A complete design and simulation framework based on Architectural Frameworks and SysML for the full lifecycle of a system

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Ing. Bombino Massimo – 21 Ottobre 2010
A complete framework for System Design & Simulation

Verification & Validation

Continuous Time Simulation

Discrete Time Simulation

Scenario Simulation

HW-SW in-the-loop simulation

Architectural & System Design

Software Design

Repository

Multi-user collaborative repository

Code

Requirements

Structure

Frameworks

Behavior

Concurrency

Collaboration

Classes

Packages

Behavior

Views

Architecture

Storage.
Design & Simulation Framework

Details

• The Core of the Framework:
  – Artisan Studio (multi-user, collaborative, full life-cycle)

• The Standards:
  – Architectural Frameworks (DoDAF, MoDAF, NAF, MDAF, UPDM, …)
  – SysML (System Modelling Language)
  – UML (Unified Modelling Language)
  – MDA (Model Driven Architecture)

• The Simulation:
  – Discrete time (Diagrams: State, Sequence, Activity)
  – Continuous & Heterogeneous Time (real-time algorithms)
  – Scenario Animation (warfare, search & rescue, …)
  – Hardware-in-the-loop (AUTOSAR, …)
**Design & Simulation Framework**

Repository: Artisan Studio, the Core of the Framework

- **What is **Artisan Studio**:  
  - **Multi-disciplinar** modelling tool  
  - Based on **OO-RDBMS** (Object-Oriented Relational DB)  
  - Scalable from single desktop access to geographically distributed international teams  
  - Simultaneous access to **up to 100 users**  
  - **Open Automation Interface** to several external tools  
  - Integrated **security** of access  
  - Native support of several **MBSE** standards (**SysML Architectural Frameworks**, **UML**, **MDA**, …)  
  - **Full life-cycle support** of system design & simulation
Design & Simulation Framework
Architectural Frameworks

- C4ISR Architecture Framework v1.0 (1997)
- MODAF v1.0 (2005)
- NAF v1.0 (2007)
- DoDAF v1.5 (2008)
- UPDM 2.0 (2009) Started Set 2009
- META-MODEL MODAF (M3) In UML Notation
- DoDAF v1.7 (2008)
- DNDAF v1.7 (2008)
Design & Simulation Framework

Architectural Frameworks

- **STRATEGIC Views**: Articulate high-level requirements for enterprise change over time – capabilities, goals, enduring tasks.
- **OPERATIONAL Views**: Articulate operational scenarios, activities, and information flows.
- **SERVICE Views**: Articulate services, their interfaces, behaviour and policy.
- **SYSTEM Views**: Articulate the solution specification – resources, functions & interactions.
- **ACQUISITION Views**: Articulate programme dependencies, milestones and statuses.
1. Structure

2. Behaviour

3. Requirements

4. Parametric constraints
Design & Simulation Framework
Discrete-time Simulation: State & Sequence Diagrams

• **Diagrams:**
  – State Diagrams (Finite State Machines)
  – Sequence Diagrams (Sequence of events)

• **Environment:**
  – Native in Artisan Studio

• **Purpose:**
  – Simulation of the states of a system *(internal & external)*
  – Internal & external triggers *(events, time, calls)*
  – Sequence diagrams could be **Input** or **Output** of a simulation
  – **GUI** could be added for control & verification of the simulation

• **Design Phase:**
  – AF, SysML, UML
Design & Simulation Framework
Discrete-time Simulation: State & Sequence Diagrams
Diagrams:
- Activity Diagrams (UML)

Environment:
- Artisan Studio interface to ExtendSim
- Developed by an ATEGO partner

Purpose:
- Automatic generation of ExtendSim projects
- Hierarchical activities & diagrams
- Simulation of the activities of a system
- Control & data tokens

Design Phase:
- (AF), SysML, (UML)
Design & Simulation Framework
Discrete-time Simulation: Activity Diagrams

Studio

ExtendSim
Design & Simulation Framework
Continuous- and heterogeneous- time Simulation

• **Diagrams:**
  – **State Diagrams** (Finite State Machines)
  – **Parametric Diagrams** (Mathematical Constraints)

• **Environment:**
  – **Artisan Studio** interface to **Mathworks Simulink**
  – Developed internally by **ATEGO**

• **Purpose:**
  – **Heterogeneous** (Continuous + Discrete) time simulation
  – Simulation of **complex algorithms** (i.e. Flight Control System, Satellite guidance, telecommunications algorithms, ...)
  – Effects of the algorithm in the system and vice-versa
  – Automatically generated code ready to be deployed on target
  – GUI for simulation control & debug
Design & Simulation Framework
Continuous- and heterogeneous- time Simulation

• Innovative approach:
  – Presented at ECMFA 2010 international conference on Model Based Architecture

• Design Phase:
  – SysML, UML
Design & Simulation Framework
Continuous- and heterogeneous- time Simulation

Simulink
Mathematical Model Synchronizer
Glue Code
Calls
Code

RTW

Studio
ACS
Code
Calls
Design & Simulation Framework
Continuous- and heterogeneous- time Simulation
Design & Simulation Framework
Scenario Simulation

• **Diagrams:**
  – Block Definition Diagrams (SysML, UPDM)
  – Internal Block Diagrams (SysML, UPDM)
  – Sequence Diagrams (SysML, UPDM)

• **Environment:**
  – Artisan Studio interface to Presagis STAGE
  – Developed by ATEGO for Selex SI and other customers

• **Purpose:**
  – Bi-directional synchronization of STAGE DB & Scenario
  – Shared objects (Platforms, Sensors, Weapons, Radios, …)
  – Shared scenario

• **Design Phase:**
  – AF, (SysML)
Design & Simulation Framework
Scenario Simulation
Design & Simulation Framework
Scenario Simulation
Design & Simulation Framework
HW-SW in-the-loop Simulation

• Environment:
  – Artisan Studio interface to ATEGO ACE
  – Developed by ATEGO and Extessy

• Purpose:
  – Hardware-in-the-loop simulation
  – Software-in-the-loop simulation
  – Model-in-the-loop simulation
  – AUTOSAR support

• Design Phase:
  – (SysML), UML
Design & Simulation Framework
HW-SW in-the-loop Simulation

ASCET™ Simulink™
Component Description
Builder
Configurator
AtegoAce Modelling Environment

Component
Component
Composite
Component
Component

AtegoAce Co-Simulation Backplane
AtegoAce Co-Simulation Backplane

Test Interface

PC 1
PC 2
PC N

CoOrdinator
M & C Tool

Tester

Configurator
Architecture Description

Simulator
Validation
Design & Simulation Framework
HW-SW in-the-loop Simulation
Design & Simulation Framework

Conclusions

• Artisan Studio:
  – Multi-user, collaborative, intra/inter-company repository
  – Full life-cycle of a system (from Architecture to Software through System design)

• Wide support of standards
  – Architectural Frameworks, SysML, UML, MDA, ...

• Full life-cycle support:
  – Architecture level, system level, software level

• Simulation support:
  – Discrete time (native environment, ExtendSIM interface)
  – Continuous & Heterogeneous Time (Simulink interface)
  – Scenario Animation (STAGE interface)
  – Hardware-in-the-loop (AUTOSAR, …)
Design & Simulation Framework
Questions & Answers
Research Projects
Standards