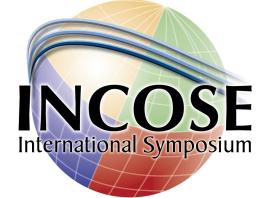


# Integrating Testability and Diagnosis methods into AIRBUS Systems Development Process

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# Overview



- Testability analysis aim and principles
- Where apply testability analysis at Airbus ?
- Testability analysis methodology for specification validation
- Testability analysis methodology for system test on FAL
- Conclusion

## ➤ Reducing testing activities effort

- About 40% of the real time critical system development cost

## ➤ How ?

- easing test design and diagnosis while ensuring a good coverage of the design and an optimal diagnosis
  - Relying on testing strategy
    - » Multiple-Clue
    - » Start-small

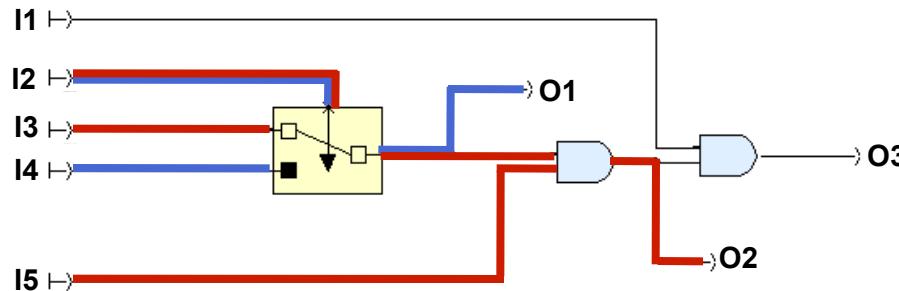
## ➤ On which ?

- Two phases of system development targeted:
  - System specification
  - System integration on FAL

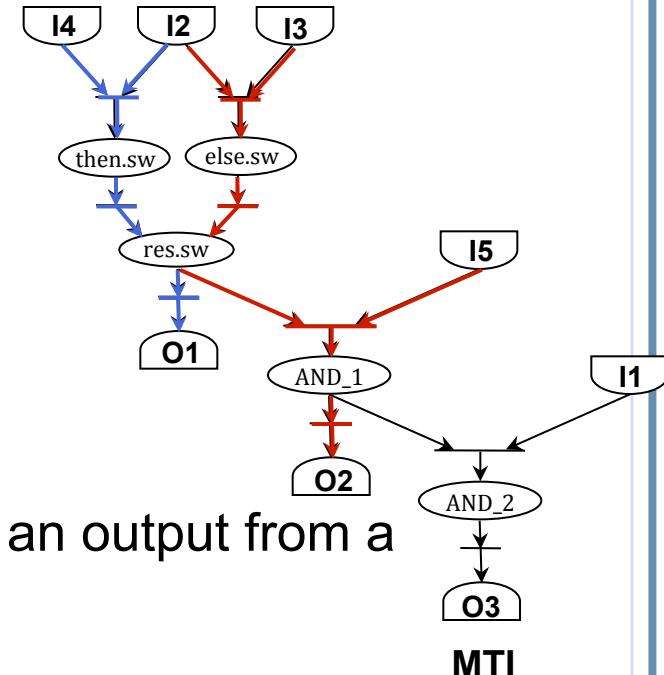
# Testability analysis principles : the flow



## ➤ Testability model (ITM – Information Transfer Model)



Data flow specification in SCADE



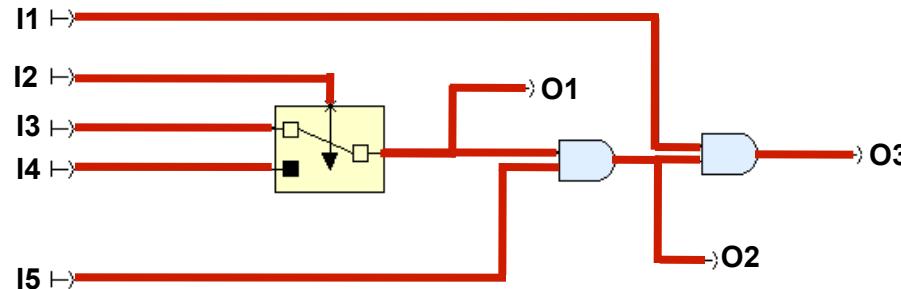
MTI

- **Flow** : information path that computes an output from a set of inputs
- Flow = Elementary function of the system
- Operators modelling criteria : branches

# Testability analysis principles

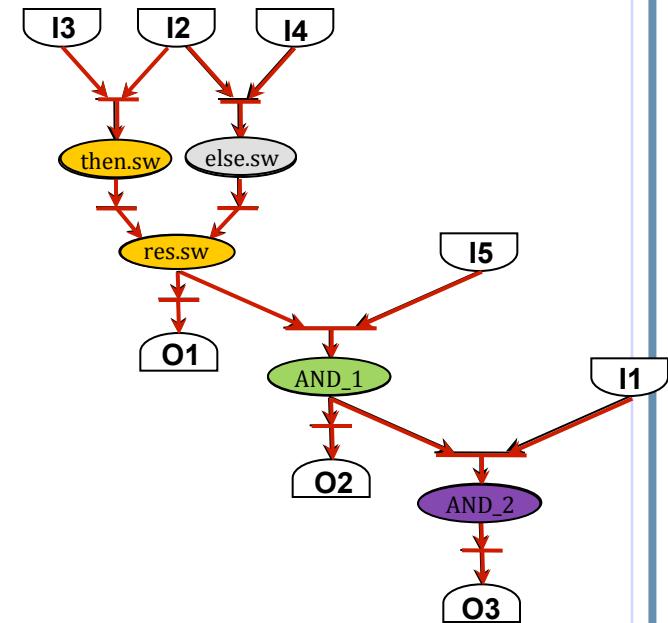
## ➤ Start-Small strategy: incremental approach

- Flows selection
- Progressive coverage of the operators and elementary functions
- Suitable for validation when designing (multiple faults)



6 flows

4 selected by start small

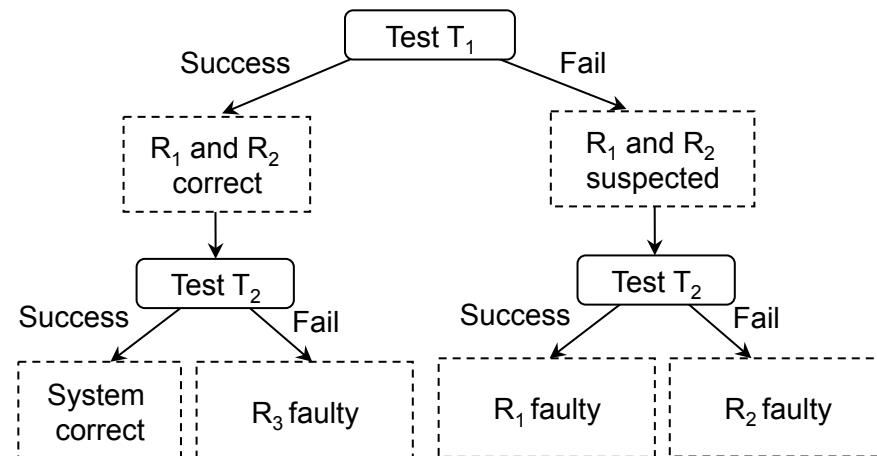
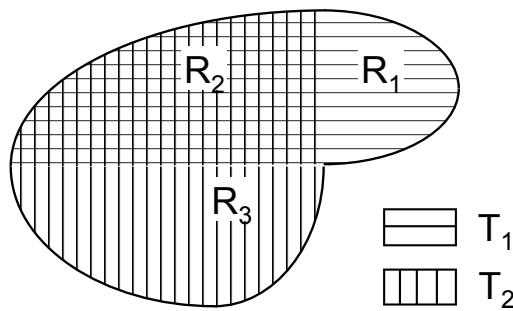


# Testability analysis principles



## ➤ Multiple-Clue Strategy : cross checking approach

- Selection of relevant tests for diagnosis
- Suitable for system verification at the end of the development and during maintenance phase (single fault hypothesis)
- Principle illustration
  - System composed of three resources ( $R_1$ ,  $R_2$  et  $R_3$ ) for which two tests ( $T_1$  &  $T_2$ ) have been selected by Multiple Clue.

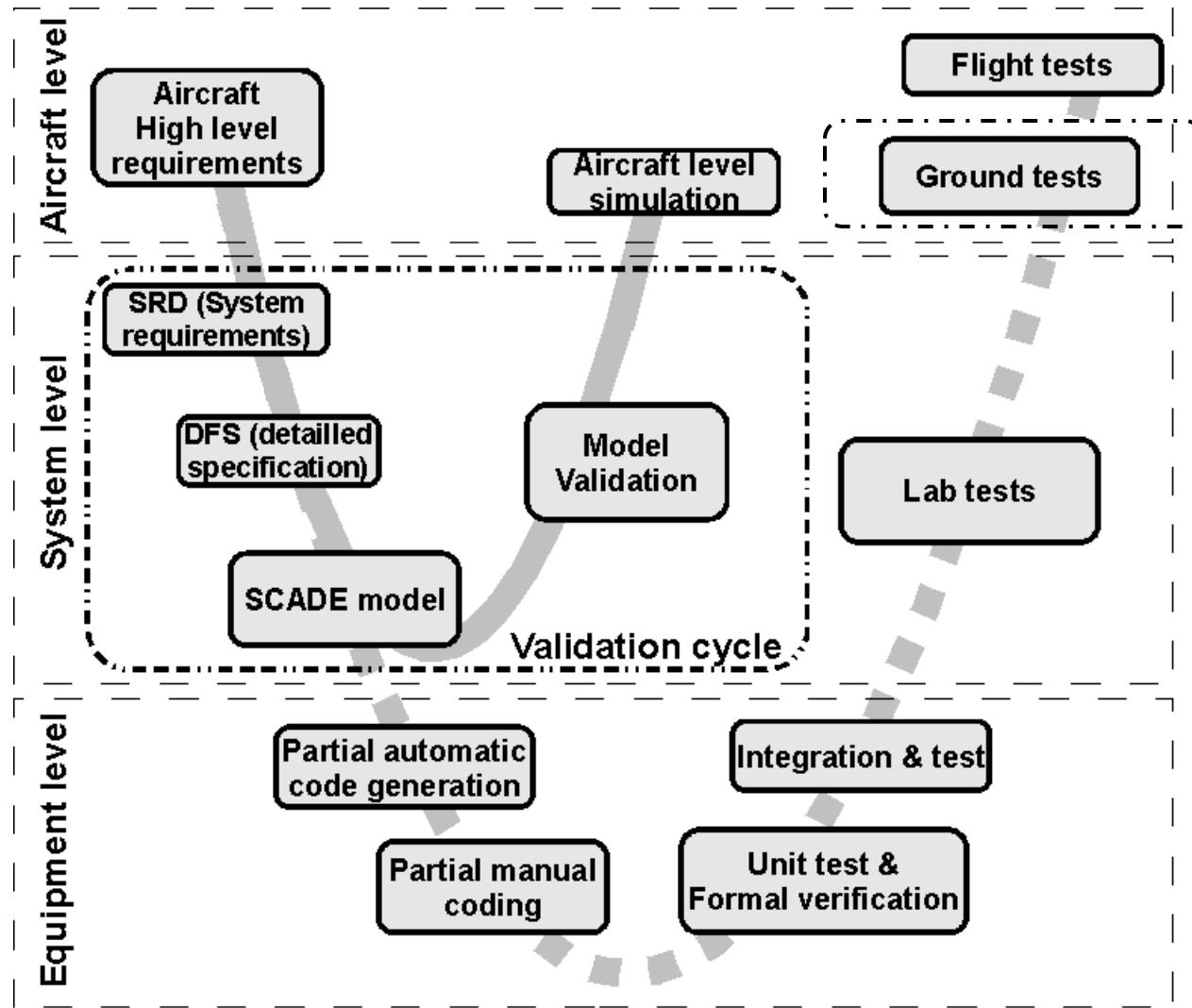


# Overview



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# AIRBUS systems development cycle



# Overview

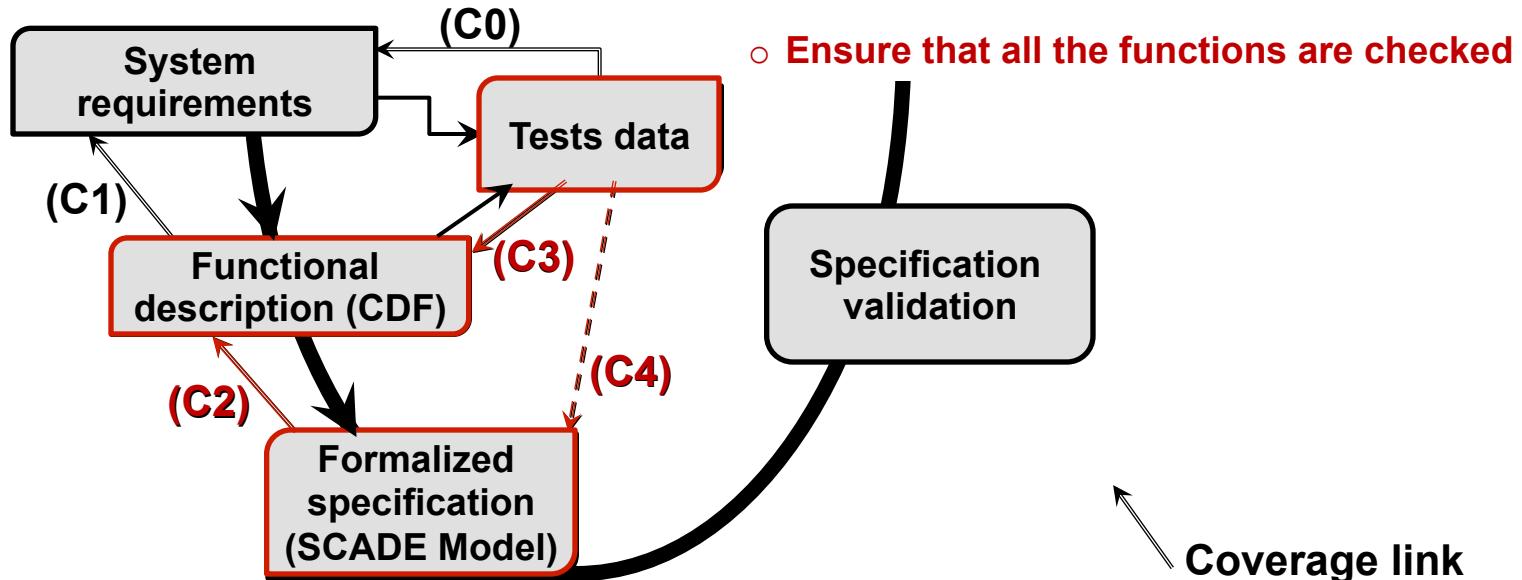


- Testability analysis aim and principles
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- Testability analysis methodology for system test on FAL
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# Supporting specification validation



## ➤ System validation description

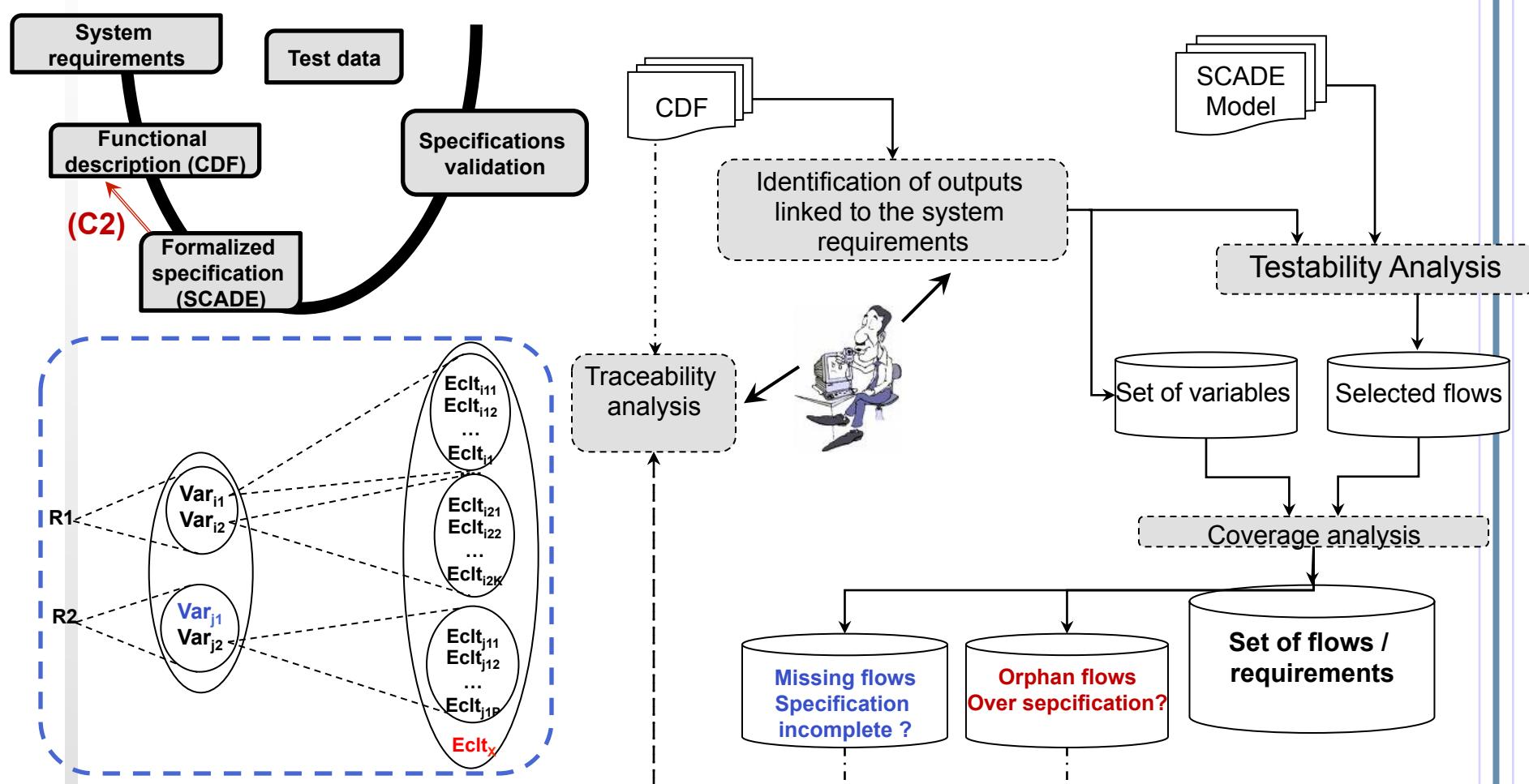


*Relying on link between functions and flows, and start small strategy to partially automate the validation traceability activities*

# Supporting specification validation



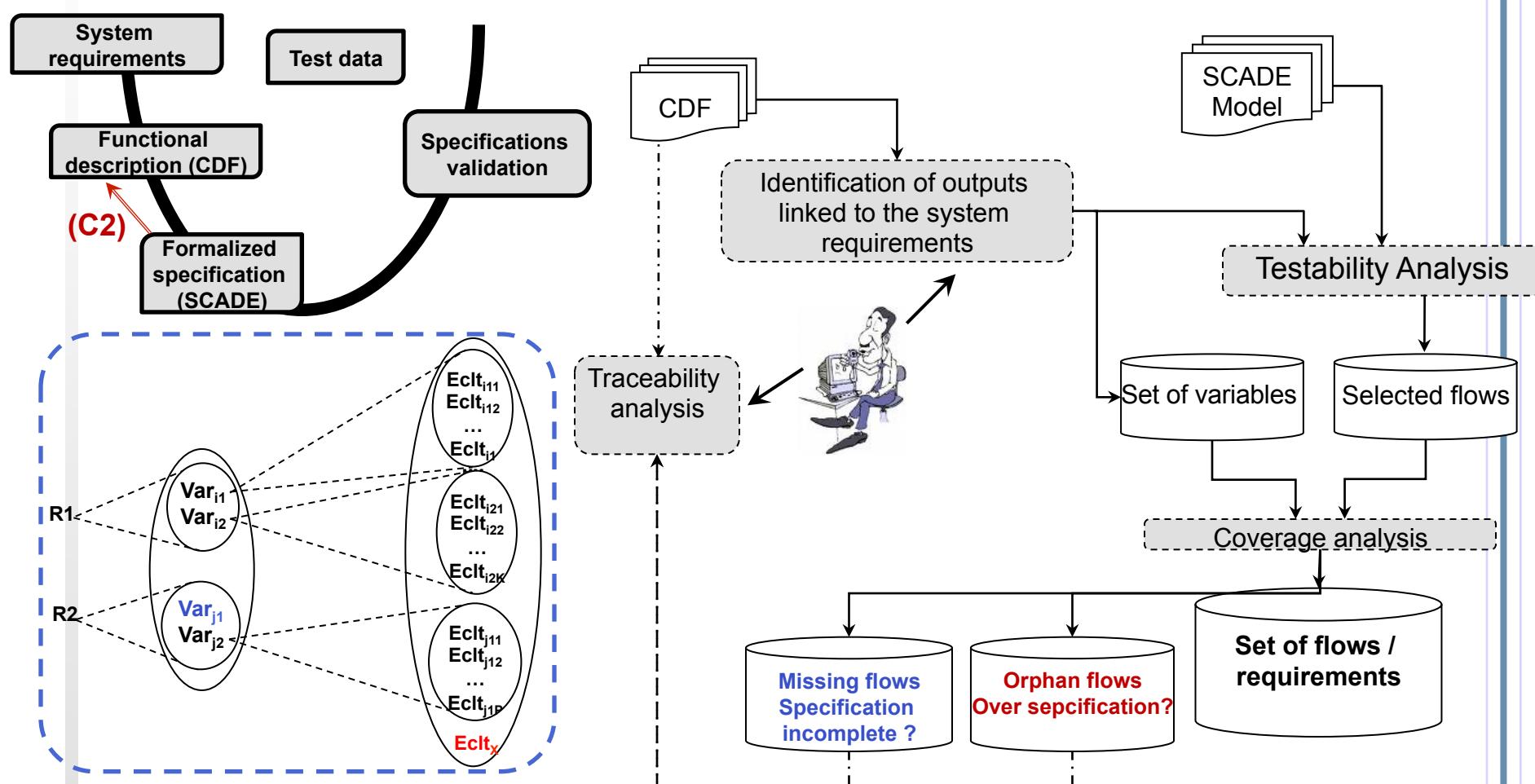
## ➤ Coverage analysis of the formal model (C2)



# Supporting specification validation



## ➤ Coverage analysis of the formal model (C2)

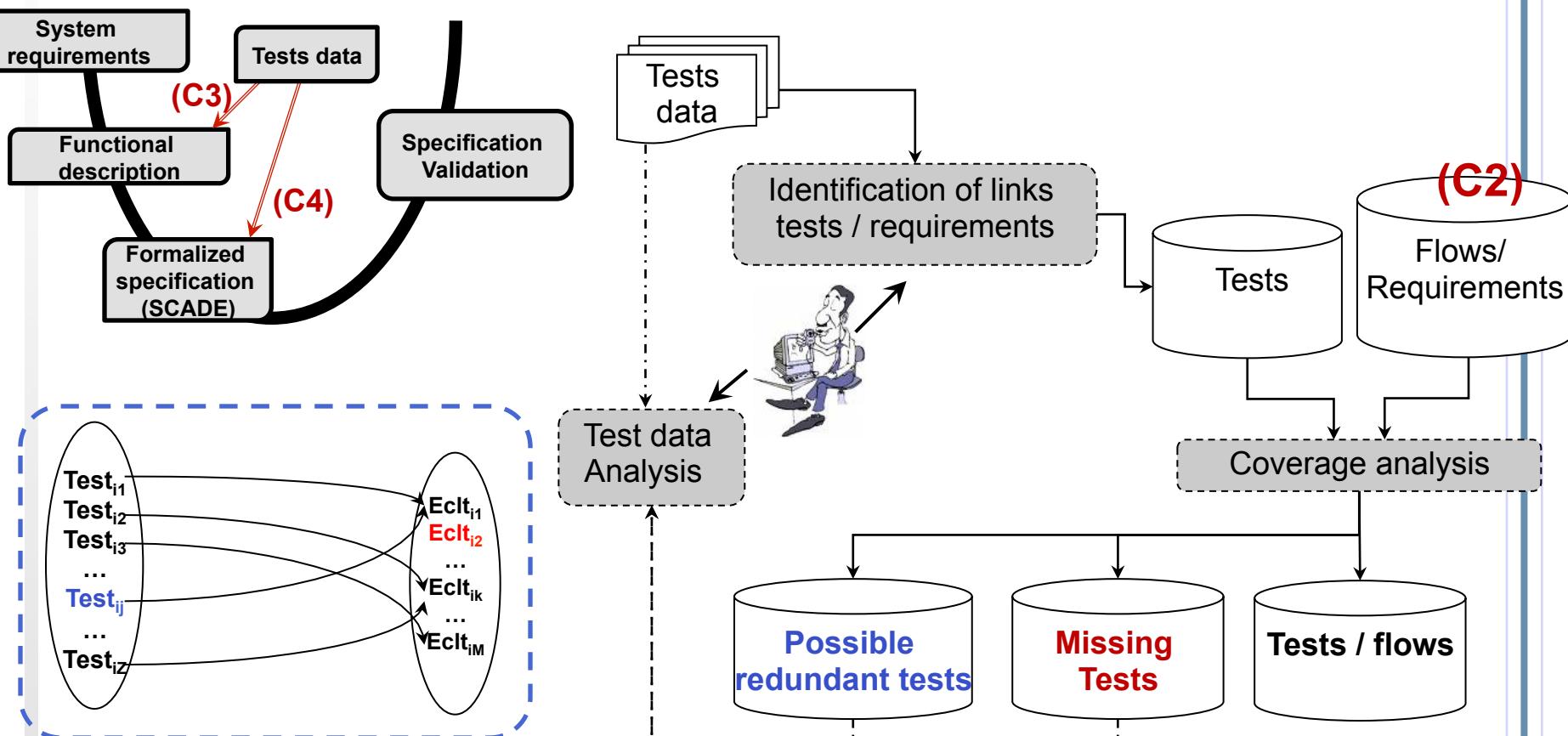


Link between flows and requirements  
based on outputs variables

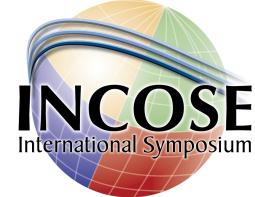
# Méthodologie d'aide à la validation



## ➤ Coverage analysis of tests (C3 et C4)



# Experiments results



- Control flight systems
  - Two systems LM1 et LM2

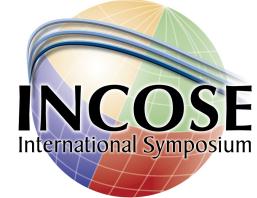
	LM1	LM2
Number of functional requirements	34	57
Number of SCADE nodes	69	146
Number of outputs variables	98	132
Number of tests defined	70	114

## ➤ Coverage analysis results

- No orphan flow
- No missing flow
- Possible redundant test
- Missing tests identified

	LM1	LM2
Number of flows	84	127
Test defined	70	114
Missing tests (minimum)	14	13

# Methodology interest



- Support test design and diagnosis
  - Provides the minimum number of tests to be defined
  - Highlight testability flows to be validated
- Automate partially the validation coverage activities
  - SCADE model versus functional requirements (missing and orphan flows)
  - Tests versus SCADE model (missing and potential redundant tests)
- Good integration into the current systems validation process

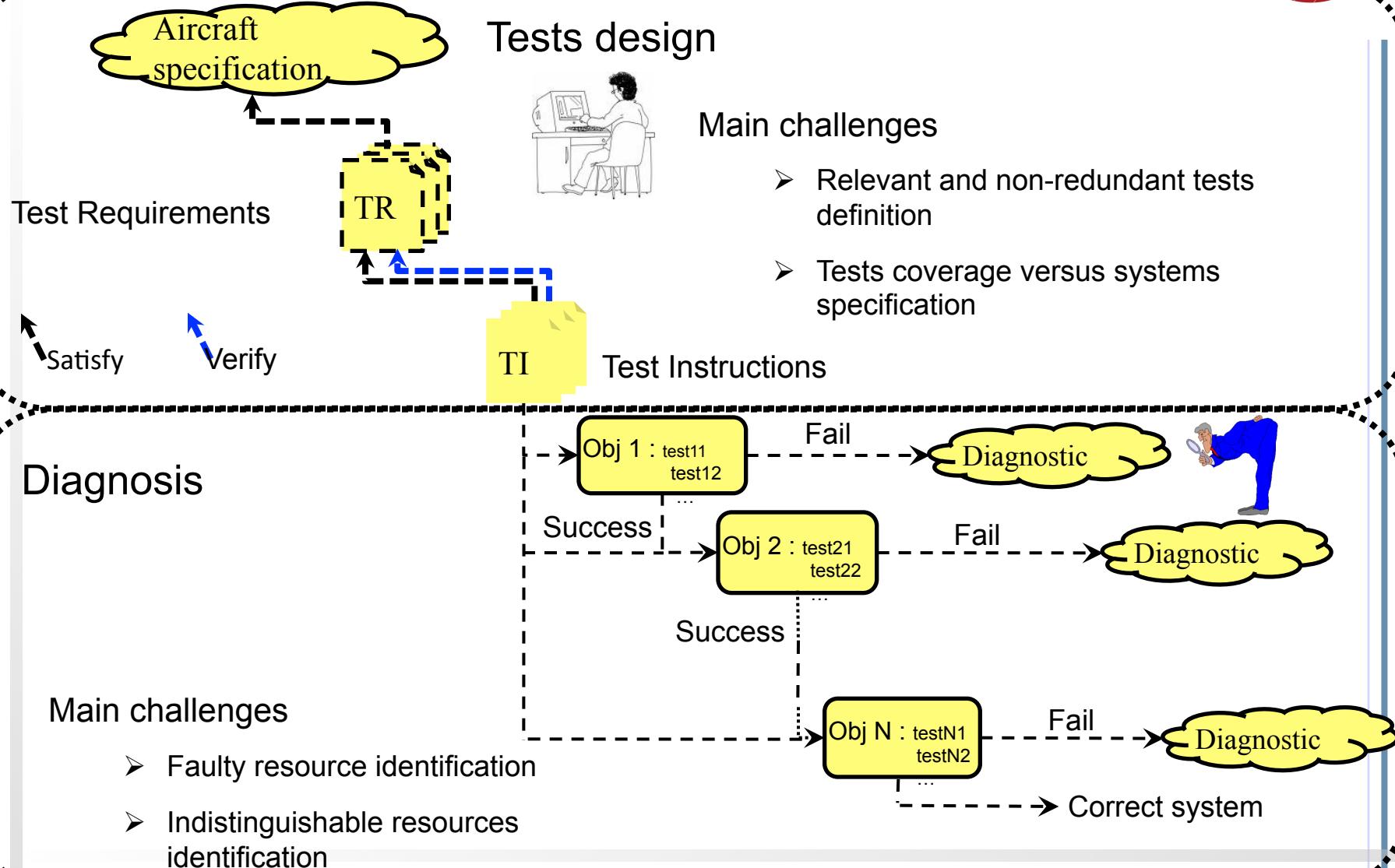
# Overview



- Testability analysis aim and principles
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- **Testability analysis methodology for system test on FAL**
- Conclusion

- **Why systems are tested on FAL?**
  - To verify installed systems and their interconnections
- Integration testing which consist in controlling that systems work properly
  - System components (computers, push buttons, sensors, etc.) are tested separately and are not faulty
  - When a component is faulty, it is replaced

# The testing process on FAL



# Improving test systems on FAL

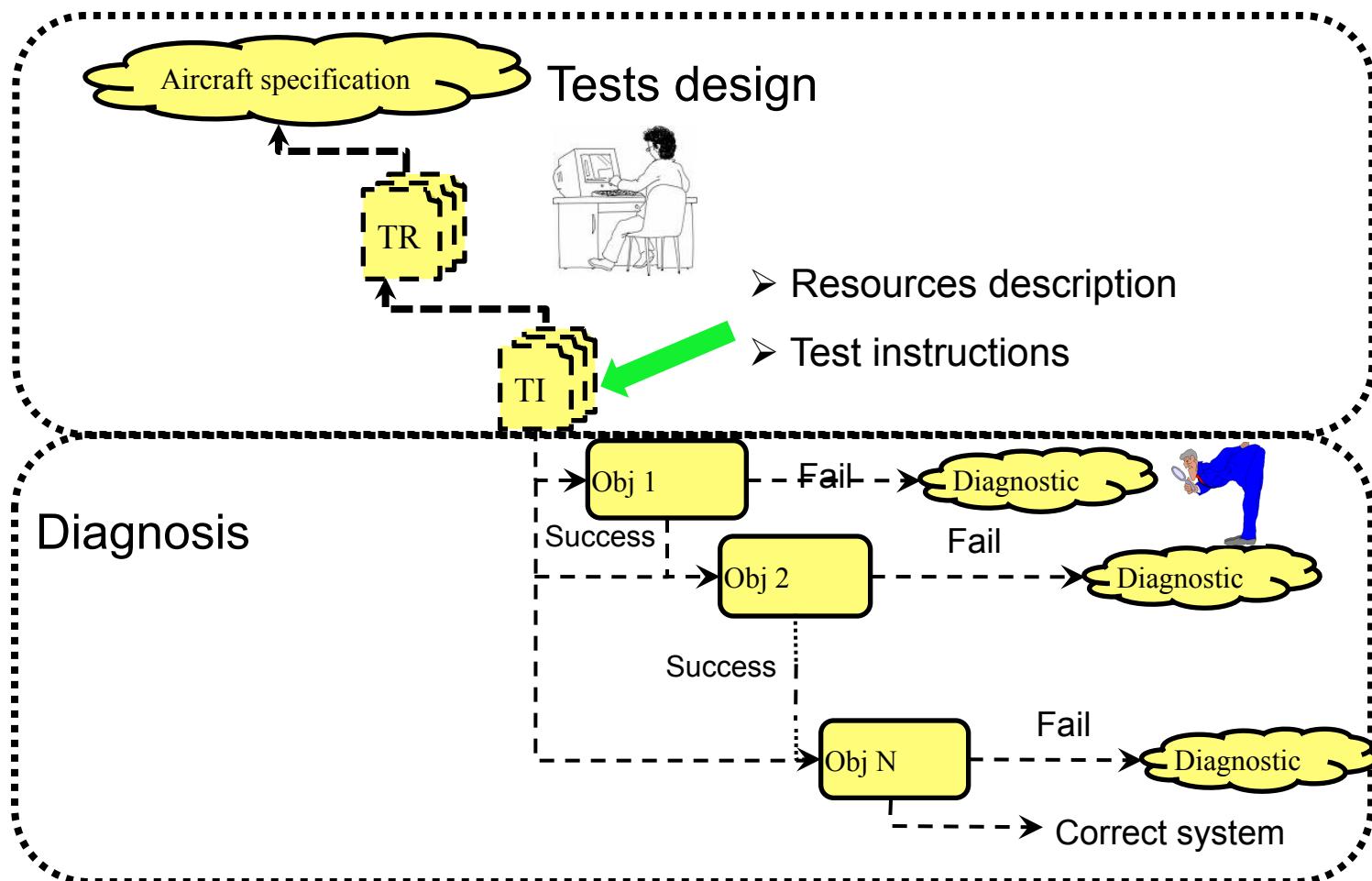


- **How to improve the present process?**
- During the test cases design phase
  - To identify relevant and redundant test cases for diagnosis
  - To identify system functions for which additional tests have to be defined to improve the diagnosis
- During the diagnosis phase after fault detection
  - To identify more precisely the faulty resource
  - To determine resources that cannot be identified as faulty by themselves
- **Using Multiple-Clue strategy**

# FAL methodology

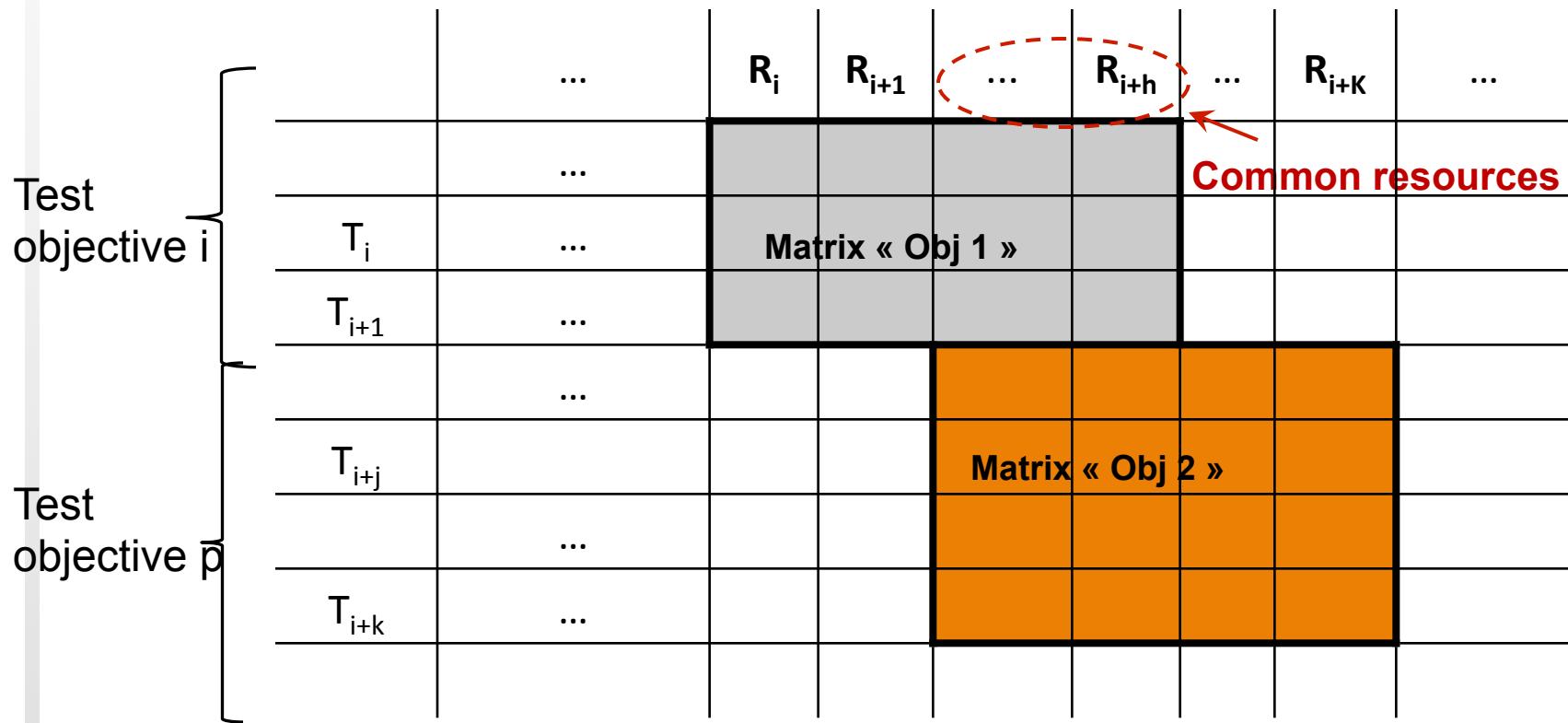
## ➤ How to apply Multiple-Clue?

- Identifying resources and tests
- Building a system model for analysis (matrix representation)



# FAL methodology

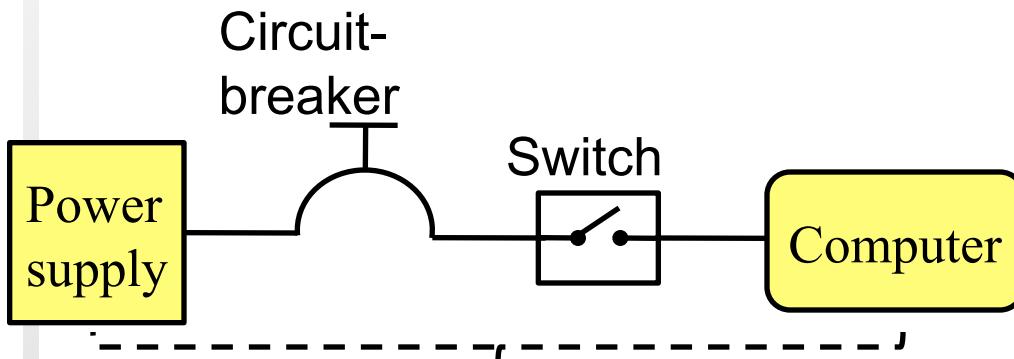
- Matrix modeling of the system under test based on tests instructions and component to be tested (circuit breaker, computer, ...)



# FAL methodology



- Multiple-Clue analysis results for each test objective
  - ***List of indistinguishable resources***
  - ***List of redundant tests***
  - ***List of relevant tests for diagnosis***



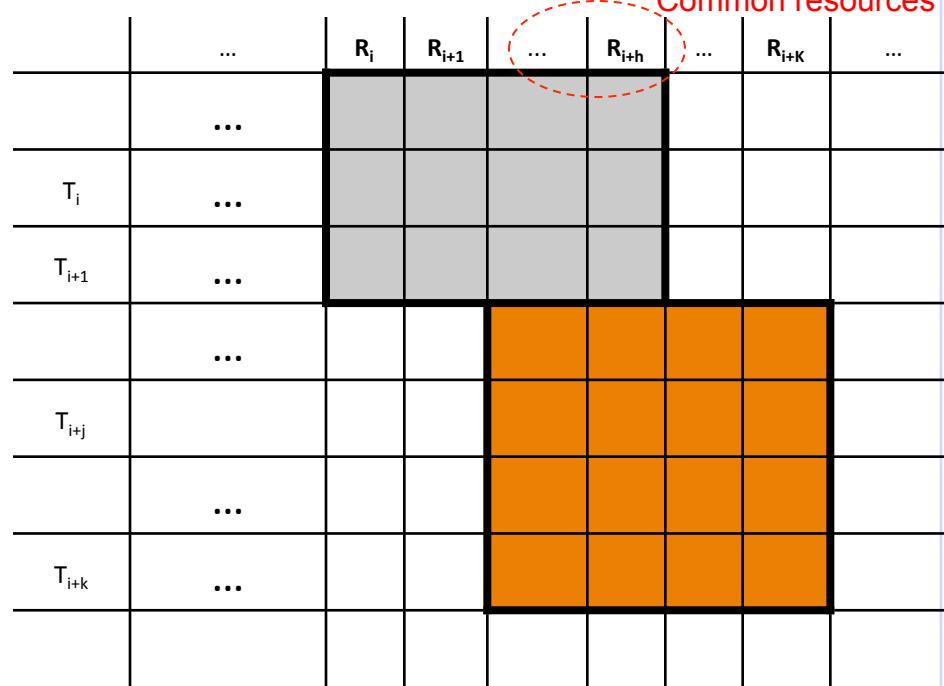
Indistinguishable resources

	<b>R<sub>1</sub></b>	<b>R<sub>2</sub></b>	<b>R<sub>3</sub></b>	<b>R<sub>4</sub></b>
T <sub>1</sub>	0	1	0	1
T <sub>2</sub>	1	0	0	1
T <sub>3</sub>	0	1	0	1
T <sub>4</sub>	0	1	1	0
T <sub>5</sub>	0	1	0	1

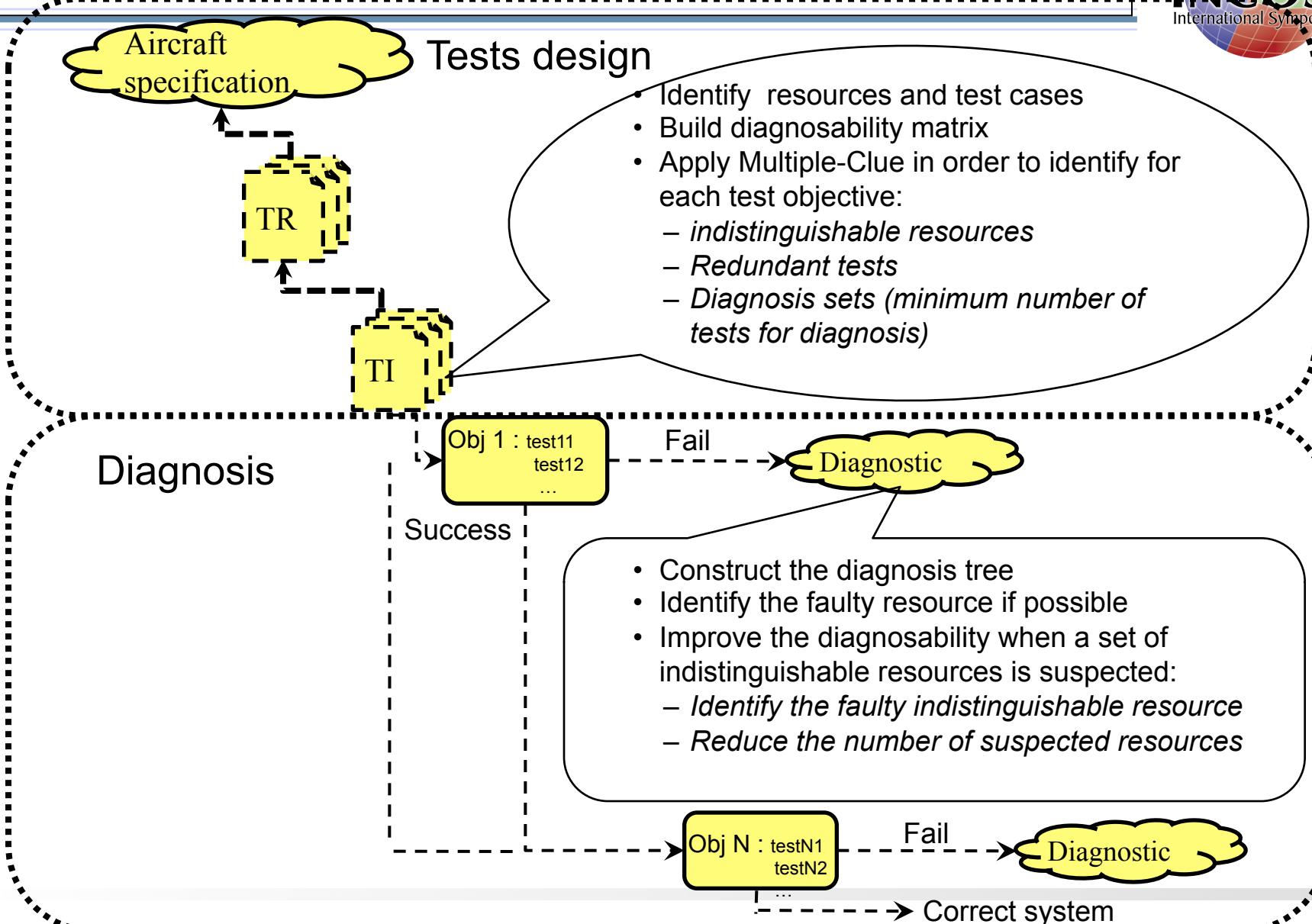
T<sub>3</sub> and T<sub>5</sub> are redundant with T<sub>1</sub>

# FAL methodology

- **How to improve the diagnosis when resources are indistinguishable?**
- A method using shared resources between test objectives has been developed in order to:
  - Help the faulty resource identification in an indistinguishable set
  - Reduce the number of suspected resources in an indistinguishable set
- Goal: reducing the diagnosis effort



# Methodology overview



# Case study



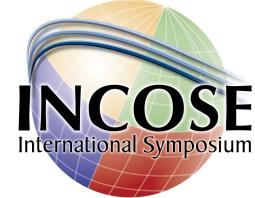
## ➤ Tracking gear orientation system characteristics

	Number
Test objectives	26
Tests	169
Resources	100

## ➤ Quantitative benefit of the methodology

	Number			
		Before	after	gain
Relevant tests for diagnosis	169	80	52%	
Redundant test for diagnosis		30	17%	
Indistinguishable sets	26	13	50%	
Average of indistinguishable sets size	8	2,5	69%	

# Interest of the methodology



- For test design engineers
  - Helpful information about relevant and redundant test cases for diagnosis
  - Useful about system functions for which additional tests have been defined to improve the diagnosis
- For test objectives verification engineers
  - Local view of test objectives diagnosis
  - Global view of system diagnosis effort
    - Guide the verification activities in order to improve the diagnosis

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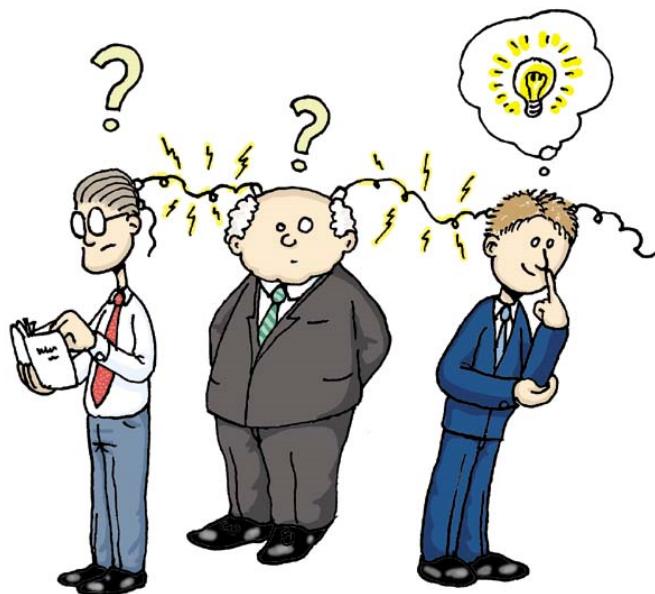
# Conclusion



- Testability concepts allowed to define :
  - A partial automation of traceability activities for specification validation
  - An help to define relevant tests on FAL
  - An improvement of diagnosis process on FAL
- Good integration of the methodologies defined in the current development process
- New experiments are necessary to consolidate the first results and envisage an operational deployment



*Thank you for your attention !*



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