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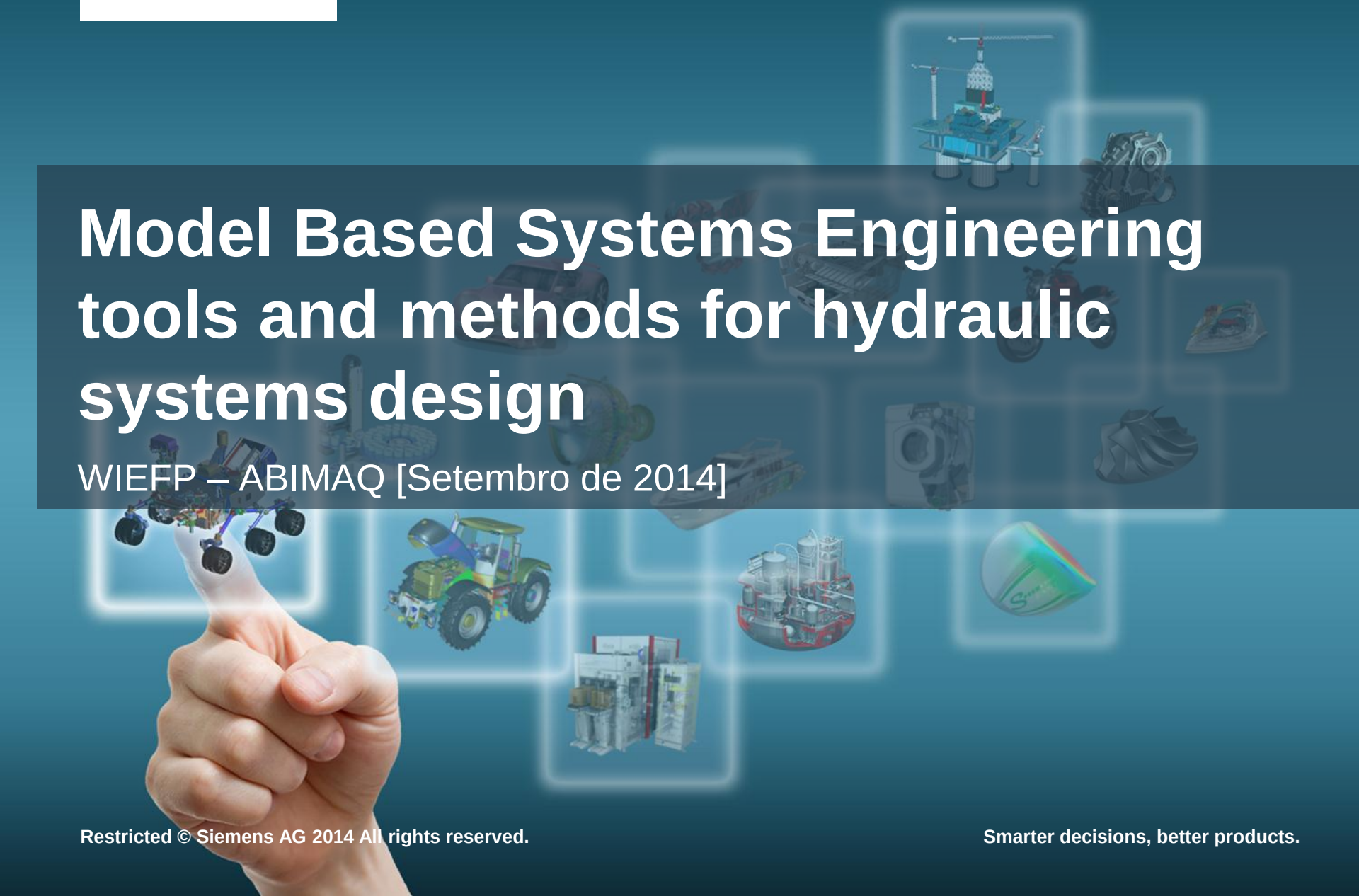
Model Based Systems Engineering tools and methods for hydraulic systems design

WIEFP – ABIMAQ [Setembro de 2014]



LMS, +30 years of Engineering Innovation
Leading partner in Test & Mechatronic Simulation

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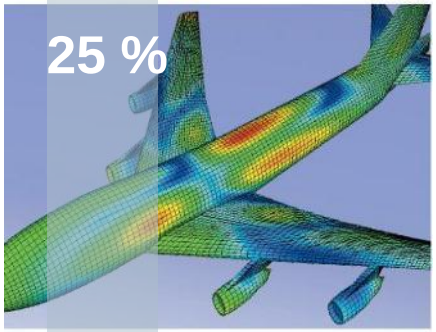


- **Worldwide leader in performance engineering**
  for global Auto & Aerospace industries
- Serving more than **100.000** R&D engineers
  … in **5.000** manufacturing companies
- Top talent in 45+ offices worldwide
  … **1.200** professionals
- Sustained **20%** growth since 2010
  … proving relevance of LMS solutions
- Visionary, industry-leading innovator
  … **25%** of budget in R&D
- LMS, A Siemens Business, enabling:
  "**Closed-Loop Systems Driven Product Development**"

R&D & Engineering

Beijing
Brasov
Breda
Bristol
Chennai
Coralville
Detroit
Hamburg
Gottingen
Kaiserslautern
Madrid
Leuven
Liège
Lyon
Torino
Toulouse
Plymouth
São Caetano do Sul
Torino
Yokohama

LMS, A Siemens Business – a Track Record of delivering Transformational Solutions

SIEMENS

Transforming is …
Addressing the future problems of our SOCIETY

FUTURE

Systems Engineering to drive PLM & to invent Transformational Industry Solutions

Horizon 2010 → **2030**

Transforming is …
Addressing the future problems of our CUSTOMERS

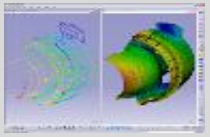
LMS 2012

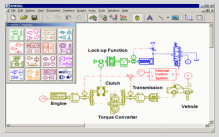
Leading Partner in Test and Mechatronic Simulation

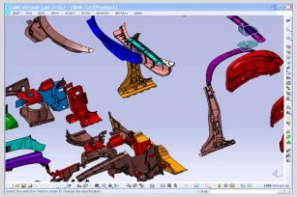
2010 → **2020**

LMS 2000

Hybrid TEST/CAE Partner



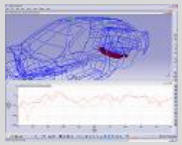




1995 → **2010**

LMS Roots

TEST-NVH Partner



1980 → **1995**

Agenda

MBSE introduction

Capability for plant modeling

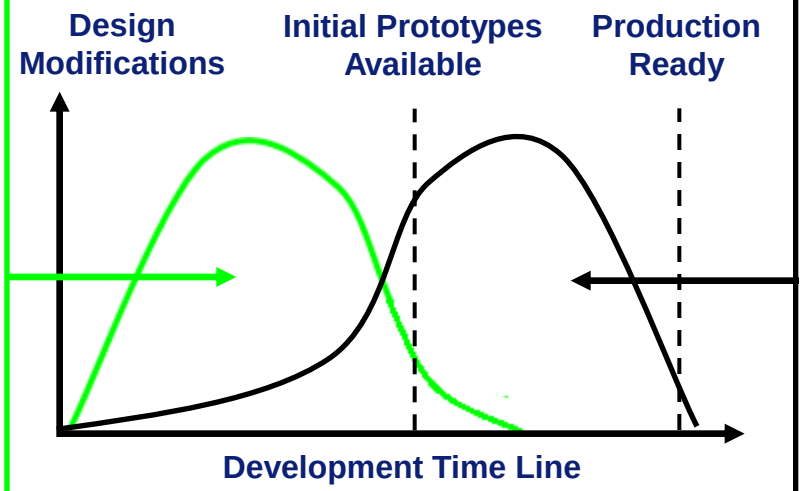
Case studies:

- Auto
- Energy
- Aero

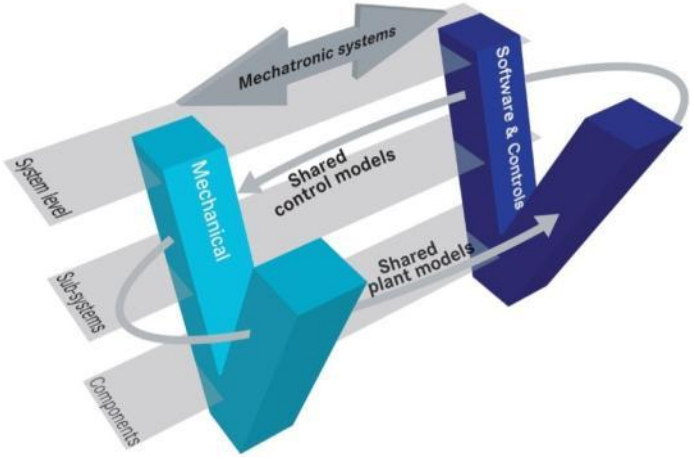
System integration study

Model-based system engineering
Frontloading Development Process

- Objective - Frontload Product Development Process
  - Reduce Late Changes ($'s)
  - Compress Timing
  - Balance & Optimize Vehicle Performance Across Multiple Attributes



- Typically 50%+ of OEM design modifications are made after prototypes become available



The Goal…

Instantiate a Managed, Efficient & Scalable

Controls & *Mechanical*

Concurrent Development Processes

Model-based system engineering
Physical modeling

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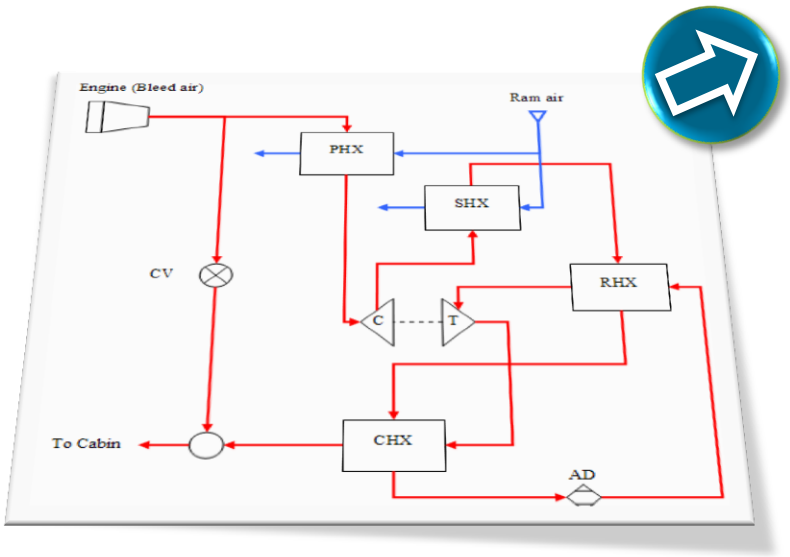
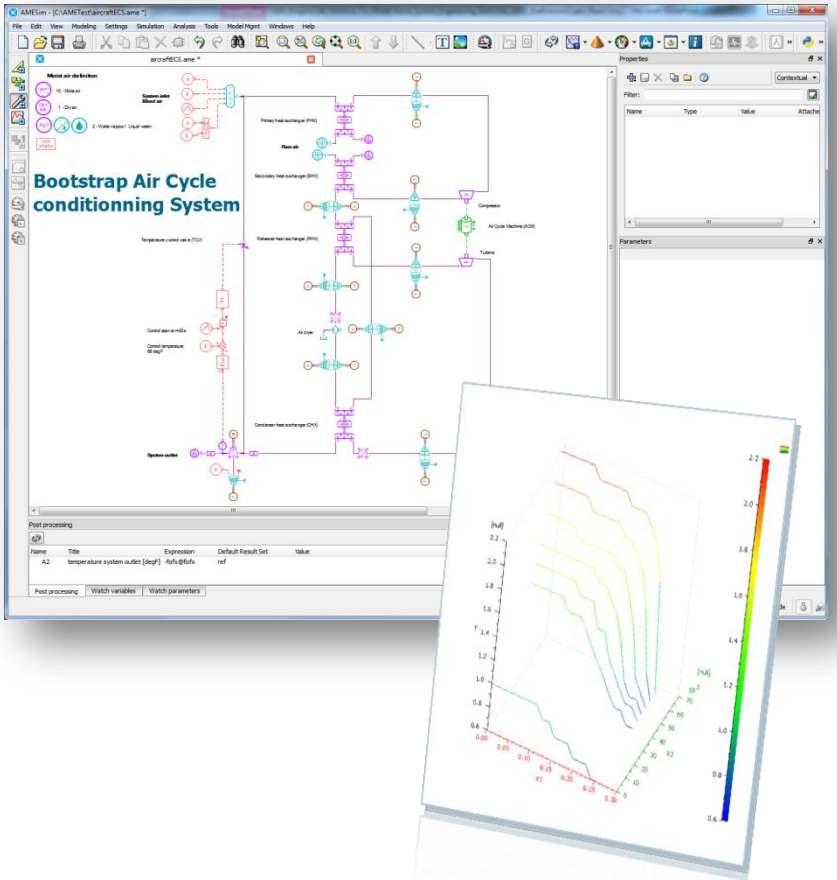
A

Platform Facilities

- **Physical** modeling approach





Fast modeling – Easy to analyze – Easy to reuse – Physical units

Model-based system engineering
Parallel mechanical and controls developments

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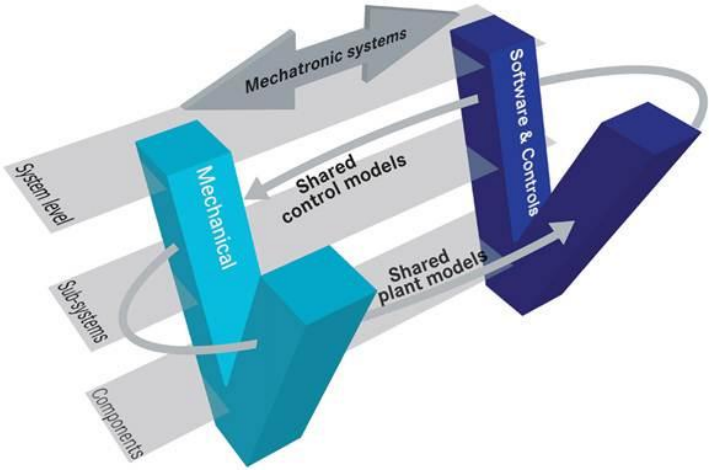
Model-based system engineering

Requirements | Specifications | Implementation | System Integration & Testing | Calibration | Vehicle Integration

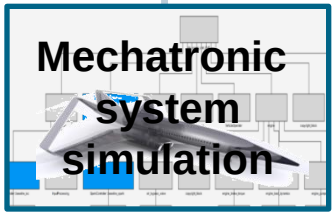


Concept Phase
Business case analysis
System architecture trade-offs

Validation Phase
Frontload system validation and calibration
Virtual/physical testing

Detailed Engineering Phase
Component, Subsystem, System Virtual Verification
Full vehicle performance simulation

“Multi-domain” systems plant models



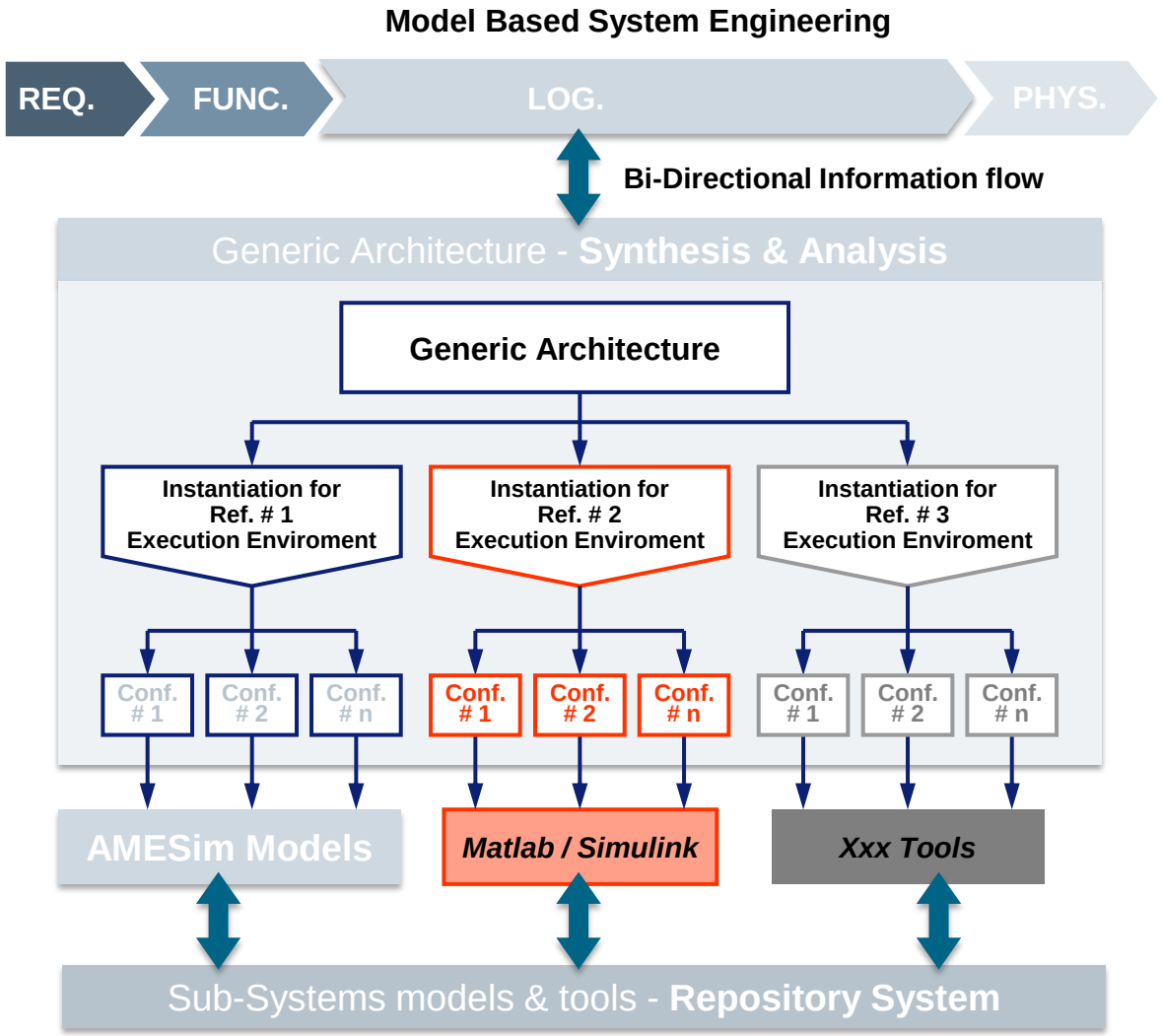
“Control” systems models

LMS solutions for model-based systems engineering

Import or Create **Architecture**

Populate the **Configurations** with available models

Run exported **Models** on execution targets



LMS solutions for model-based systems engineering

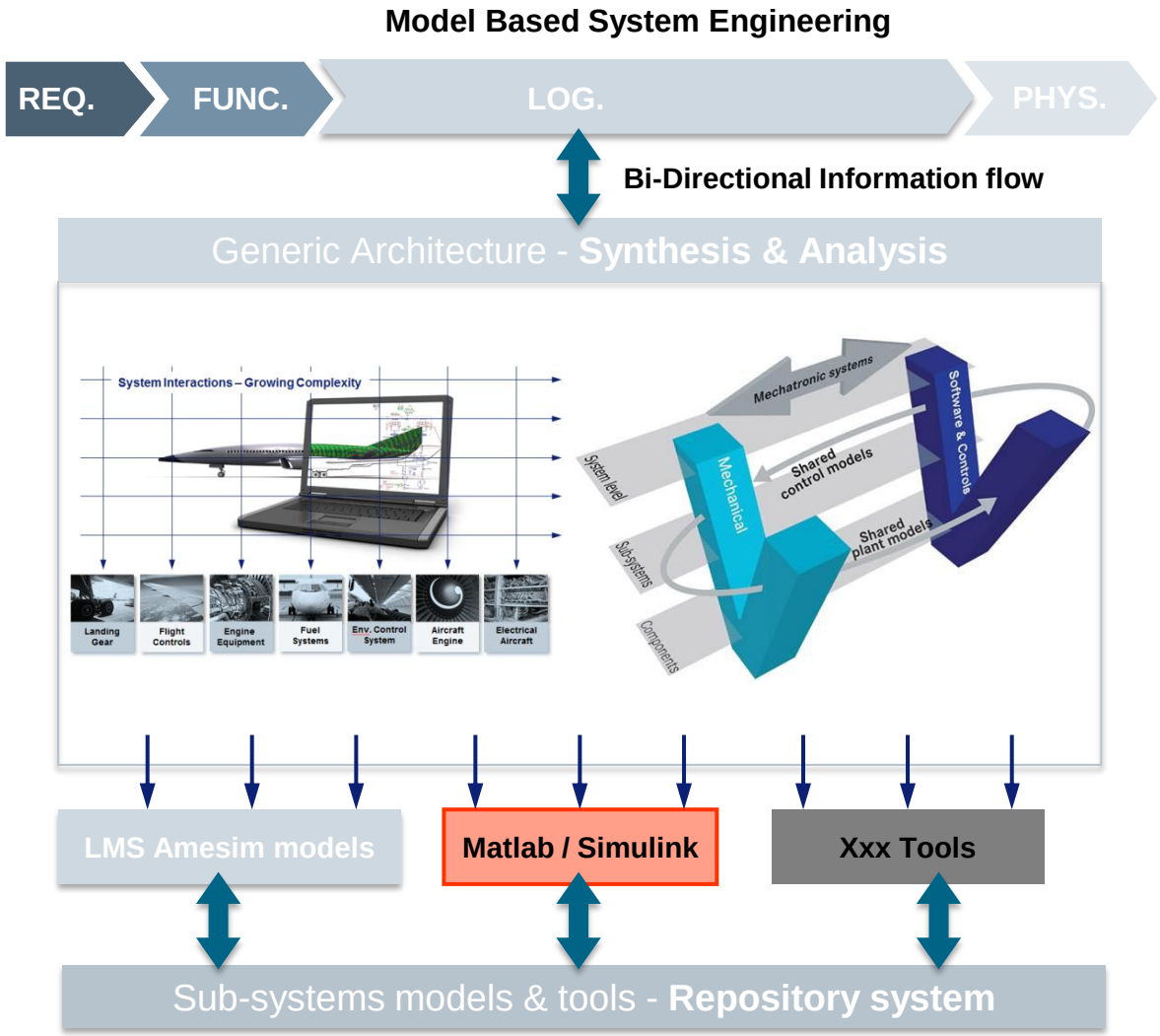
LMS ENGINEERING INNOVATION

Software AND Services

for

Model Based System Engineering

- LMS Imagine.Lab **System Synthesis**
- LMS Imagine.Lab **Amesim**
- LMS Imagine.Lab **Sysdm**



Agenda

MBSE introduction

Capability for plant modeling

Case studies:

- Auto
- Energy
- Aero

System integration study

LMS Imagine.Lab Solutions
From Physics Based Authoring …
… to Model Based System Engineering

SIEMENS

Automotive & Ground Vehicles

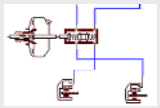
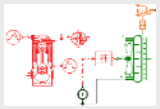
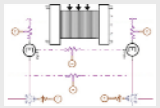
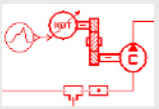
- Internal Combustion Engine
- Transmission
- Thermal Systems
- Vehicle Dynamics
- Electrical Systems

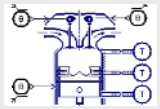
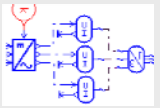
Aerospace & Defense

- Landing Gear & Flight Controls
- Engine Equipment
- Environmental Control Systems
- Fuel Systems
- Aircraft Engine
- Electrical Aircraft

Mechanical Industries

- Pumps & Compressors
- Electro-Hydraulic Valves
- Fluid Actuation Systems
- Heat Exchangers
- Heat Pumps / Refrigerators
- Electrical Systems

Fluids | Thermodynamics | Energy | Control | Mechanical | Internal Combustion Engine | Electrical

40 Libraries / 4,000 Multi-physics Models

- Validated and maintained
- Supporting multiple levels of complexity
- No need for details physics expertise

Plant modeling for controls validation
Real-time simulation

NATIONAL INSTRUMENTS · MATLAB SIMULINK · ETAS · dSPACE · RT-LAB

Open environment,
Connected to the CAE world

The MathWorks · MODELICA · VBA · FLUENT · python

Simulation data and model management
Configuration & architecture management

AMESim

SysDM / System Synthesis

Collaborative Platform for Model-Based System Engineering

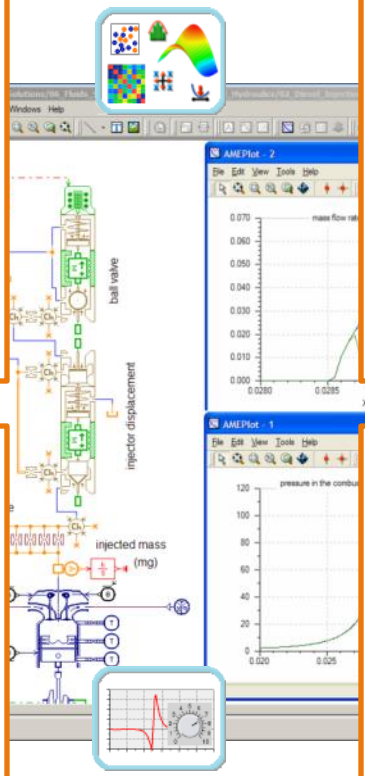
LMS Imagine.Lab AMESim (1/2)

The Open and Productive Development Environment

Simulate and analyze multi-physics controlled systems

INTUITIVE GRAPHICAL INTERFACE

- User-friendly modeling environment
- Seamless connection between various validated and predefined components
- Display of the system throughout the simulation process
- Several customization and scripting tools



UNRIVALLED NUMERICAL CORE

- Capability to robustly execute inhomogeneous dynamic systems
- Advanced numerical techniques (ODE, DAE)
- Dynamic selection of calculation methods
- Discrete partitioning, parallel processing and co-simulation

ADVANCED ANALYSIS TOOLS

- Fast Fourier Transform
- Plotting facilities, 2D/3D post-processing tools
- Spectral map & Order Tracking
- Linear analysis (eigenvalues, modal shapes, root locus, and transfer function representation)

OPEN-ENDED PLATFORM

- Efficient integration with 3rd party software for SiL, MiL, HiL, real-time simulation, MBS, process integration and design optimization
- Generic co-simulation interface to couple to dynamic 3D models
- Modelica-compliant platform

LMS Imagine.Lab AMESim (2/2)

The Validated, Off-the-Shelves Physical Libraries

Chose after 4500 multi-domain models

FLUIDS

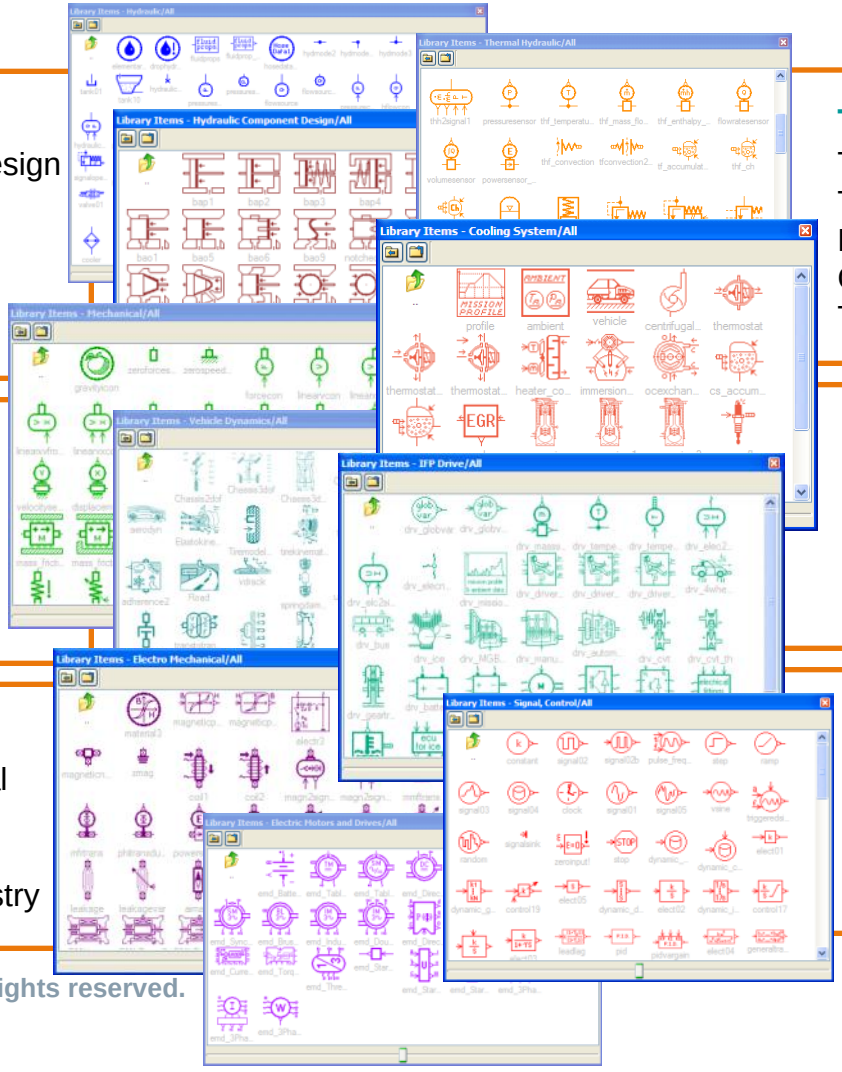
Hydraulic, Hydraulic Component Design
Hydraulic Resistance, Filling
Pneumatic, Pneumatic Component Design
Gas Mixture, Moist Air

THERMODYNAMICS

Thermal, Thermal Hydraulics
Thermal-Hydraulic Component Design, Thermal Pneumatic, Cooling, Air-Conditioning
Two-Phase Flow

MECHANICS

1D mechanical, Planar mechanical
Transmission, Cam & Followers
Finite-Elements Import
Vehicle Dynamics



ENGINE

IFP Drive, IFP Engine
IFP Exhaust
IFP C3D, CFD-1D

ELECTRICS

Electrical Basics, Electromechanical
Electrical Motors & Drives
Electrical Static Conversion
Automotive Electrics, Electrochemistry

CONTROLS

Signal and Control
Engine Signal Generator

Agenda

MBSE introduction

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System integration study

Volvo Construction Equipment: Powertrain design and Thermal Management for Volvo's haulers and loaders

SIEMENS

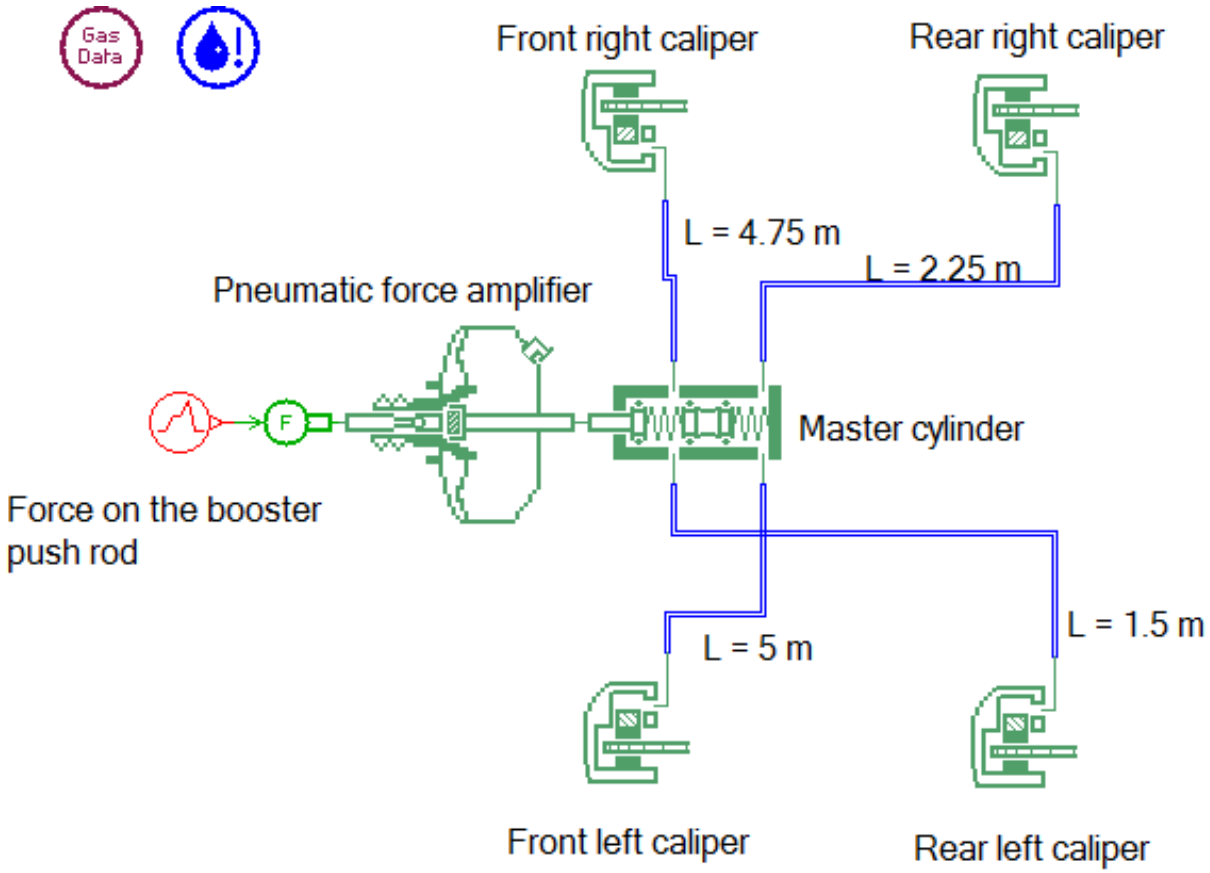
- **Challenges**
  - Accurately predict the fuel consumption and operability of loaders and haulers.
- **Solution**
  - A computational framework (SamSim) including several tools (e.g. Excel, MBS tool, Matlab/Simulink).
  - LMS Imagine.Lab Transmission, Fluids Systems and Thermal Management solutions
- **Benefits**
  - Efficient synthesis tool for the modeling of the whole vehicle and its various systems
  - Study of **the interaction and behavior of systems combining mechanical, thermal, hydraulic and electrical domains**.
  - Volvo CE decided to replace their legacy code to implement AMESim throughout the SamSim package in order to be able to **design a complete system within one single environment.**

"The good results obtained with AMESim led us to massively invest and widely deploy the AMESim package, making it a decisive component of our global simulation platform."

Jonas Larsson, Simulation coordinator haulers and loaders, Volvo Construction Equipment

VOLVO Volvo Construction Equipment

DEMO of a complete braking system



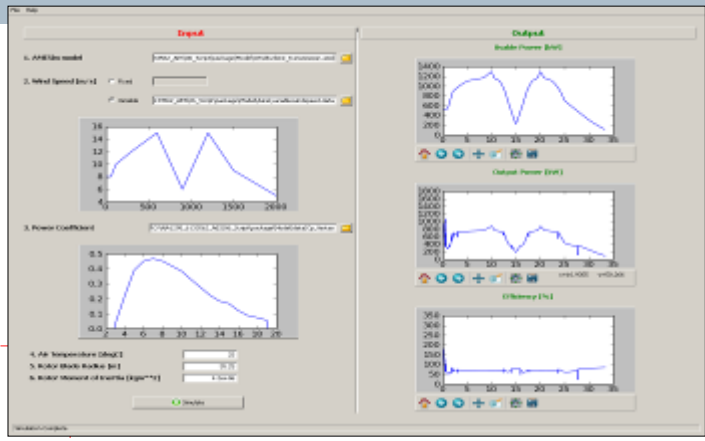
Concept modeling of an original Wind Turbine design

Challenge:

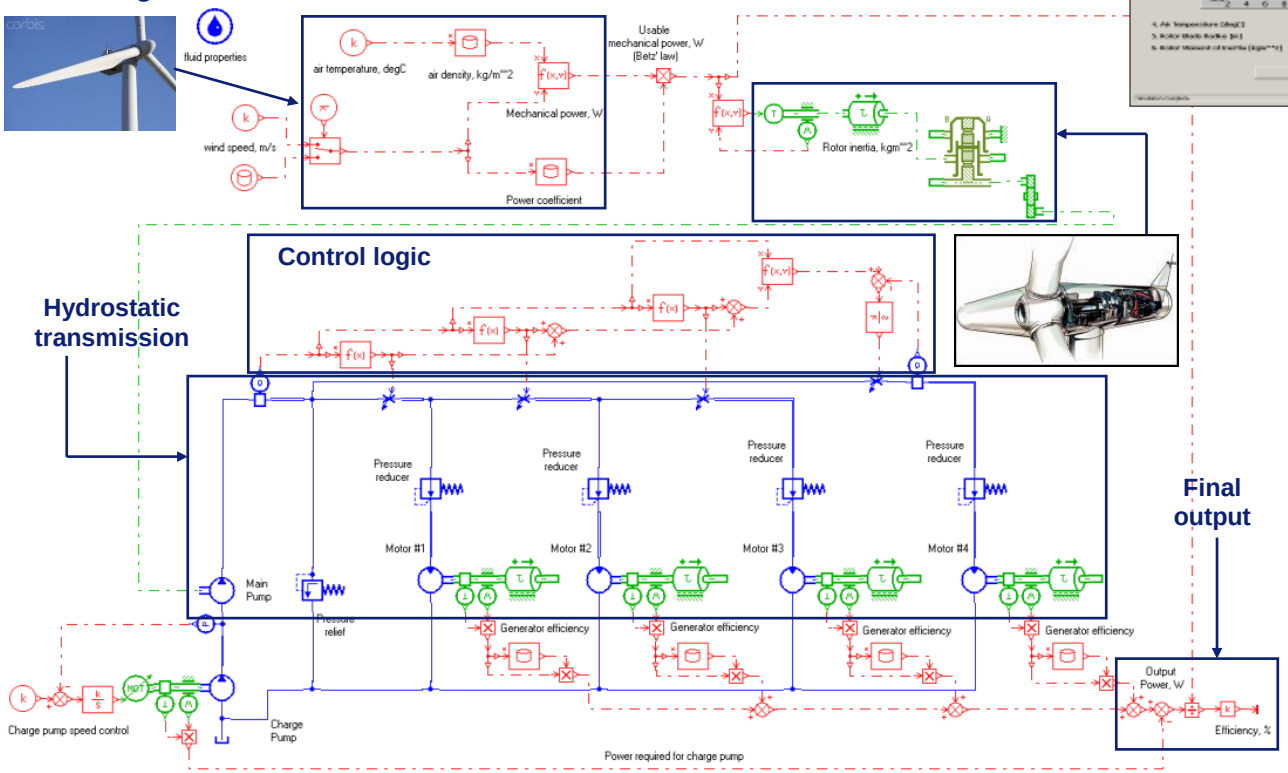
Evaluation of a hydraulic power transmission concept

Solution:

Multi-physics 1D simulation



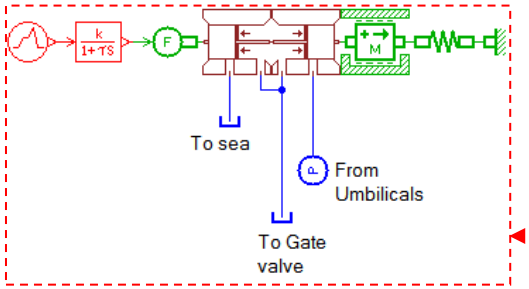
Imagine.Lab model

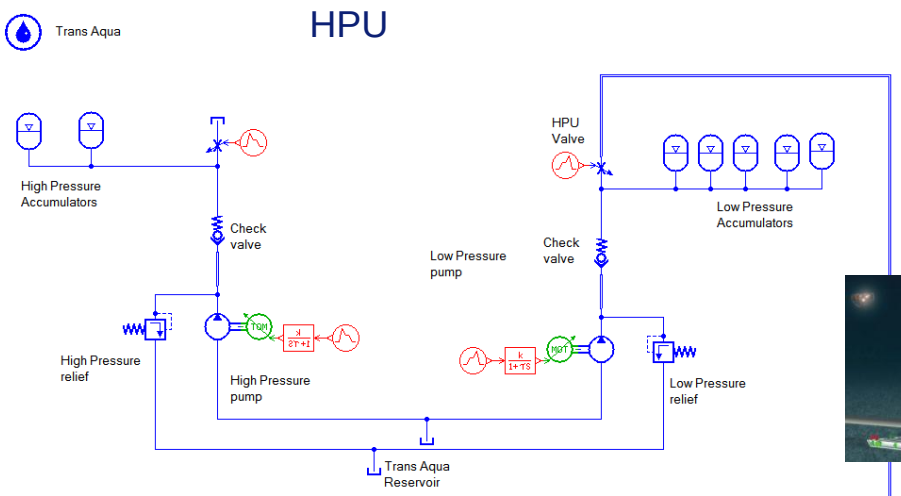


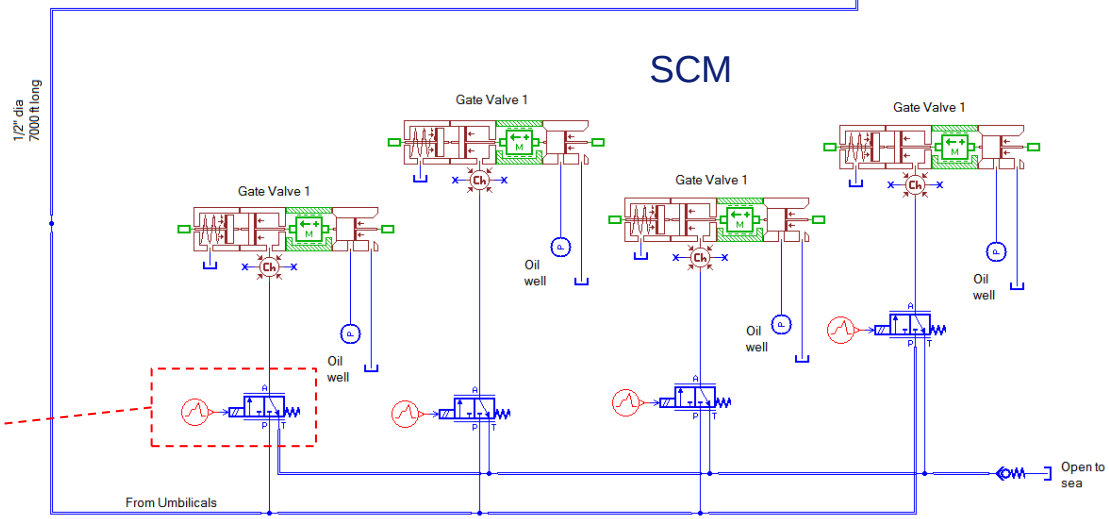
Complete Assembly of the Subsea Control System

This schematic shows the complete assembly of the subsea hydraulic control system

- HPU
- Umbilicals
- SCM
- Gate valves/ Actuators
- Christmas trees
- HPU Valve
- Vent Valve (ESD)







Moog Servo valve model in AMESim

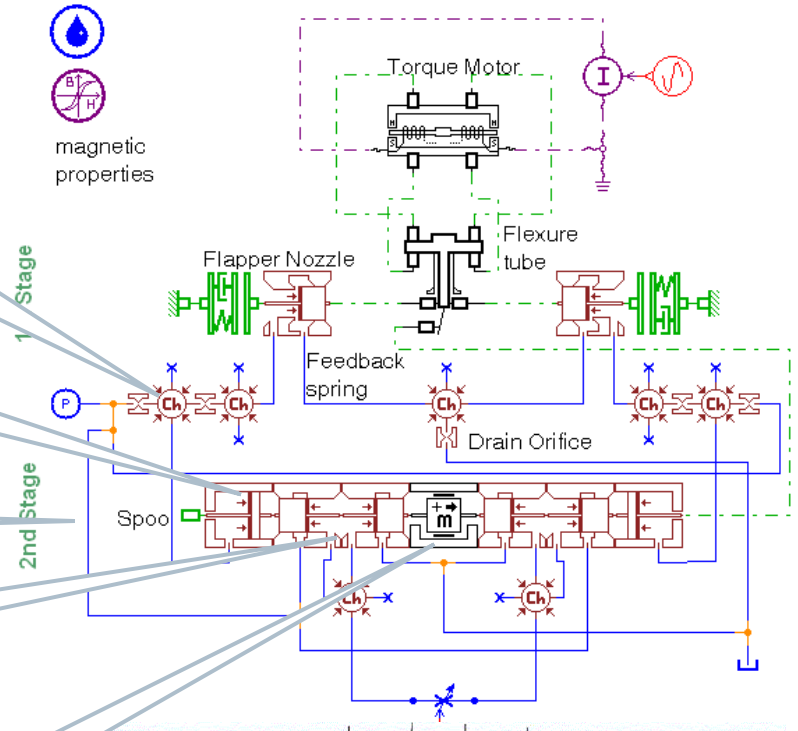
Compressibility

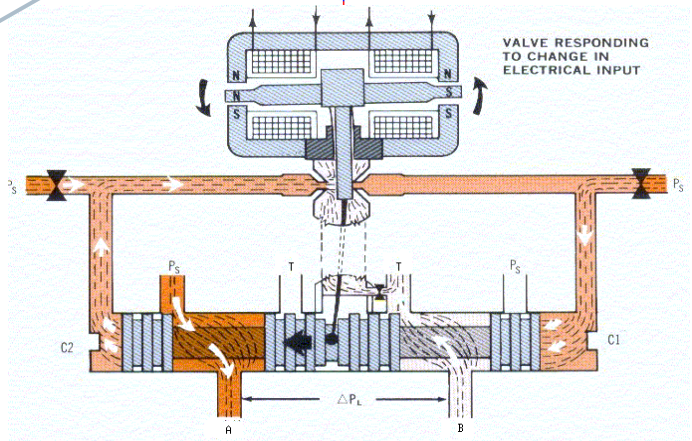
Real geometry
Jet force

Line (dynamics)

Active area
+ spring

Inertia
Friction





Landing Gear Steering System

Messier-Bugatti
Groupe SAFRAN

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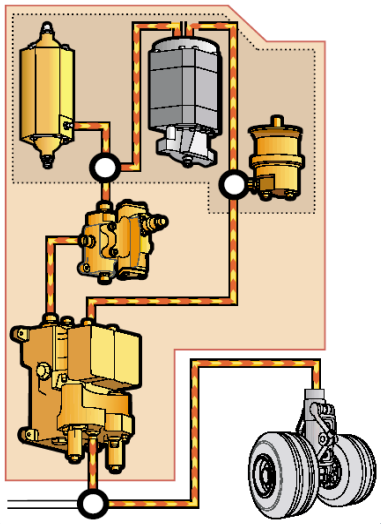
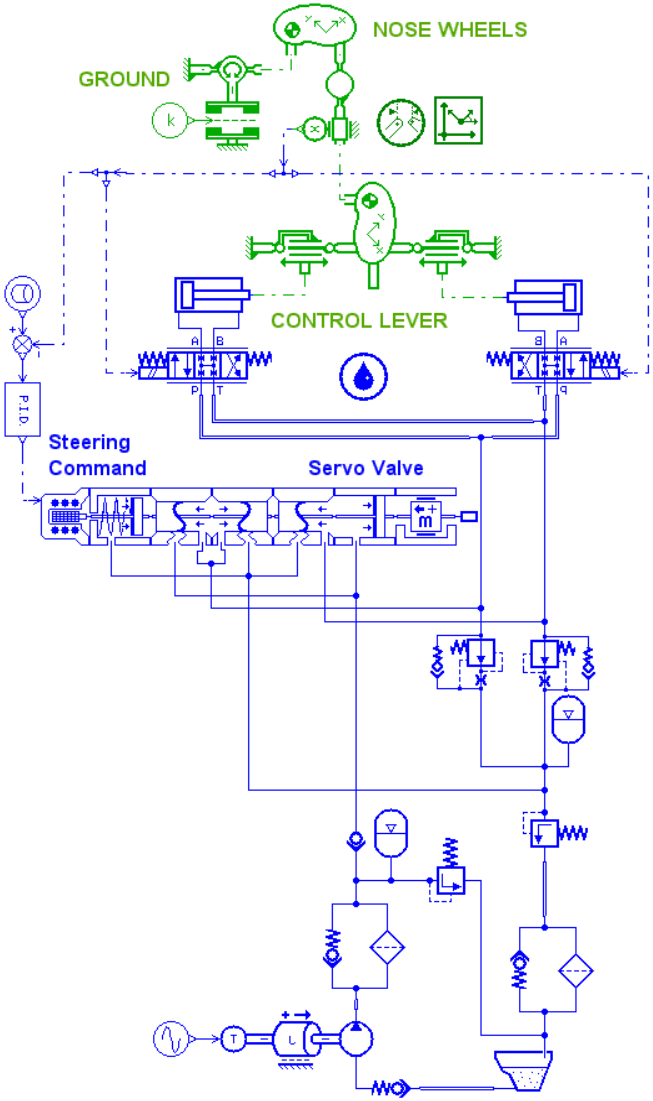
Key Objectives:

Assess the risk of the Airbus A380's new steering ***system overheating***

Integrate and ***optimize*** the compromise between local electro-hydraulic generation ***system sizing*** & ***system performance*** in the ***early product*** development stages





Landing Gear Steering System

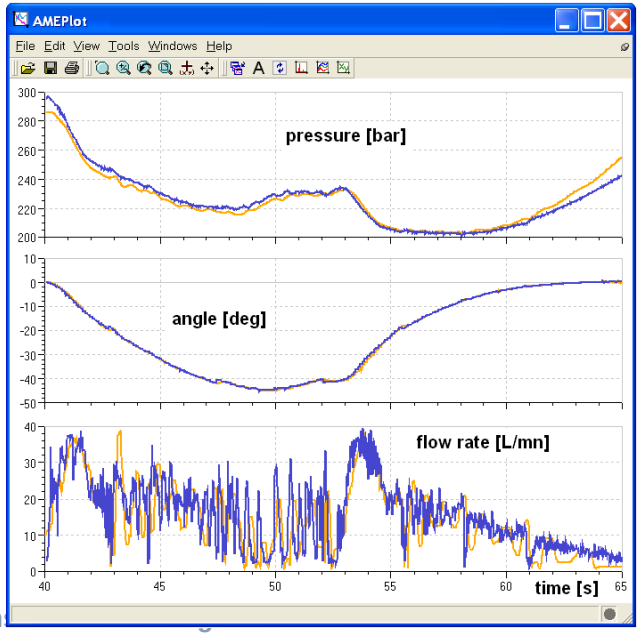
Messier-Bugatti
Groupe SAFRAN

SIEMENS

Success Factor:

Used AMEsim to implement a **predictive model**.

This new model allowed Messier-Bugatti to not only analyze the ***hydraulic behavior*** of the system (in terms of performance, stability, etc.), but also to observe the ***thermal characteristics*** of the hydraulic circuit and assess the need for heat exchangers.



"Simulation enabled us to anticipate and reduce the inherent risks to the development of a new technology by a validation upstream of the technical choices. Simulation results obtained in the early project stages using AMESim were later confirmed on test benches with a very good accuracy".

Stéphane MACHUT, Messier-Bugatti

Agenda

MBSE introduction

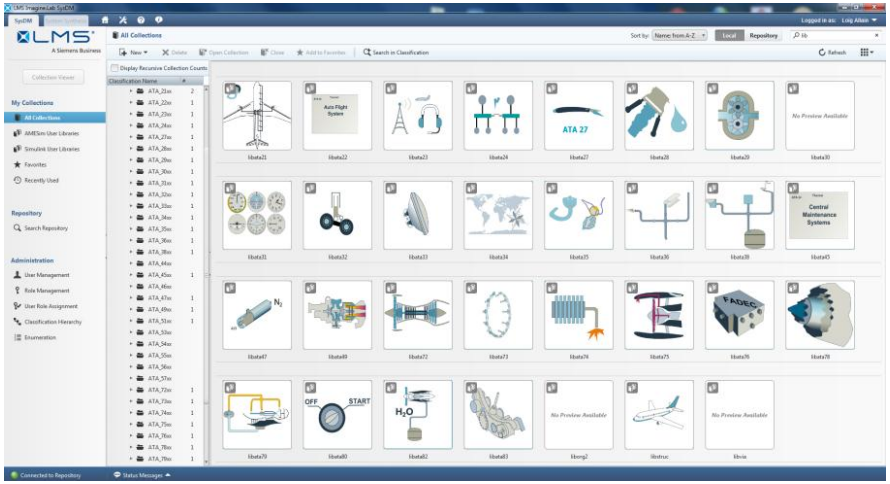
Capability for plant modeling

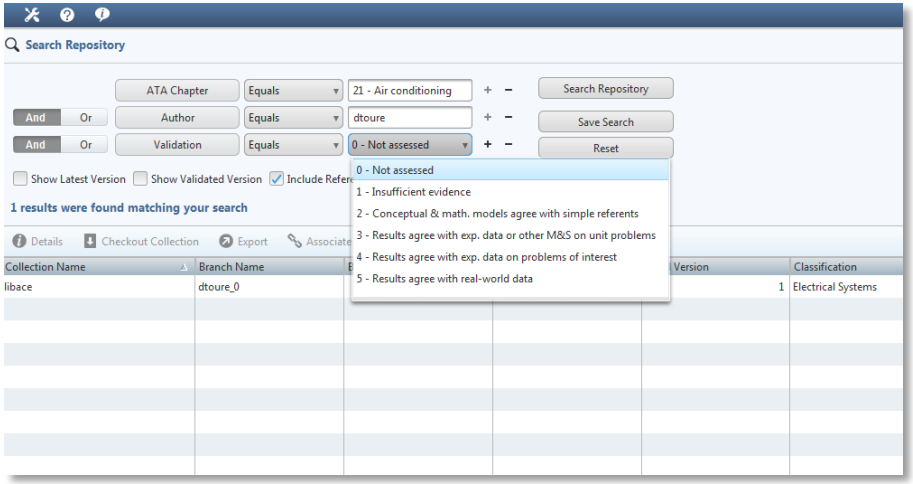
Case studies:

- Auto
- Energy
- Aero

System integration study

LMS Imagine.Lab SysDM
System Data & Configuration Management Tool





Organize

- Hierarchical handling (virtual elements and collections)
- Domain or organization-relevant classification and visualization
- Intuitive search and retrieval

Control

- Asynchronous collaborative workflows with role-based access control
- Customized collaboration workflows (check-in, check-out, syndication…)

Share

- Version (lifecycle) and Variant management (branching)
- Addressing needs from both control and system engineering communities

Capitalize

- Open Infrastructure
- Support of AMESim, Simulink and other Model authoring tools

LMS Imagine.Lab System Synthesis
The system architecture and configuration tool

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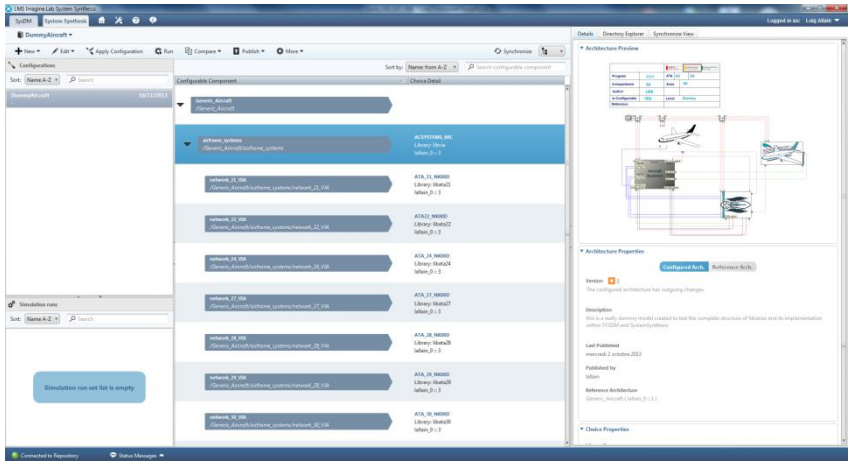

Import / Define Architecture

- Extract or Import Architecture
- Define System / Subsystem / Component hierarchy
- Define Port and Connection

Create Configurations

- Configure at multi-level system models from available libraries
- Store and re-use system configuration for « what-if » studies

Launch Simulations

- Create pre-defined sets of simulation tasks
- Launch heterogeneous simulation

Requirement Driven Model Based Development

- Map Requirements, verification & System Configuration
- Bi-directional Impact analysis

SIEMENS

Thank you

Smarter decisions, better products.

Contact Information

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Smarter decisions, better products.