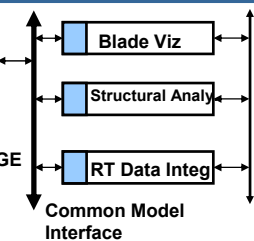


# Turbine Dynamic Structural Analysis



**Finite Element Analysis**  
**Real-Time Data <--> Models**

- Developed 1995-2000
- Used at AEDC, Rolls Royce, GE



## ◆ Domain-Specific Models of Blade Vibration Analysis

- Blade Structural, Material Properties, Data Systems

## ◆ Generate On-Line Simulation Coupled to Real-Time Data

- Finite Element Analysis
- Dynamic Strain/Stress Computed
- Data Verification

## ◆ Blade Vibration Visualization

## ◆ Coupled to Real-Time, Parallel Data Analyzer

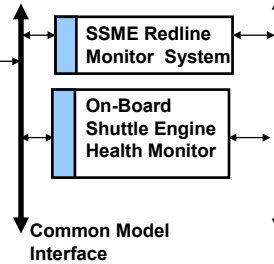


# Space Shuttle Engine Health Monitoring



## Real-Time Turbopump Monitoring High Speed DSP

- Developed 1995-1998
- Used at NASA/MSFC, SSC,
- Flown on STS-96



### ◆ Domain-Specific Models of Instrumentation System

- Algorithms, Networks, Mapping

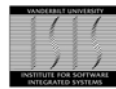
### ◆ Generate Embedded Real-Time Instrumentation System

- Real-Time Analysis on Parallel DSP System
- Dynamic Visualization of Data
- Low-Latency, Real-Time Engine Cut-off Alarm

### ◆ Rapid System Specification and Evolution



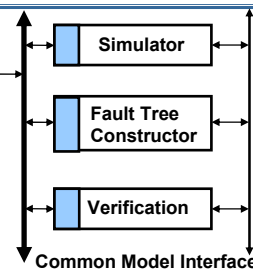
# Integrated Safety and Reliability Analysis



## State Space Analysis Tool

- Behavior Models
- Physical Models
- Failure Models

- Developed: 1996-2000
- In use at Sandia National Labs
- Used for validation of weapon systems



### ▪ Domain-Specific Models of System Behavior and Structure

- System behavior, physical structure, component failures

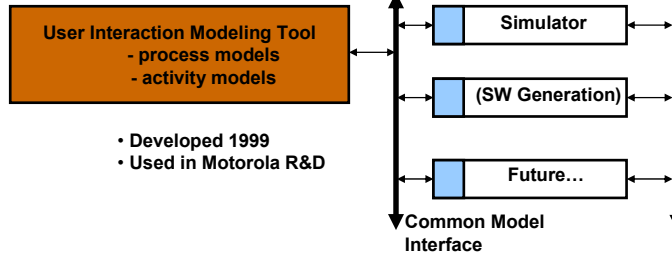
### ▪ Model verification and validation

### ▪ Automatic Fault Tree Generation

- Safety/reliability fault trees can be generated from the integrated model
- Uses COTS fault tree analysis software



# Motorola Cell-Phone Simulator



## ◆ Domain-Specific Models of Cell Phone User Interface

- Menu's, Options, Operational State

## ◆ Generate Simulations Cell Phone

- Pre-build Testing
- Human Factors Analysis
- Run-Time Software Generation (Future)

## ◆ Rapid Phone Operation Specification and Evolution