

# MATLAB EXPO 2018

## Model-Based Design per sistemi powertrain

From concept to production

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# Agenda

- **Introduction**
- **Motivation & Challenges**
- **Model-Based Design: why is a necessity**
- **Product Innovation**
- **PWT Model-Based Design toolchain**
- **Future developments**

# INTRODUCTION

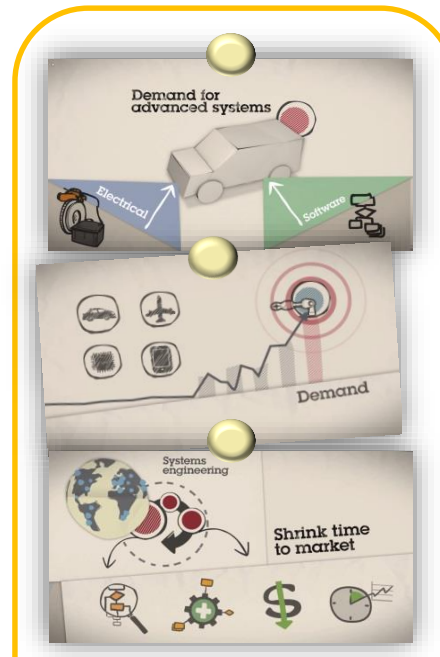


# INTRODUCTION

- ❑ OEM achievements: Business demand, System Development and Quality
- ❑ Know-how preserve
- ❑ Product distinctive
- ❑ Time2Market (reduction)

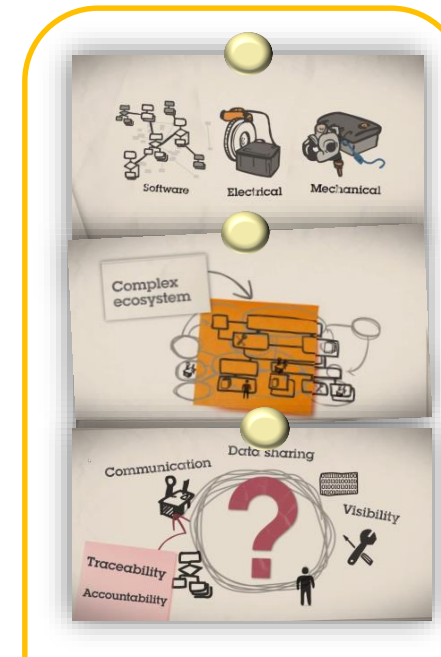
## Operations

- **A process is** a series of steps and **decisions** involved in the way work is completed
- **System Development Life Cycle** represents a **process** for designing, testing and implementation of software application



### Business Demand (BD)

- Advanced functionality
- Minimize cost
- Ensure time2market



### System Development (SD)

- Complex systems
- Unique Requirements
- E/E SW development



### SDLifeCycle (SDLC)

- Communication
- Visibility
- Quality

# MOTIVATIONS & CHALLENGES

- Speed up development of new concept
- Methodologies and unified toolchain for code production



**Competitiveness**



**Intellectual  
property**



**Technology  
know-how**



**Exclusive  
product**



# MODEL-BASED DESIGN: WHY IS A NECESSITY

**Model-Based Systems Engineering** is the formalized application of **modeling** to support system requirements, **design**, **analysis**, **verification** and **validation** activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.”

INCOSE SE Vision 2020 (INCOSE-TP-2004-004-02, Sep 2007)

	Document Based	MBSE Based
Information	- Mostly Text - Add Hoc Diagrams - Loosely coupled, repeated in multiple documents	- Visual and Textual - Constructs Defined once and re-used - Shared across Domains - Consistent notation in diagrams - Defined relationships
Information Views	- By Document	- Provides Viewpoints - Filters By Domain, Problem Space, etc.
Measuring Change Impact	- Spans across Multiple Documents - Often Text Reqts. Are isolated from Structure and Behavior	- Relationships define traceability paths - Natural part of the modeling process - Programmatically Automated
Measuring Integrity - Completeness, Quality & Accuracy	- By manual inspection	- Programmatically Automated - Animation of Spec

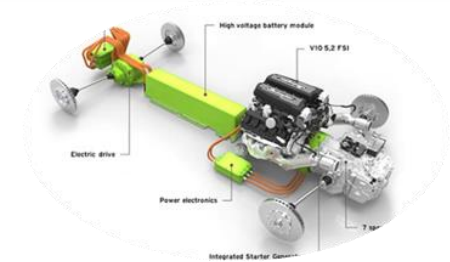
MBSE allows productive cooperation with stakeholders, improving quality, increasing productivity and reducing risk.

## Why Model based design is useful

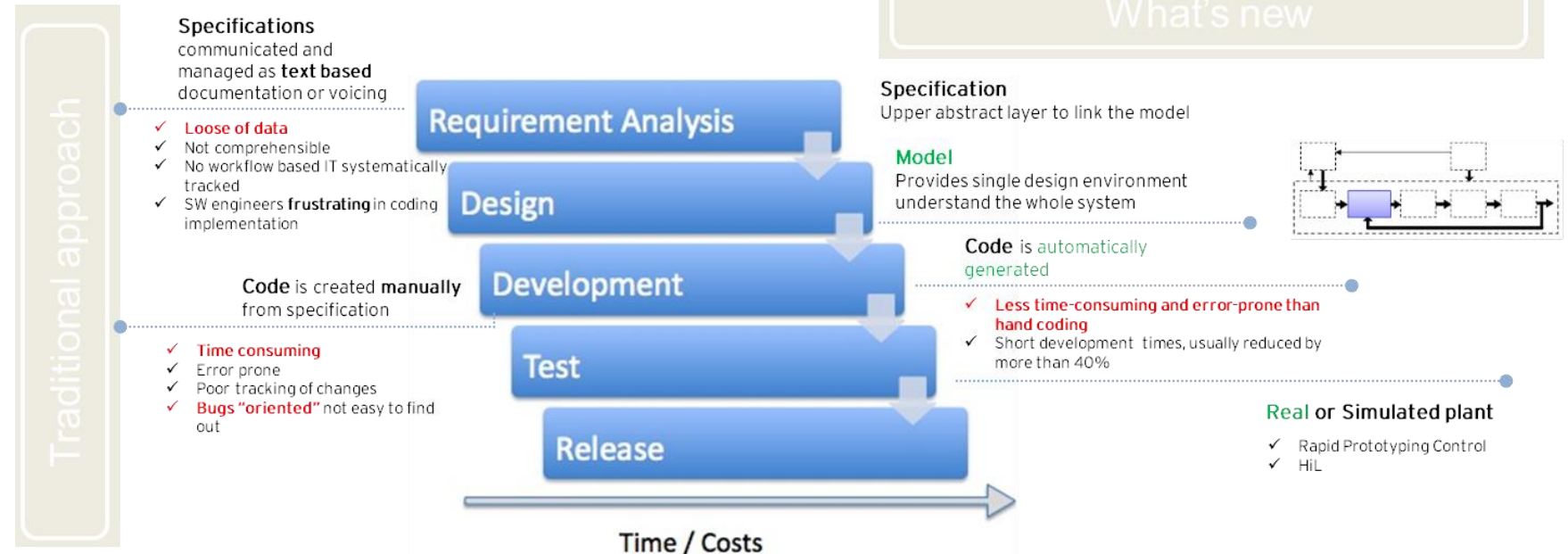


### COMPLEXITY

- of component and technology driven mainly by customer functions and efficiency requirements.
- of innovative technologies show several component updates during the vehicle life cycle
- of function network for torque control management



### What's new



# PRODUCT INNOVATIONS (1/2)

## Kers



«**Model-Based Design** has allowed evident benefits in function development producing a new mentality to the software design»

## Powertrain tells...

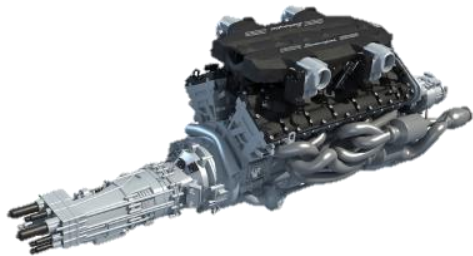
## VVT



In **2010** a first tentative towards MBD approach was achieved integrating the KERS torque management entirely designed in **Matlab** along with **Gallardo** engine torque control. The experiment was successful and carried to **prototype** the vehicle in order to evaluate the benefits in performances (emission and driveability)

In **2012** the goal to make on **production series** some functionalities on **Aventador** project was achieved. Starting from the Kers experiences done in function development, new challenges was faced in term of code integration and fixed point design to be accomplished with the embedded project. A crucial role was the supplier collaboration

## Pullaway



## Kers

Kinematic Energy Recovery System is able to store and release energy to the vehicle for improving performances

## VVT

Vane cam phasers are used in ICE for changing the valve timing lifting up and down the intake and exhaust valves for improving vehicle performances

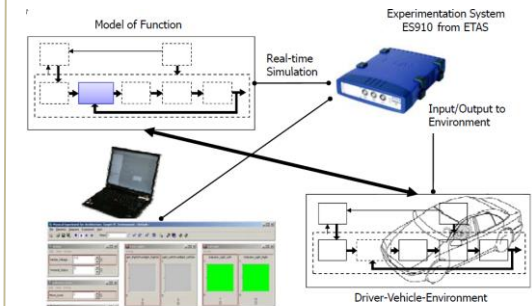
## PullAway

The functionalities allows to the driver to start the vehicle based on the acceleration requested

## Rapid Control Prototyping

When the vehicle is available the new functionalities development can be tested simply and fastly by running it on RT target.

The Simulink model, designed on the PC, can be targeted by using InteCRIO tools. ETAS910 (RT target) allows the RT communication among the host and the vehicle.

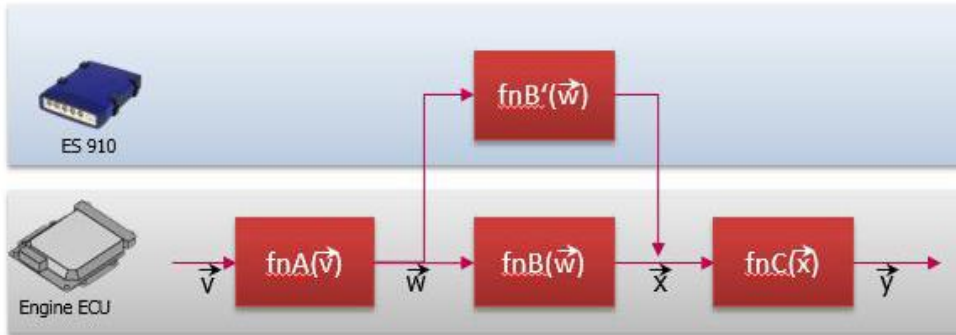


Following this technique and MBD methodologies it's possible testing the effectiveness of changes reducing development time conversely from traditional approach

# PRODUCT INNOVATIONS (2/2)

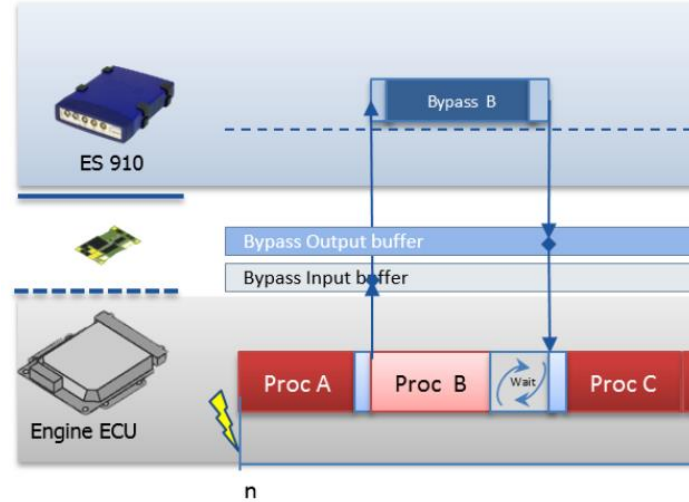
## Rapid control prototyping

External bypass is a common method to prototype or enhance ECU algorithms rapidly. Data read from ECU is used as inputs to the bypass algorithm created in Simulink and executed externally.



The output of the bypass is fed back into the ECU and used instead of the output of the algorithm calculated on the ECU

## Service based bypass (SBB)



1. Individual bypass input variables of the bypass are copied at each service point
2. Bypass always gets always the last ECU values and executes exactly the same inputs and time function (replace or improve)
3. Bypass output data is written into the ETK and into the ECU at the end of the service point after synchronization

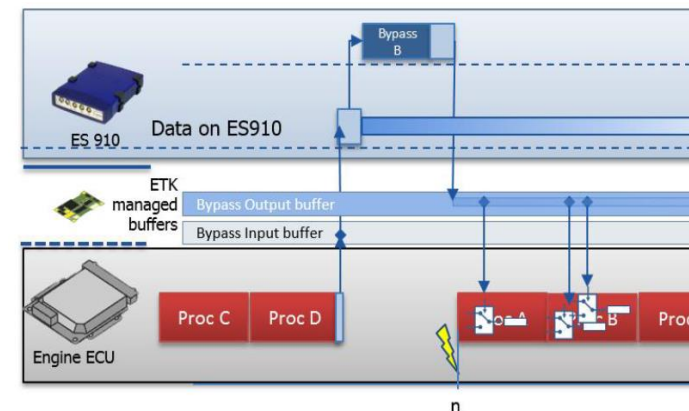
Pro

- Fully synchronized bypass execution with no raster delay

Cons

- ECUs scheduling idea

## Hook based bypass (HBB)



1. All bypass variables are copied at once from ECU, typically at the end
2. After bypass the outputs are written in the ETK buffer
3. Each var is read back at the corresponding ECU software

Pro

- Low impact on ECU load and timing behaviour
- No information on ECU scheduling needed
- Minimal interrupt load
- One or more vars can be bypassed



# PWT MODEL-BASED DESIGN TOOLCHAIN

## How tool works

- Linking requirement to documentation (V&V)
- Model (SLK, ML, SF)
- Implementation
  - MAAB rules guideline check
- Sync model version to GitHub
- Analysis (V&V)
  - MIL vs. SIL
  - Test coverage
- SW Specification (SL ReportGenerator)
- Code Generation (Embedded Coder)
  - Target customization
  - Library implementation

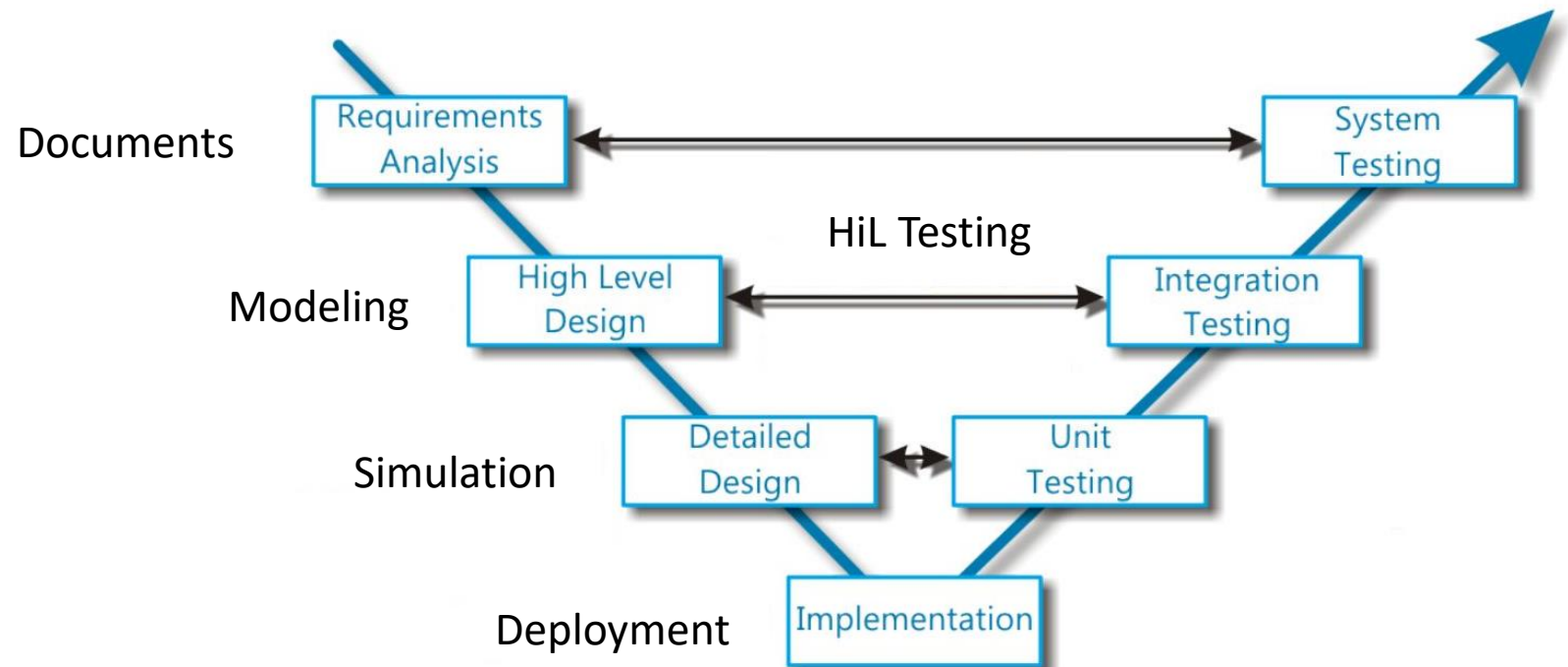
## Features

- Distributed app

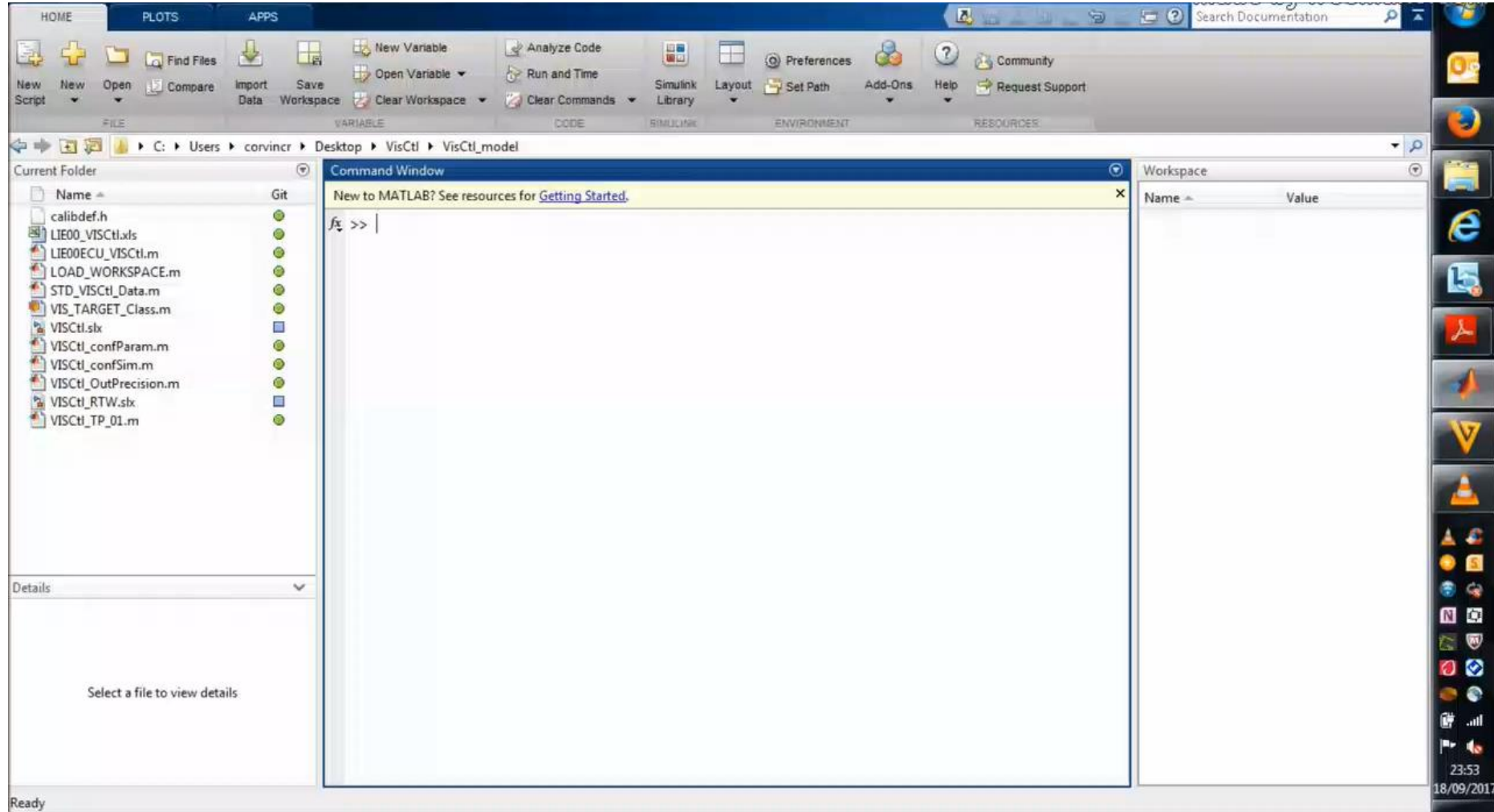
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## Is it possible integrate data for function development?

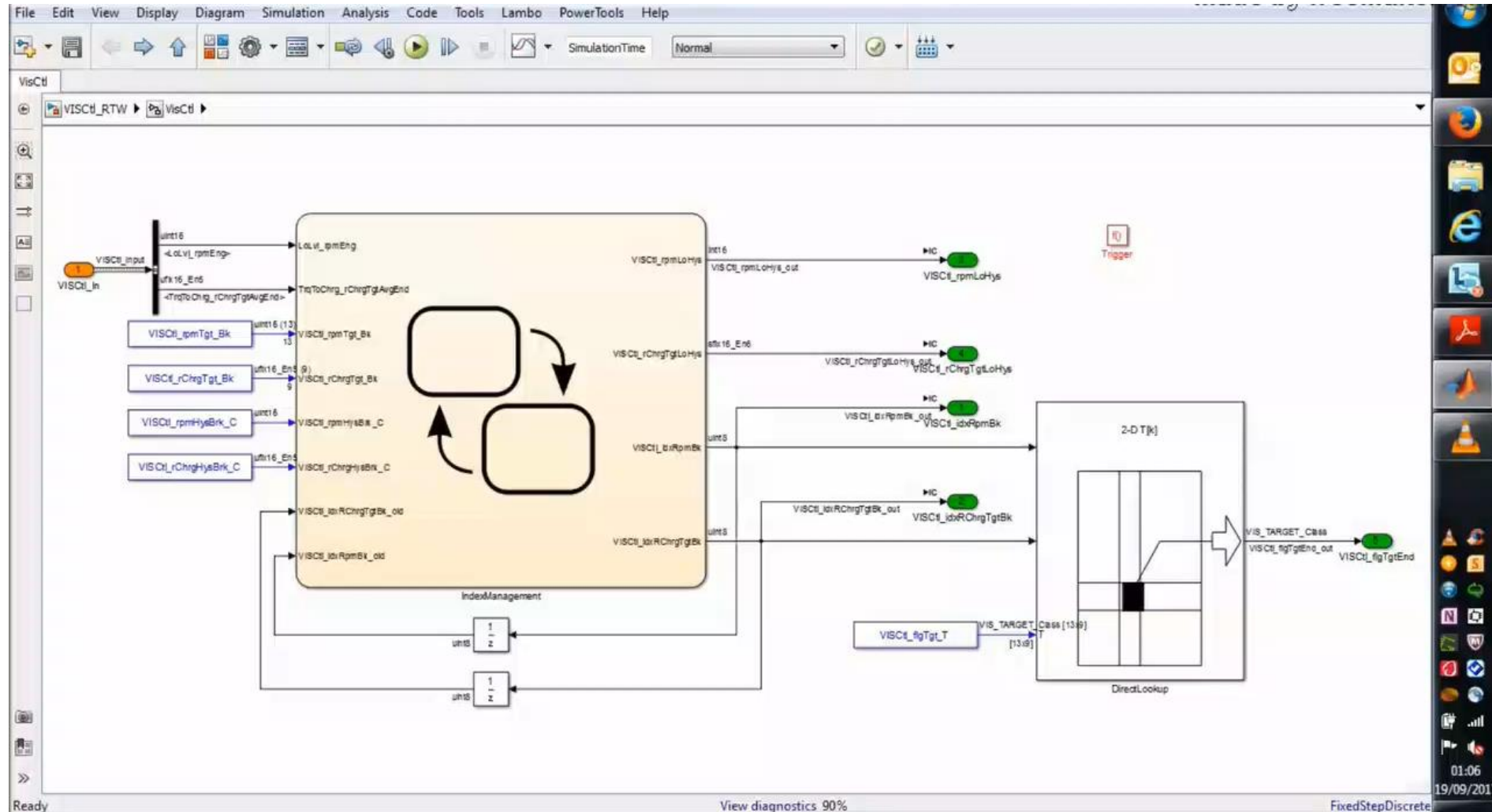
«By using MathWorks products the function development process automation it was possible raising in effectiveness and efficiency in the early stage of development»



# PWT MODEL-BASED DESIGN TOOLCHAIN



# PWT MODEL-BASED DESIGN TOOLCHAIN



# Future developments

## Toolchain enhancements:

- **System Architecture (database)**
- **Model Requirements**
- **Consistency checks of custom MAAB rules**
- **PolySpace checks**



**Thanks for your patience**