



END-TO-END MBSE APPROACH FROM SYSML SYSTEM DEFINITION TO SYSTEM V&V



3DEXPERIENCE®

PRESENTERS

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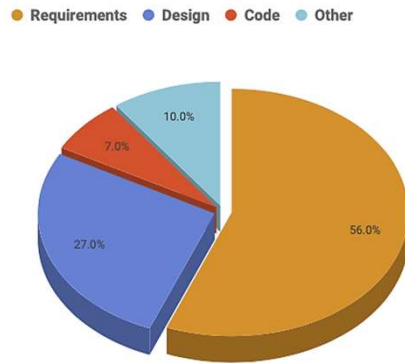
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REQUIREMENTS ENGINEERING CHALLENGES

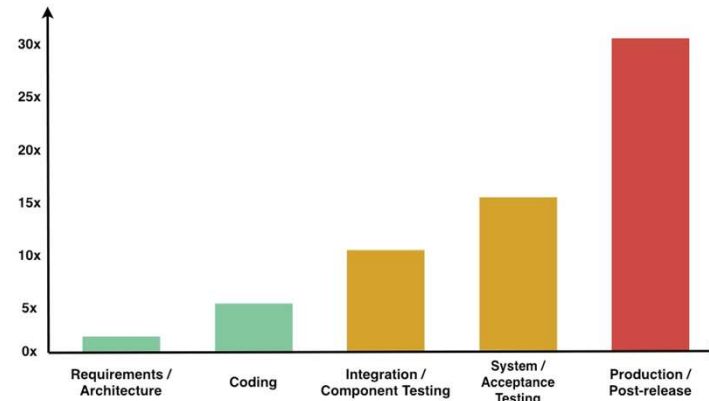
Most of the system defects are introduced during the requirements specification phase, but the overwhelming majority of these faulty requirements is detected much later

Share of software defects introduced by phase



Source: "Requirements-based testing process in practice," IJTEM, Vol.1 No 4, 2010

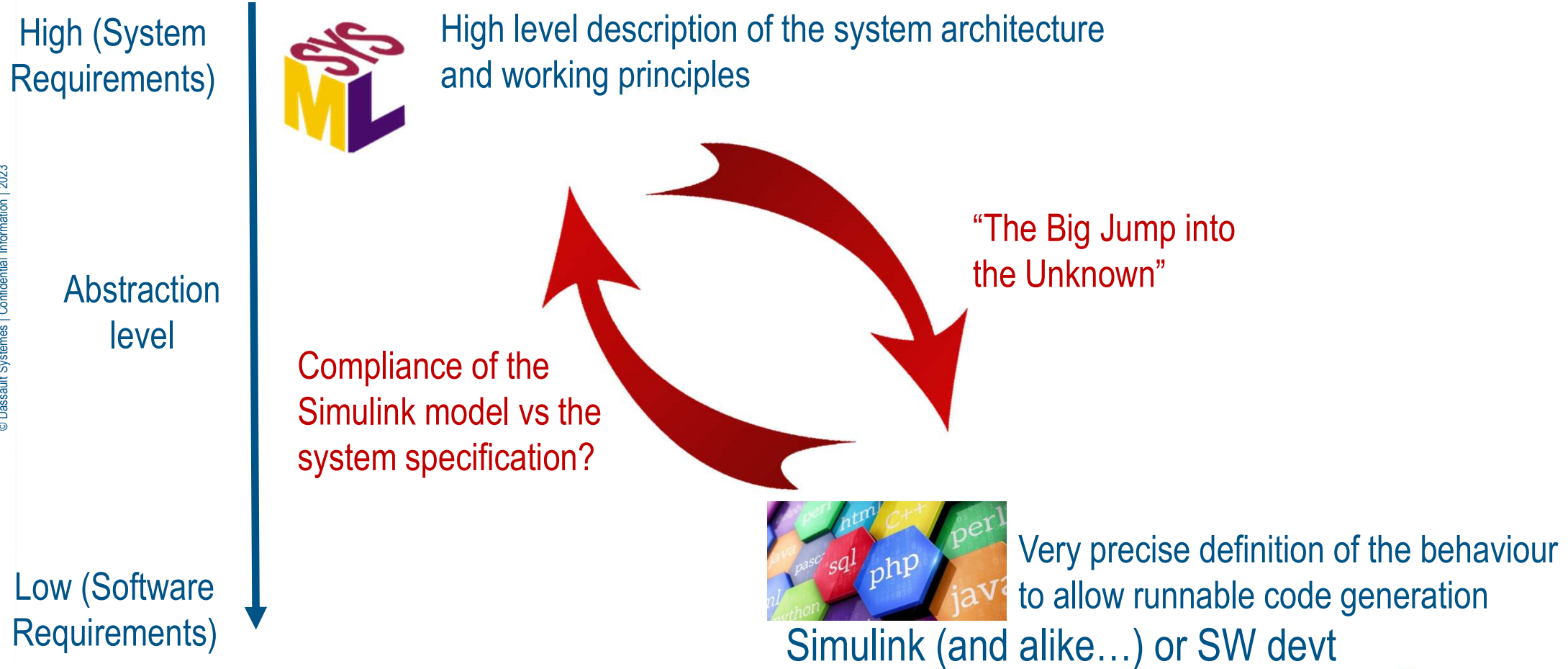
Relative cost to fix bugs, based on time of detection



What we've heard from customers

- "We know we have poor quality requirements, which cause miscommunication of need resulting in **cost and time overruns**."
- "**Software complexity** is increasing yet there is pressure on requirements authors to produce higher quality requirements faster."
- "**Errors in requirements** are often not picked up until integration time and sometimes not at all."

REQUIREMENTS ENGINEERING CHALLENGES



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CHALLENGES AND STIMULUS SOLUTION

- Make requirements right the first time and automate functional tests

Pain #1

Despite a thorough assessment of the system in the MBSE phase and the use of advanced model-based design tools, **a gap still remains between system and software requirements**, which will cause late and costly redesign.

Pain #2

Despite the quality of system specifications produced in the early phase and the use of test automation tools, **the creation of test cases remains massively manual** and their maintenance cost very high as requirements evolve.



CATIA Stimulus allows system architects and software designers to collaborate and **derive accurate software requirements that meet system requirements.**

CATIA Stimulus allows test engineers to reuse already validated requirements to **automatically check that the software (and later, the integrated system) complies with its requirements.**

End-to-End Process Overview

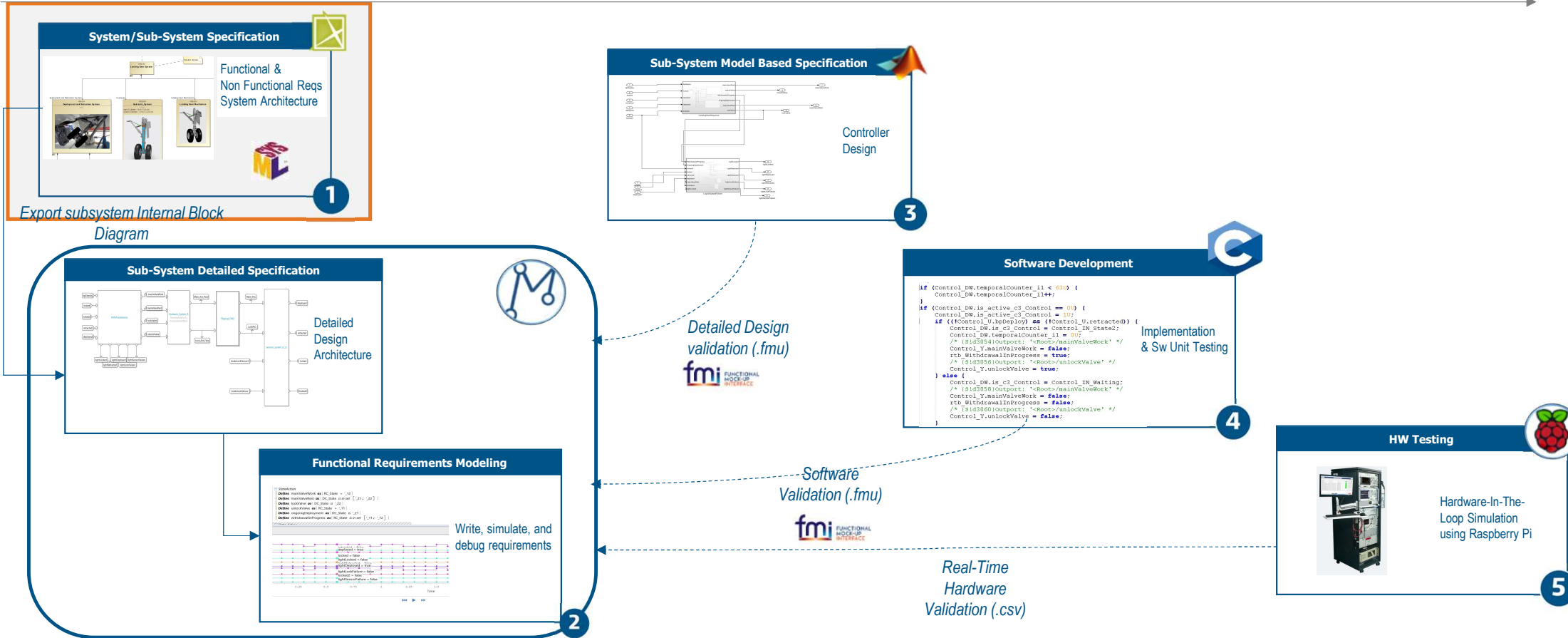
SYSTEM DESCRIPTION

REQS-IN-THE-LOOP

MODEL-IN-THE-LOOP

SOFTWARE-IN-THE-LOOP

HARDWARE-IN-THE-LOOP



Requirements Manager

- Requirements Management
- Define and Trace Requirements
- Quality check rules and assistance

3DEXPERIENCE PLATFORM



Traceability manager

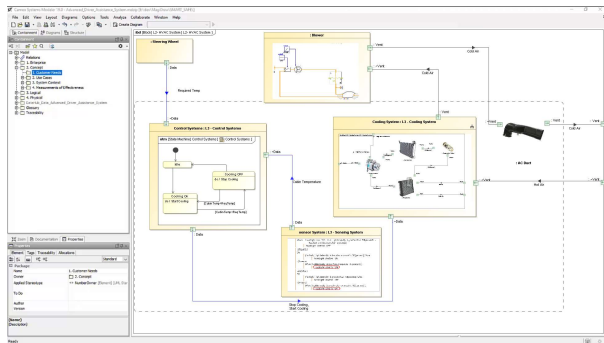
- Model preview and navigation
- Model annotation
- Traceability and impact analysis



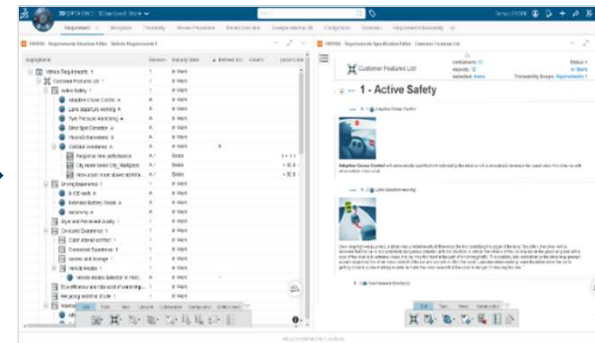
INTEGRATE WITH MBSE AND REQUIREMENTS TOOLS

- Synchronize data with CATIA Magic and 3DEXPERIENCE/DOORS

Systems Engineering



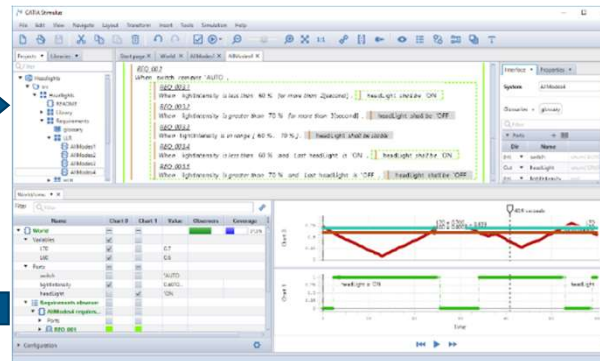
Requirements Engineering



Synchronize Requirements

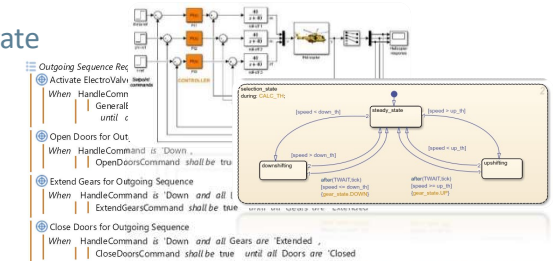


Software Engineering



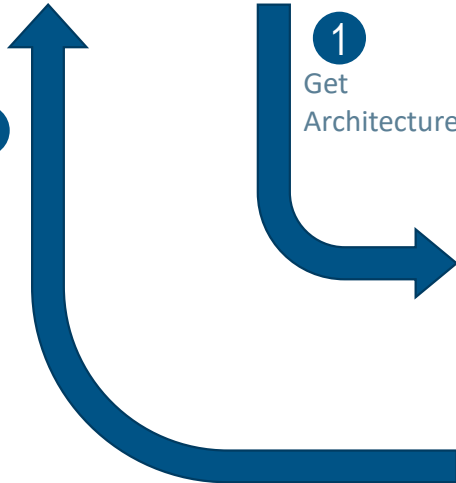
Get software component Requirements

Verified and accurate software requirements for software design



Propose software Architecture Changes

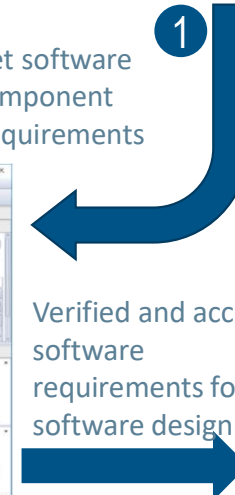
3



1 Get Architecture

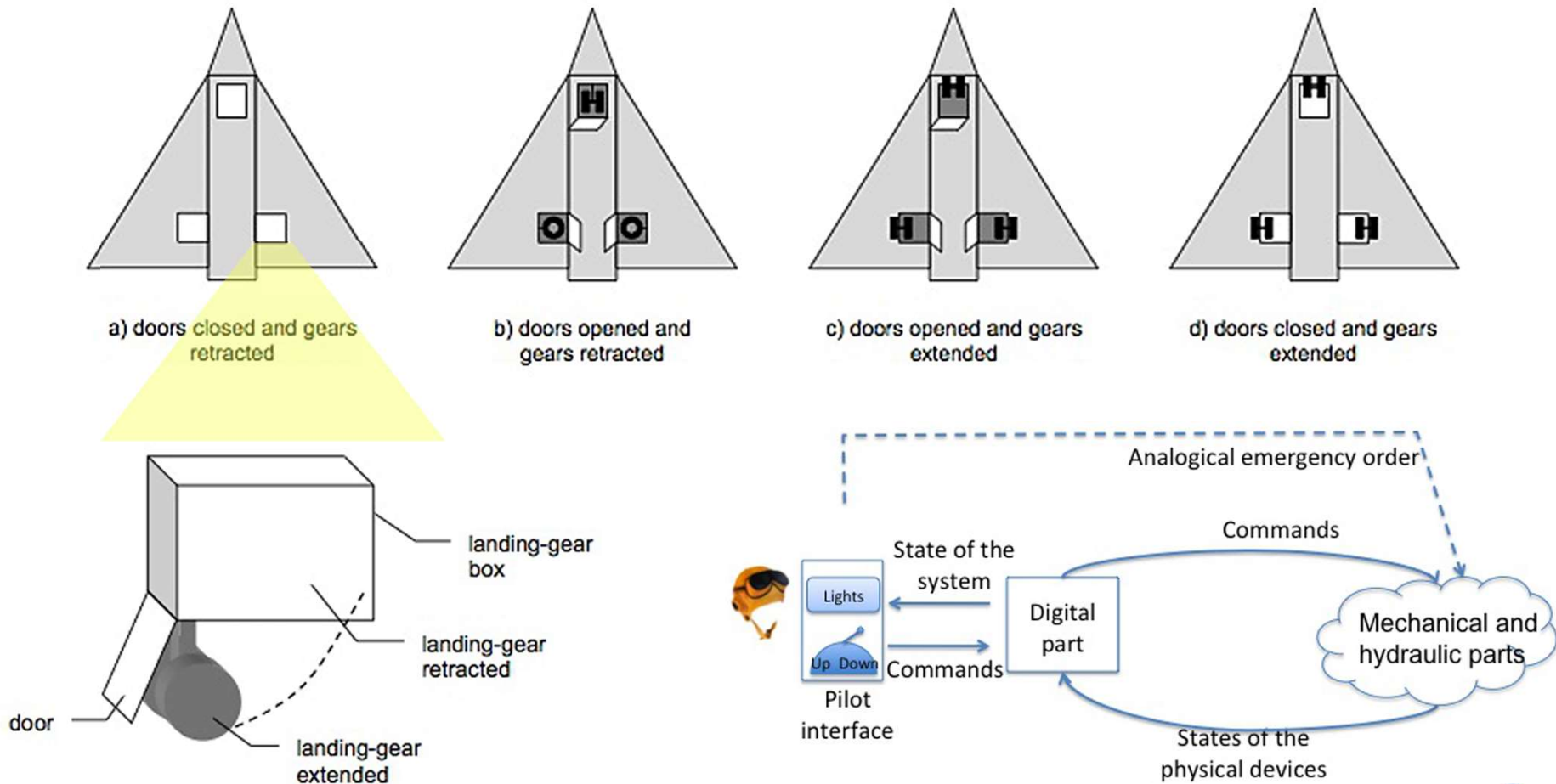
2 Author, simulate and debug the software requirements

4



LANDING GEAR CONTROLLER CASE STUDY

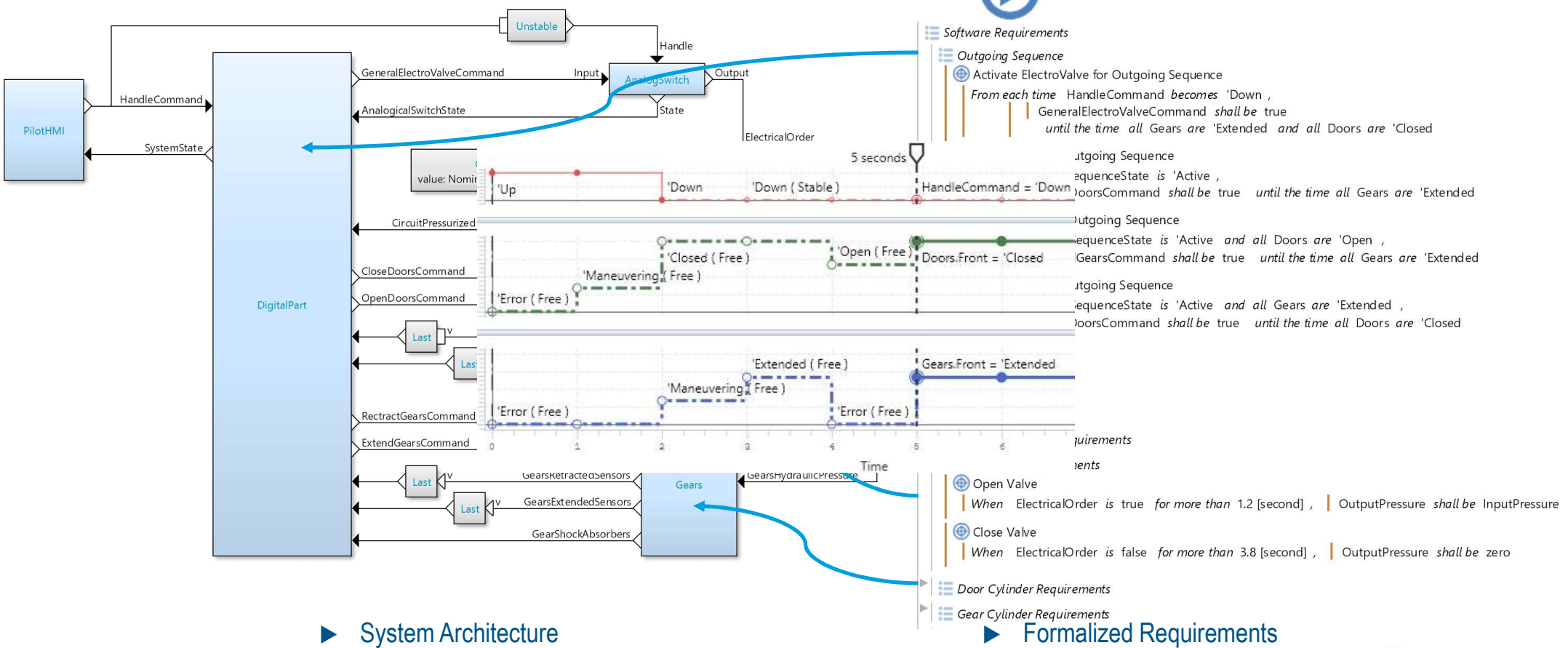
From the paper "landing gear system" by Frédéric Boniol and Virginie Wiels



REQUIREMENTS-IN-THE-LOOP FUNDAMENTALS

Allocate formalized requirements to System architecture

... AND SIMULATE! 



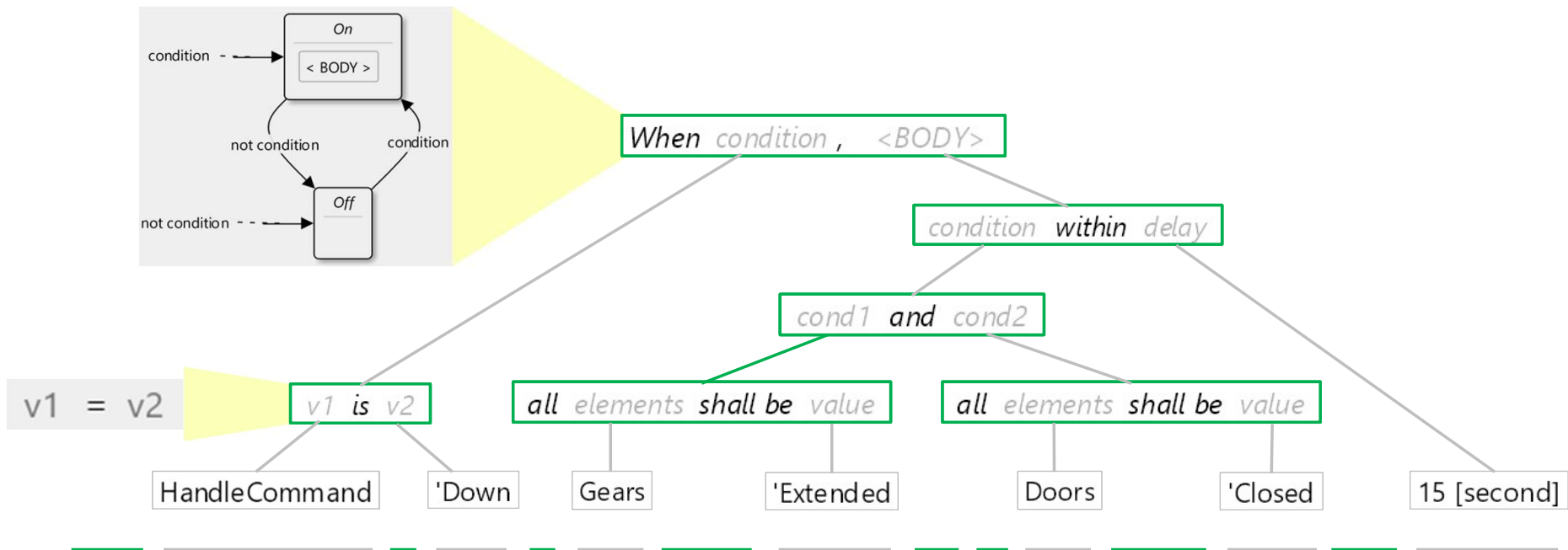
► System Architecture

► Formalized Requirements



FORMALIZE TEXTUAL REQUIREMENTS

Write unambiguous requirements by composing templates



When HandleCommand is 'Down, all Gears shall be 'Extended and all Doors shall be 'Closed within 15 [second]

SPECIFY THE LANDING GEARS DIGITAL PART

► Original informal requirements

Outgoing sequence. The outgoing of gears is decomposed in a sequence of elementary actions. **When the gears are locked in retracted position, and the doors are locked in closed position**, if the pilot sets the handle to “Down”, then the software should have the following **sequence of actions**:

1. stimulate the general electro-valve isolating the command unit in order to send hydraulic pressure to the maneuvering electro-valves,
2. stimulate the door opening electro-valve,
3. once the three doors are in the open position, stimulate the gear outgoing electro-valve,
4. once the three gears are locked down, stop the stimulation of the gear outgoing electro-valve,
5. stop the stimulation of the door opening electro-valve,
6. stimulate the door closure electro-valve,
7. once the three doors are locked in the closed position, stop the stimulation of the door closure electro-valve,
8. and **finally** stop stimulating the general electro-valve.

The previous sequences should be interruptible by counter orders (a retraction order occurs during the let down sequence and conversely) **at any time**. In that case, the scenario continues from the point where it was interrupted.

- Monolithic specification as related requirements cannot be considered independently
- Vague and non testable specification of counter-orders

► CATIA Stimulus requirements

☰ Outgoing Sequence Requirements

- ⊕ Activate ElectroValve for Outgoing Sequence
When HandleCommand is 'Down ,
GeneralElectroValveCommand shall be true
until all Gears are 'Extended and all Doors are 'Closed
- ⊕ Open Doors for Outgoing Sequence
When HandleCommand is 'Down ,
OpenDoorsCommand shall be true until all Gears are 'Extended
- ⊕ Extend Gears for Outgoing Sequence
When HandleCommand is 'Down and all Doors are 'Open ,
ExtendGearsCommand shall be true until all Gears are 'Extended
- ⊕ Close Doors for Outgoing Sequence
When HandleCommand is 'Down and all Gears are 'Extended ,
CloseDoorsCommand shall be true until all Doors are 'Closed

- Independent requirements which shall always be true whatever the state of the system
- Robust to counter-orders, testable
- Debugged through trials & errors thanks to simulation

REQUIREMENTS SIMULATION

► Original informal requirements

The switch is closed each time the handle is moved by the pilot, and it remains closed for 20 seconds. After this duration, the switch automatically becomes open. In the closed position, the switch transmits the electrical order from the digital part to the general electro-valve. In the open position, no electrical order is sent to the electro-valve. Because of inertial reasons, the transition from the two states takes a given amount of time: from open to closed 0.8 second, from closed to open 1.2 seconds

► CATIA Stimulus requirements

State Requirements

- Close switch on Handle

After each time HandleMove becomes true , State shall be 'Closed within 0.8[second]

- Release switch after 20 seconds

20 [second] after the last time State became 'Closed , State shall be 'Open within 1.2[second]

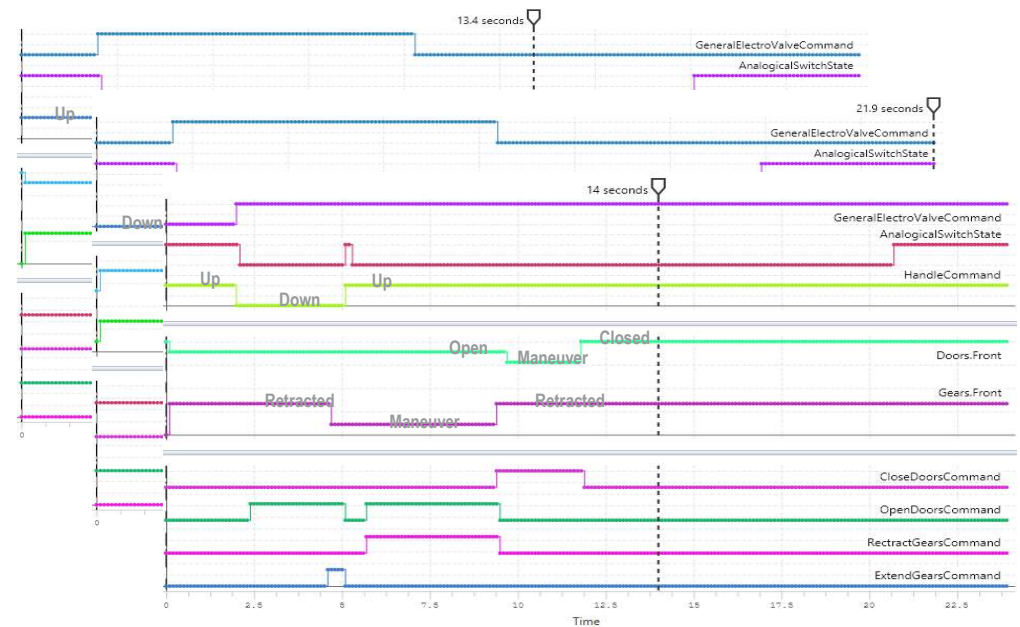
Output Requirements

- Closed State

When State is 'Closed , Output shall be equal to Input

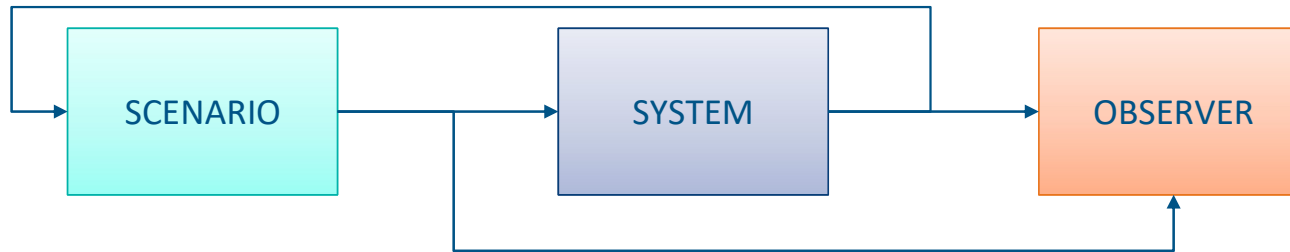
- Open State

When State is 'Open , Output shall be equal to false



MODEL-BASED TESTING | GENERIC TEST BENCH PATTERN

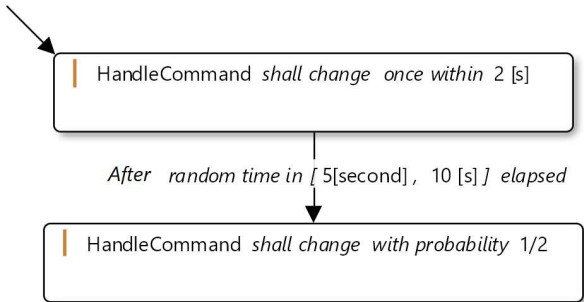
Automatically check any executable system artefact against its requirements



Stimulate the system with a generic scenario that generates different test vectors

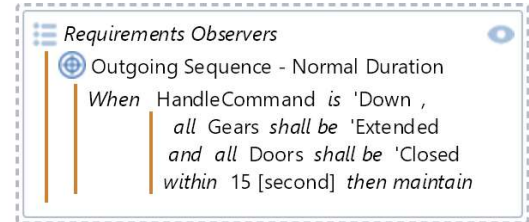
Execute the system under test, which can be a Stimulus model, a FMU component or a log file

Check that the system under test complies with its requirements



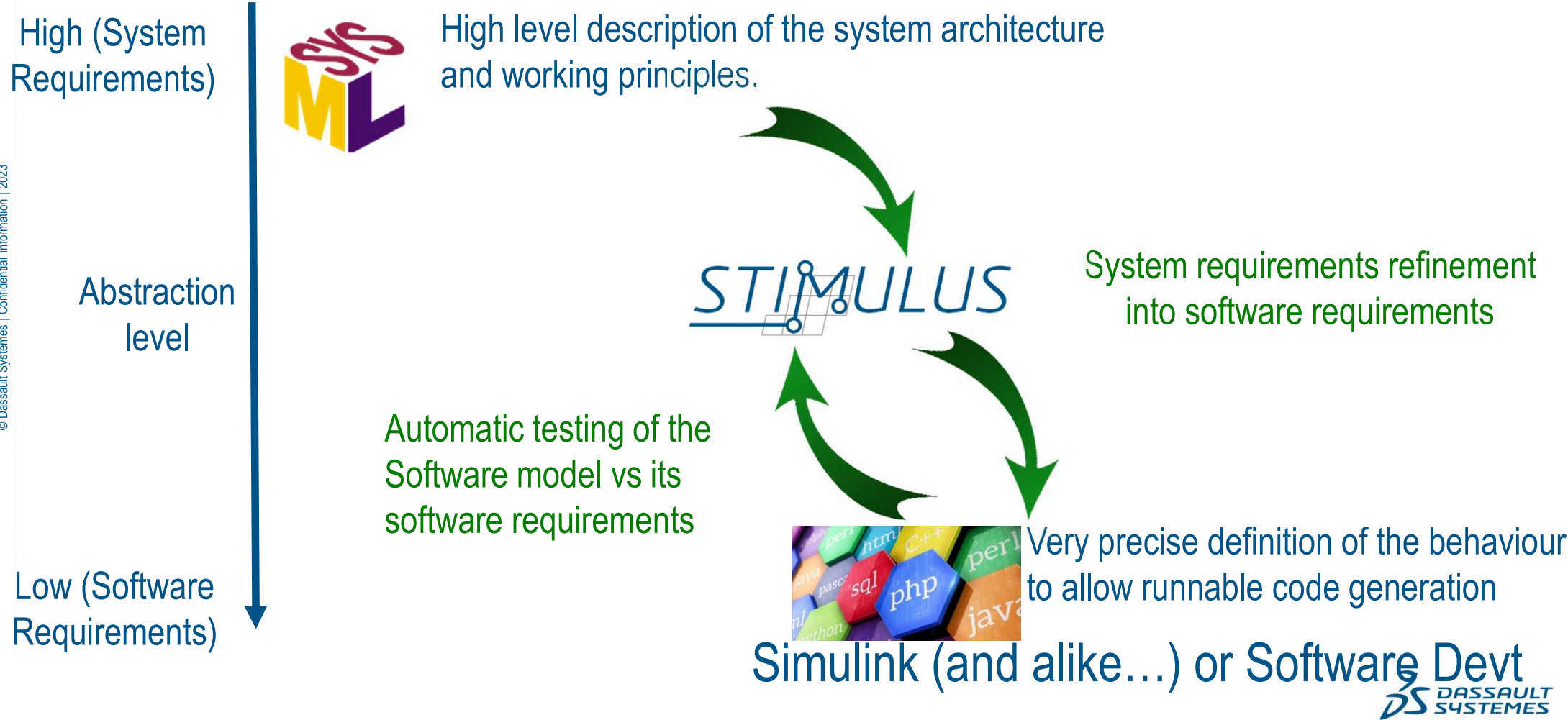
Outgoing Sequence - Open Doors

	A	B	C	D	E	F	G
947	47.25	false	Closed	false	100.0	Down	5.130660295
948	47.3	false	Closed	false	100.0	Down	4.566740274
949	47.35	false	Closed	false	100.0	Down	1.240065336
950	47.4	false	Closed	false	100.0	Down	1.135035514
951	47.45	false	Closed	false	100.0	Down	0.923843383
952	47.5	false	Closed	false	100.0	Down	0.432556152
953	47.55	false	Closed	false	100.0	Down	0.147773742
954	47.6	false	Closed	false	100.0	Down	0.026779174
955	47.65	false	Closed	false	100.0	Down	0.024061203
956	47.7	true	Closed	false	100.0	Up	89.75249481
957	47.75	true	Closed	false	100.0	Up	90.765625
958	47.8	true	Closed	false	100.0	Up	93.82458114
959	47.85	true	Closed	false	100.0	Up	96.56552505
960	47.9	true	Closed	false	100.0	Up	97.99860763
961	47.95	true	Closed	false	100.0	Up	99.14630126
962	48.0	true	Closed	false	100.0	Up	99.31278991



KEY POINTS AND TAKEAWAYS

RIL: THE MISSING LINK BETWEEN MBSE AND MBD

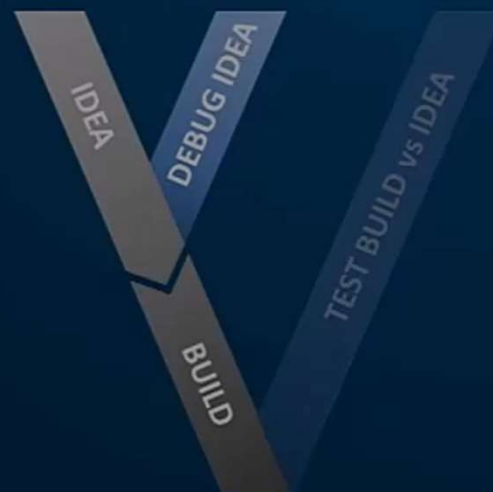




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STIMULUS

Simulate and Validate
your Functional
Specification



 CATIA

 DASSAULT
SYSTEMES

Q&A

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