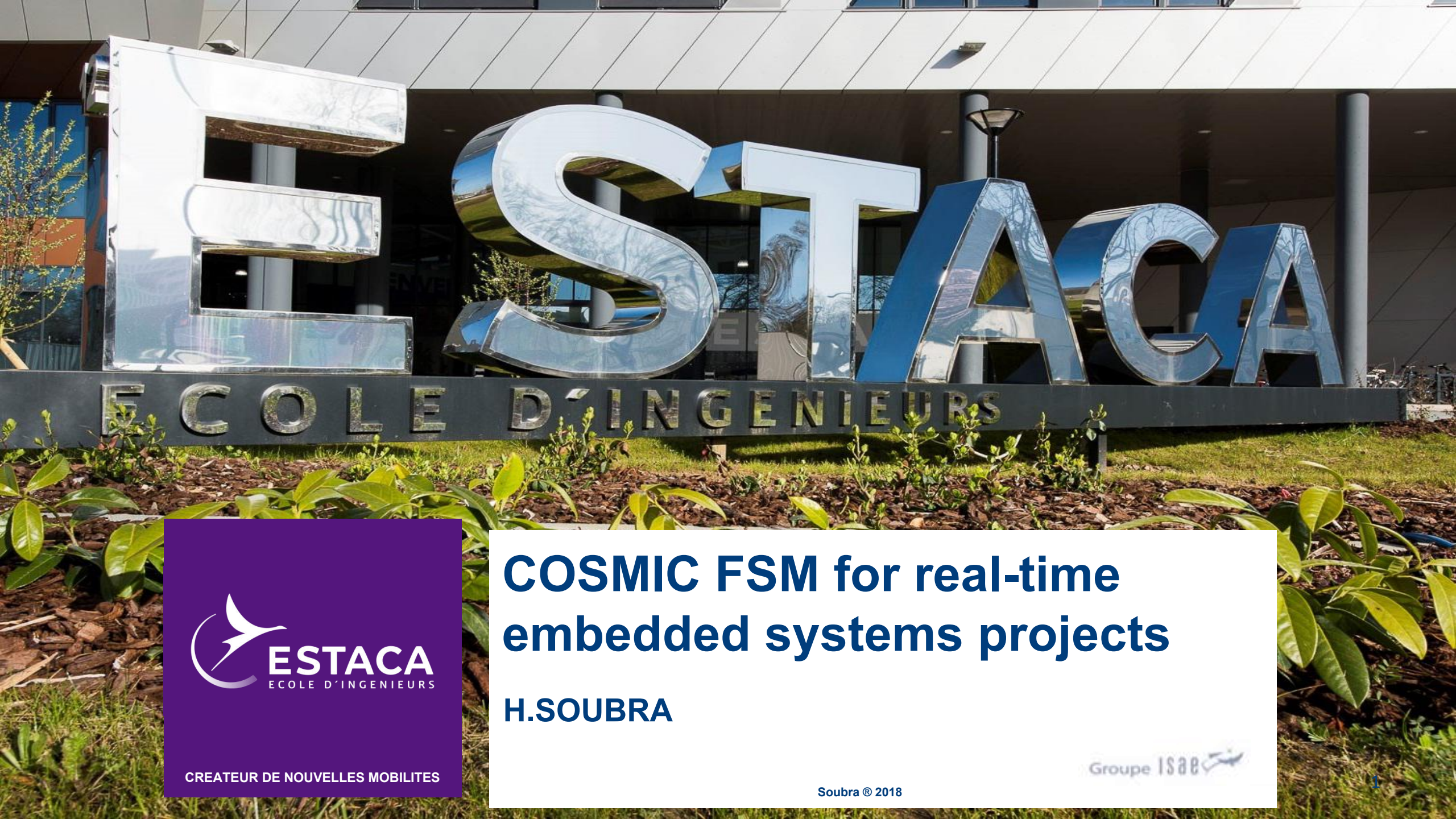


ESTACA
ECOLE D´INGENIEURS

CREATEUR DE NOUVELLES MOBILITES

# COSMIC FSM for real-time embedded systems projects

H.SOUBRA

Groupe ISAE

# Agenda

Introduction

COSMIC Method

Case studies

Conclusion

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**Introduction**

COSMIC Method

Case studies

Conclusion

# Introduction

- Embedded systems aka « Cyber Physical » systems are everywhere! And today they are Connected (Iot, IoV, IoD, IoE, etc), and where Software plays a crucial role.

- Software functional size can be used for a number of purposes: to obtain system related technical indicators early in the design phase (e.g. processor load, etc.), which in turn can impact performance. It can also be used to estimate development Effort, etc.


Image Source: https://www.economie.gouv.fr

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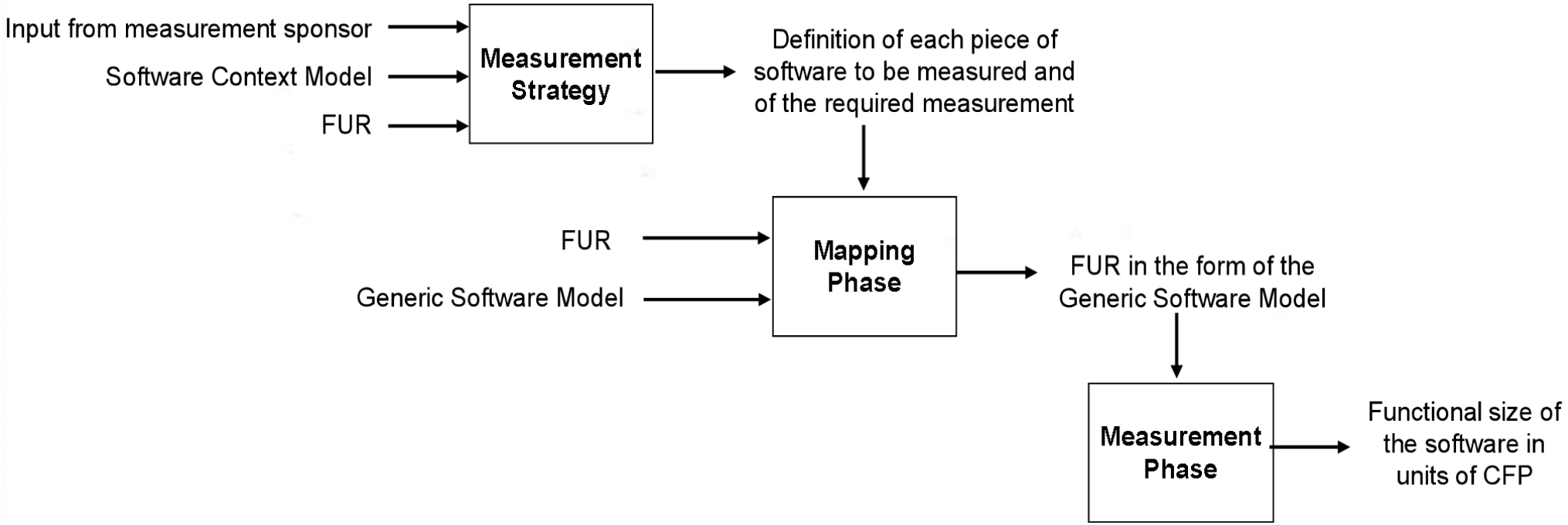
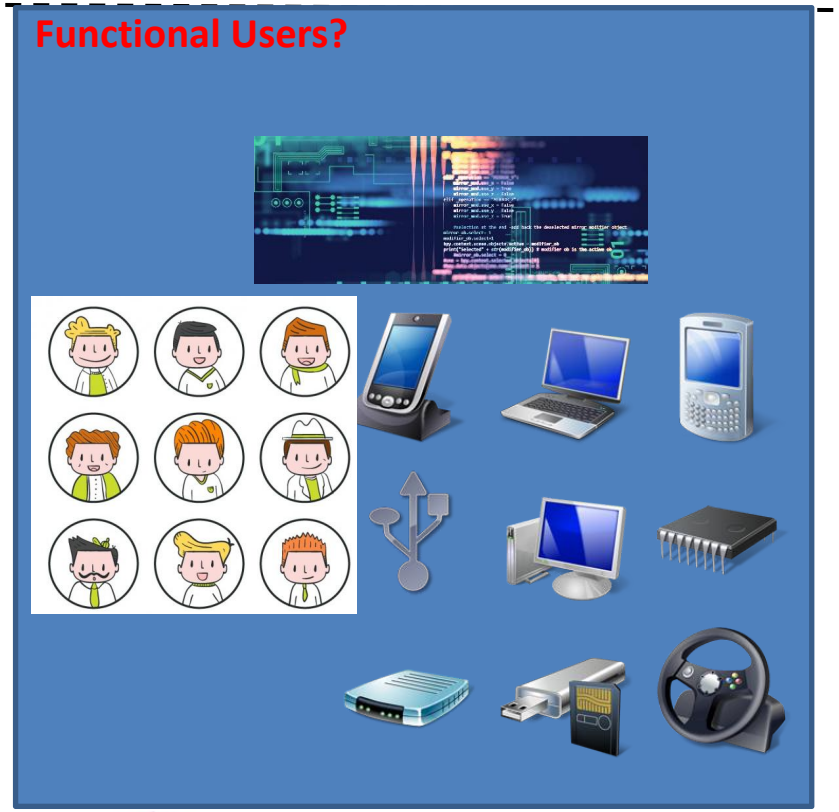
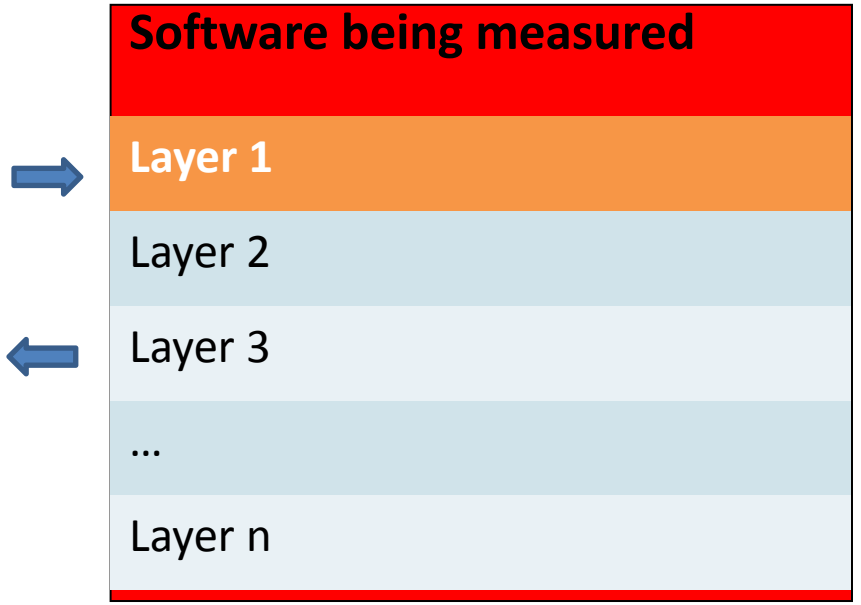
# COSMIC's 3-stage Measurement Process



# The COSMIC Measurement Strategy Phase

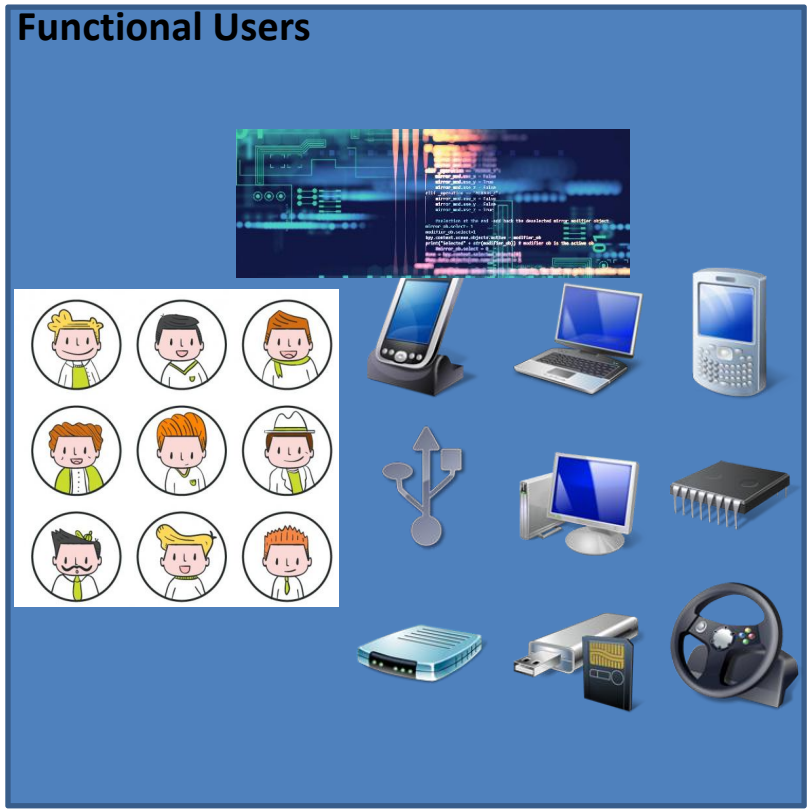
In the Strategy phase, the software to be measured, its users, the layers, etc. are defined

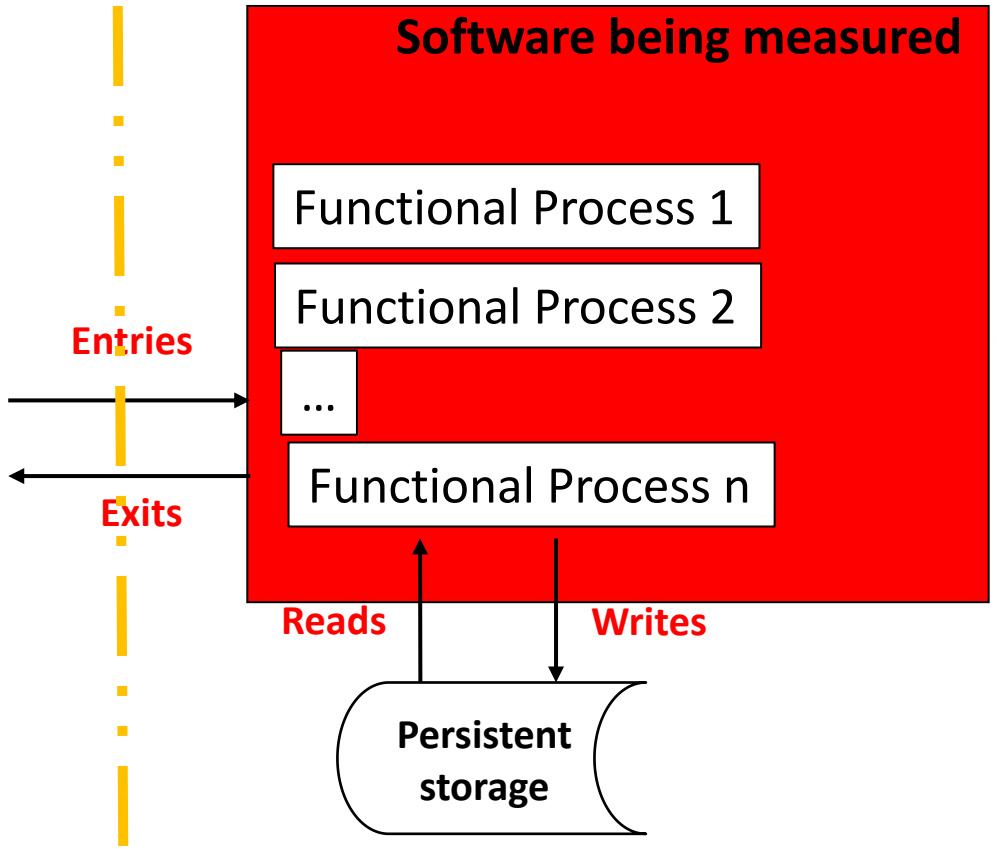


# The COSMIC Mapping Phase

In the Mapping phase: the functional processes, Triggers, the data movements, etc. are identified.




1'Data Movement'= 1 CFP (COSMIC Function Point)

# The COSMIC Measurement Phase

Size of Software = the total of data movements of all functional processes


**A functional process must at least have :**

**{ A triggering Entry + a Write or an Exit}**

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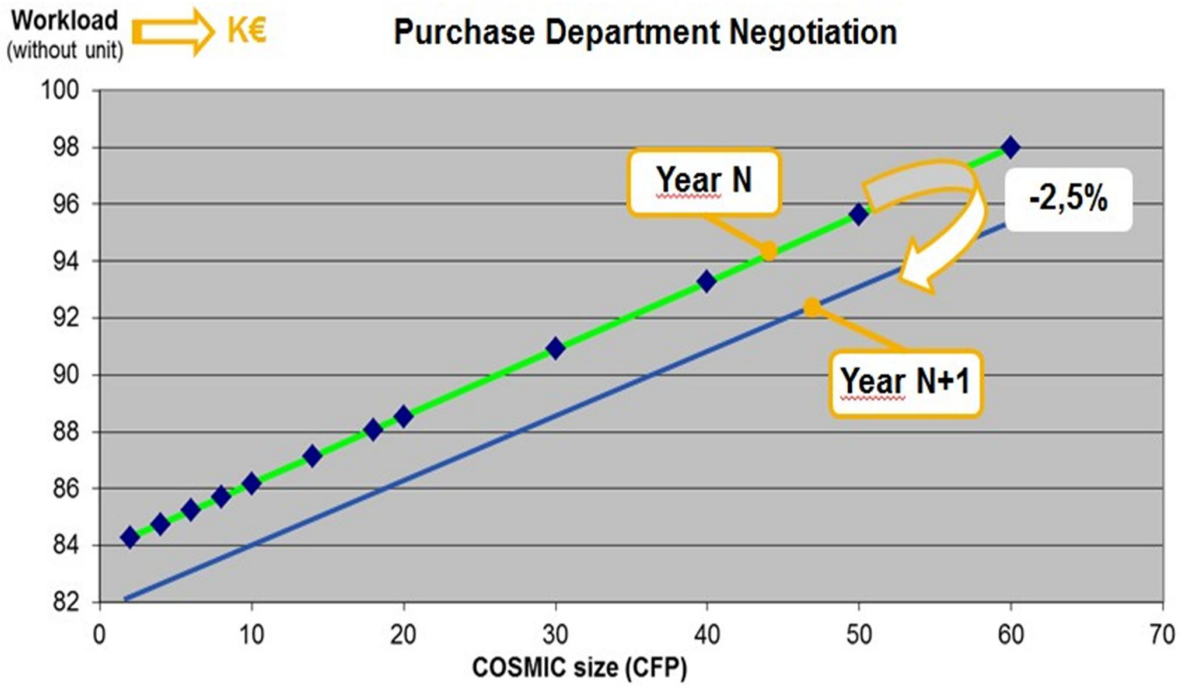
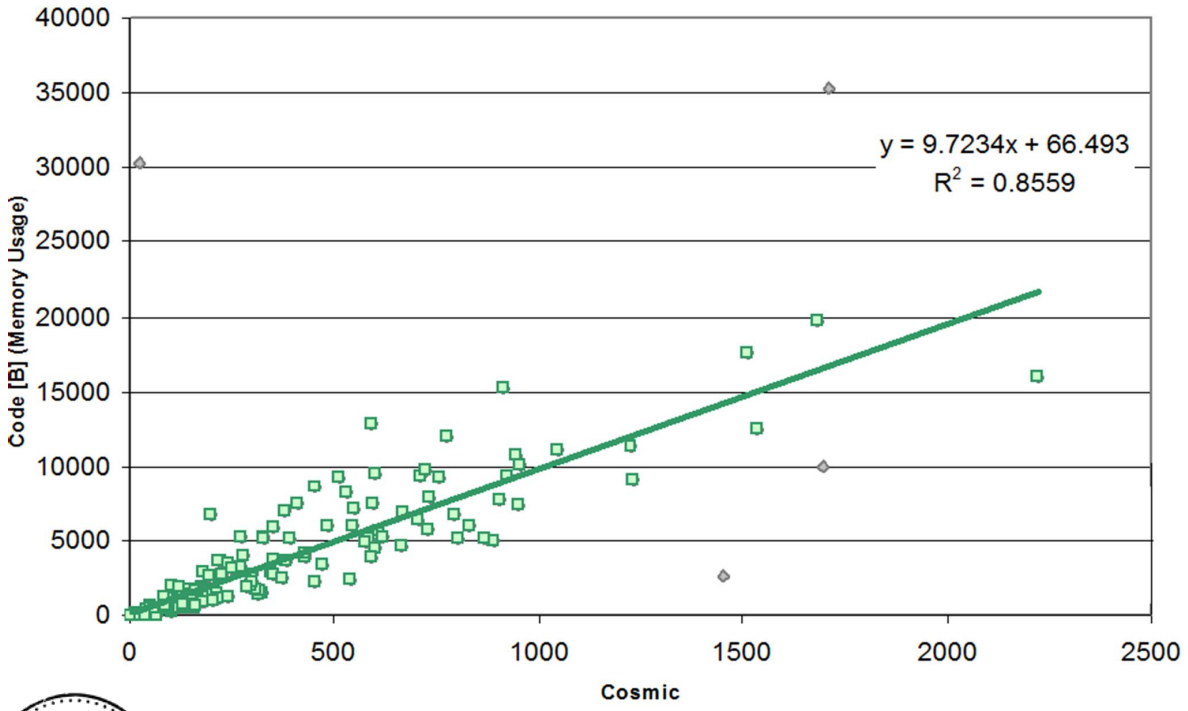
# Automotive: Simulink : cost estimation (Renault) + memory size estimation

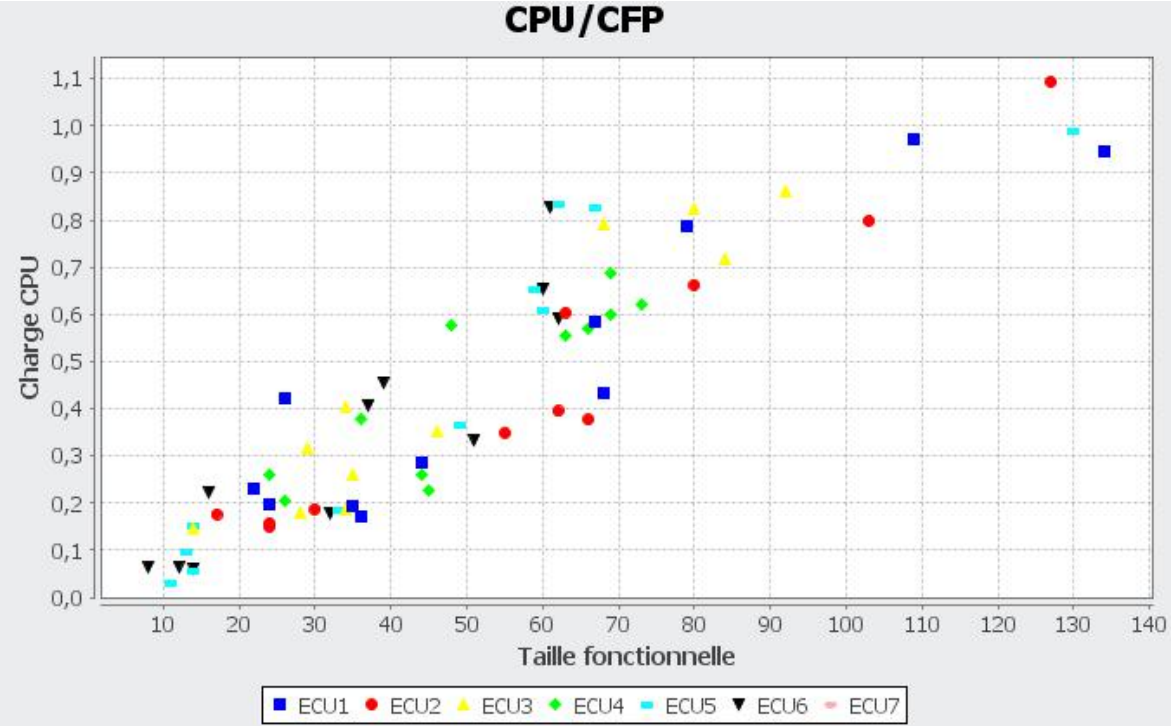


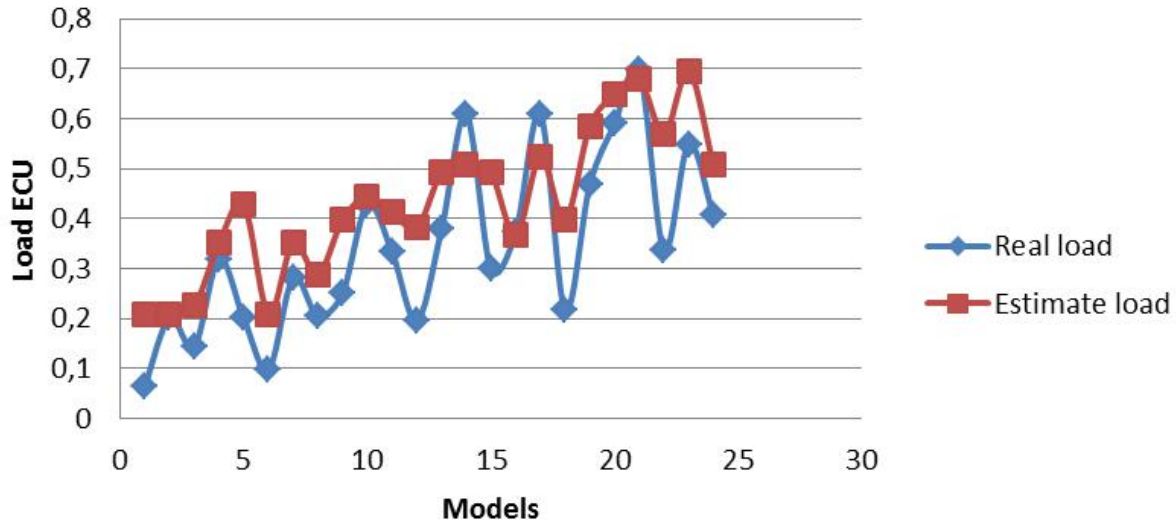





Automated!

# Automotive: Processor Load Estimation in Autosar

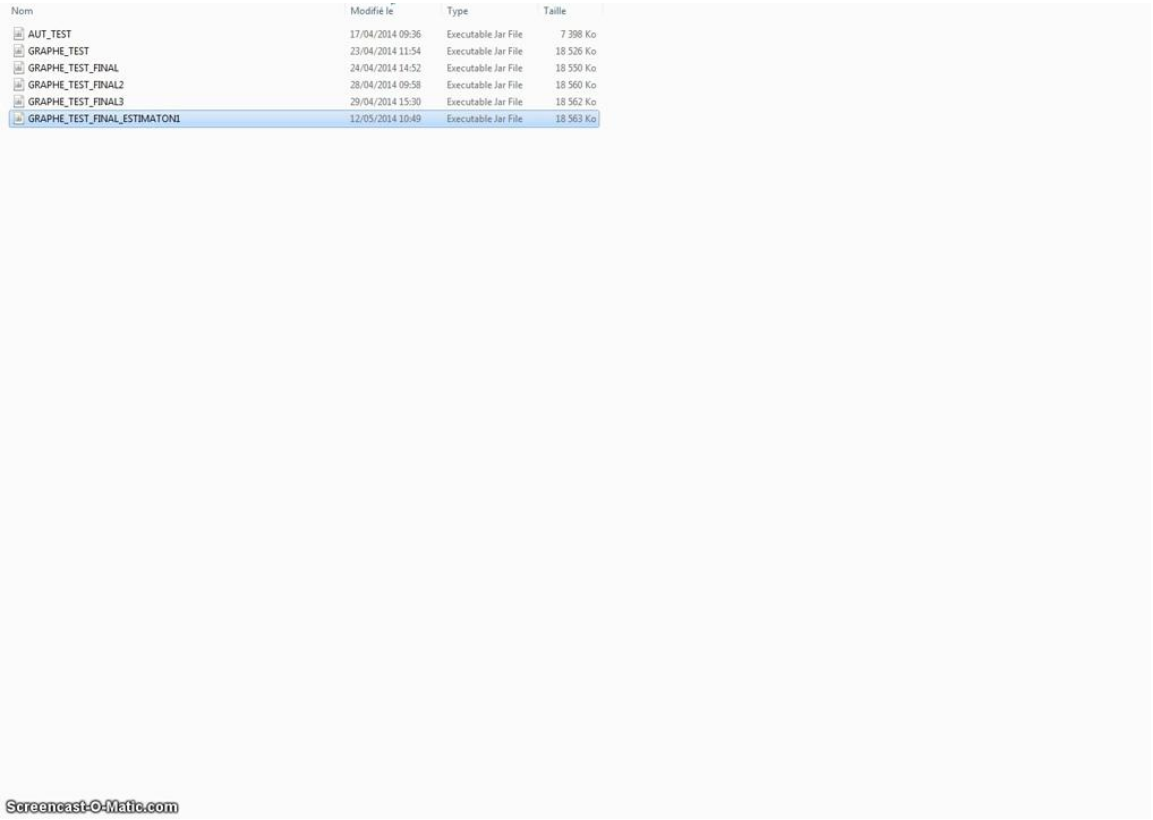




Automated!

# Demo AUTOSAR tool



# Aeronautics : SCADE (automated tool)

Figure 7: The RollControl Node

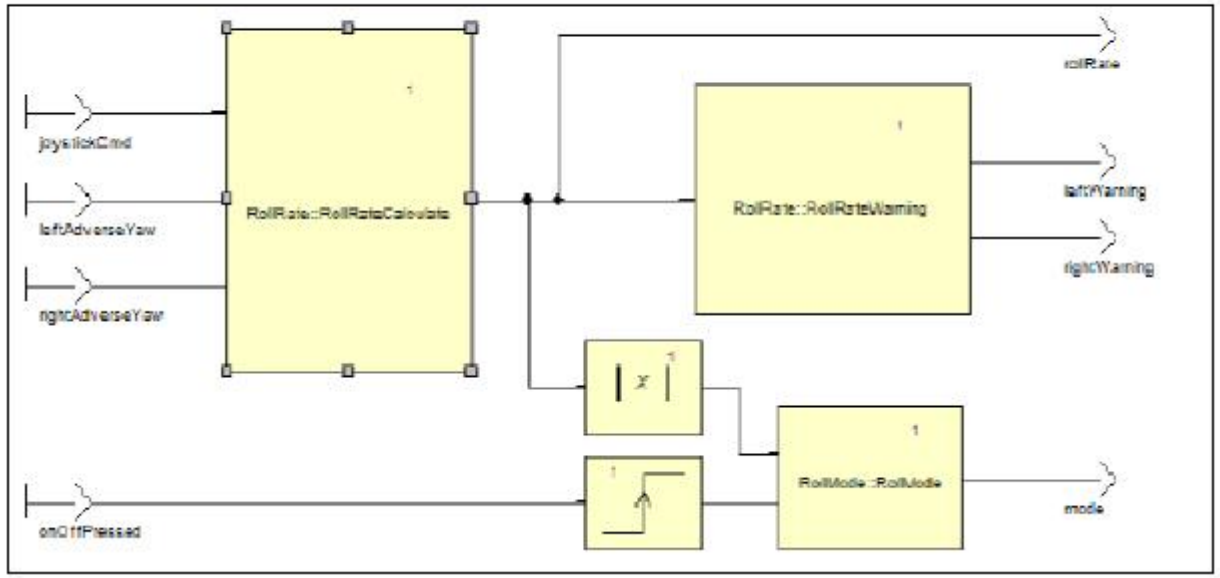



Table 4: Functional Size of The Systems Measured

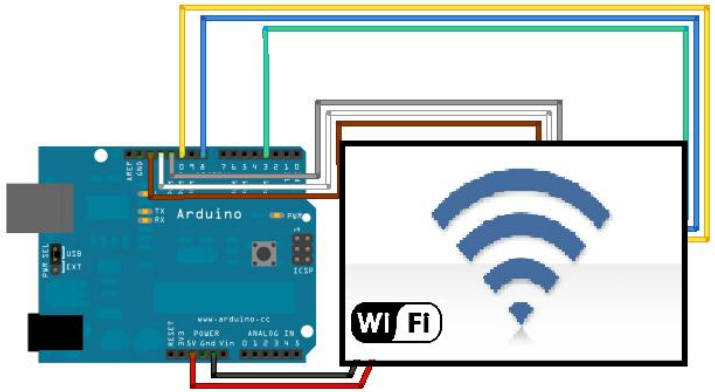
| System | Number of FP identified | Number of Entries identified | Number of Exits identified | Total size in CFP | Total Manual Measurement time in minutes |
|---|---|---|---|---|---|
| Pilot | 24 | 45 | 32 | 77 | 105 |
| Flight Control | 19 | 66 | 44 | 110 | 151 |
| Digital Stop Watch | 6 | 15 | 11 | 26 | 39 |
| Cruise Control | 11 | 45 | 20 | 65 | 92 |
| ABC_N | 3 | 7 | 6 | 13 | 22 |
| Roll Control | 5 | 12 | 9 | 21 | 31 |

# Demo SCADE tool

# FSM for IoT challenges

COSMIC functional size represents a numerical value for a quantity representing the functionality of the software.

For example, organizations that wish to limit the functionalities of their end-systems (RTES) can use COSMIC size as an indicator to define maximum functionality thresholds (in CFP) for different devices having different power sources used in IoT end devices.




| Device Type | Energy source | Maximum allowed size (hypothetical) |
|---|---|---|
| Type 1 | Coin cell battery | 15 CFP |
| Type 2 | Thin-film solid-state rechargeable lithium batteries | 25 CFP |
| Type 3 | Supercapacitor | 30 CFP |
| Type 4 | AAA batteries | 5 CFP |

# IoD: QGroundControl (in progress, energy needs see paper presentation )

- **Step 1**
  - Drone hardware design and assembly
  - support for multi energy source
- **Step 2**
  - drone programming
  - creation of different mission profiles
- **Step 3**
  - use COSMIC to measure software size for each mission profile
- **Step 4**
  - Observe the energy consumption for each mission profile and for each energy source
- **Step 5**
  - create estimation models based on the results of steps 3 and 4

# COSMIC with Simulink



- A COSMIC based FSM procedure for RTES software designed using Simulink.
- The design of the FSM procedure is based on the mapping of key concepts in Simulink & COSMIC ISO 19761.
- The background study for this procedure was conducted at Renault SA using Electronic Control Unit SW functional requirements expressed with the Simulink tool.


*The procedure was automated initially via a prototype tool - developed to demonstrate the feasibility of such automation and then an industrial tool based on the prototype was released.*

# COSMIC with Simulink



- The procedure provides a set of rules for obtaining the functional size of software and reducing the measurement variance caused by the interpretations of individual measurers…

- … the rules were then updated to cover measurement variance caused by different design input models made by different designers which implement the same functional requirements.

# COSMIC w/ Simulink Measurement rules 1

| Rule number | Rule description |
|---|---|
| 1 | Identify 1 functional user for each external subsystem that interacts (sends and/or receives data to/from) any FP identified |
| 2 | Identify 1 boundary between any external subsystem interacting with the subsystem (Model Block) to be measured. |
| 3 | Identify 1 functional process for each non virtual atomic subsystem containing at least one functional block. |
| 4 | Identify 1 default functional process for all identified virtual subsystem which are not defined within any atomic subsystem block, and containing at least 1 functional block. |

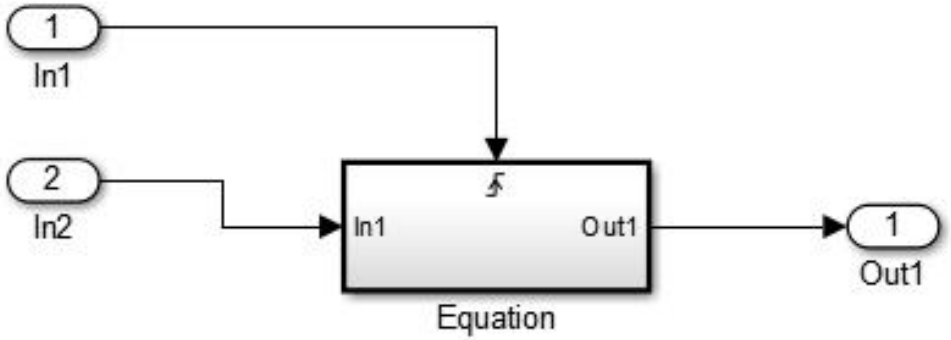
# COSMIC w/ Simulink Measurement rules 2

| | |
|---|---|
| 5 | Identify a 1E data movement – and COSMIC triggering event – for the TriggerPort, EnablePort, or Function-Call Generator. |
| 6 | Identify a 1E data movement for each InPort (or any other Source Port) connected via a line to the input of a functional block. |
| 7 | Identify a 1E data movement for each line of each atomic subsystem (identified as a functional process) and connected to the input of a functional block. |
| 8 | Identify a 1X data movement for each OutPort (or any other Sink Port) connected via a line to the output of a functional block. |
| 9 | Identify a 1X data movement for each line of each atomic subsystem (identified as a functional process) and connected to the output of a functional block. |
| 10 | Identify a 1R data movement for each DataStoreRead identified in this functional process and connected to the input of a functional block. |
| 11 | Identify a 1W data movement for each DataStoreWrite identified in this functional process and connected to the output of a functional block. |

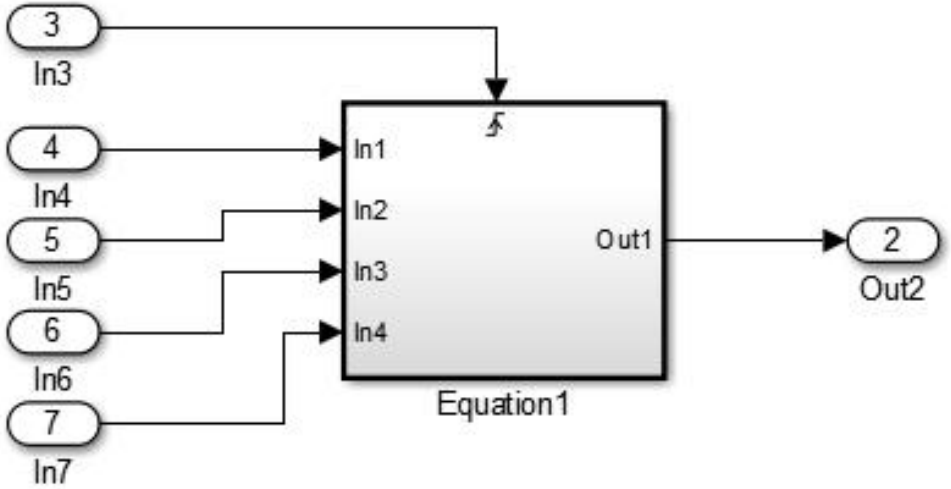
# COSMIC w/ Simulink Measurement rules 3

| | |
|---|---|
| 12 | Aggregate the CFP related to the data movements identified in a specific FP to obtain the functional size of that process. |
| 13 | Aggregate the CFP related to the data movements of (or identified in) the functional processes of (or identified in) the whole system to obtain the functional size of that system. |

# COSMIC w/ Simulink Measurement Example

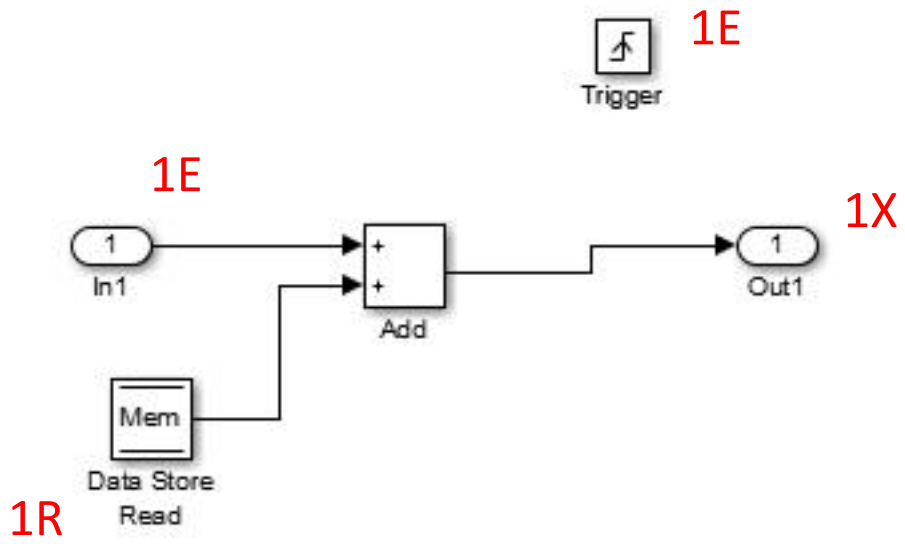






# COSMIC w/ Simulink Measurement Example

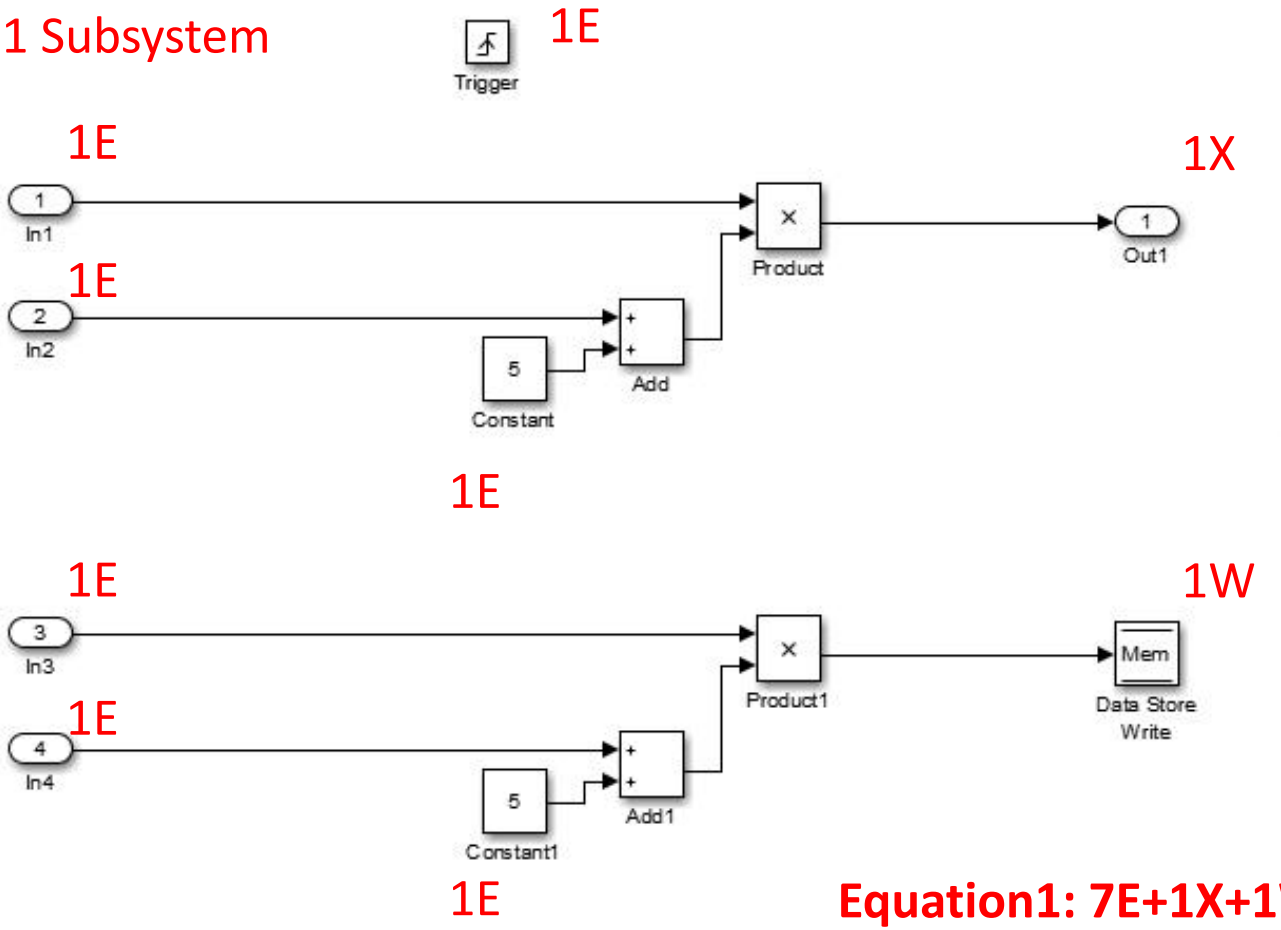
Inside the Equation Subsystem




**Equation: 2E+1X+1R= 4 CFP**

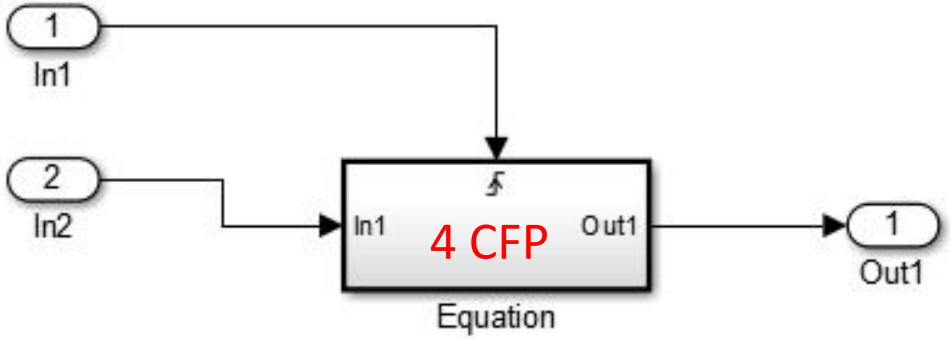
# COSMIC w/ Simulink Measurement Example

Inside the Equation1 Subsystem



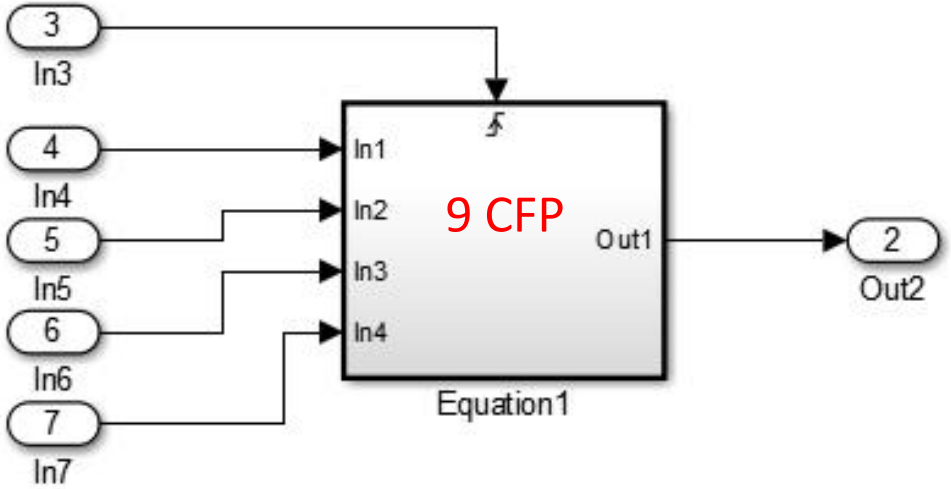

**Equation1: 7E+1X+1W= 9 CFP**

# COSMIC w/ Simulink Measurement Example





**Size (Whole SW) = Size (Equation) + Size (Equation_1) = 13 CFP.**



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# Conclusions

Embedded systems are pervasive, distributed and even connected!

Real time embedded systems rely heavily on Software.

Huge potential of COSMIC FSM in RTES domain:

- to estimate development effort and measure productivity,
- to manage energy efficiently.
- to estimate memory size.
- To predict processor load, network load, etc…
- …