

Challenges Regarding Automation of Requirements-based Testing

R. Gerlich¹, R. Gerlich¹, Maria Hernek², J. Ramachandran²
Allan Pascoe³, Glenn Johnson³

Data Systems in Aerospace DASIA 2017

May 30 – June 1, 2017, Gothenburg, Sweden

¹ Dr. Rainer Gerlich BSSE System and Software Engineering
Immenstaad, Germany
E-Mail: Rainer.Gerlich@bsse.biz
Ralf.Gerlich@bsse.biz

² European Space Agency (ESA/ESTEC)
Noordwijk, The Netherlands
E-Mail: Maria.Hernek@esa.int,
Jinesh.Ramachandran@esa.int

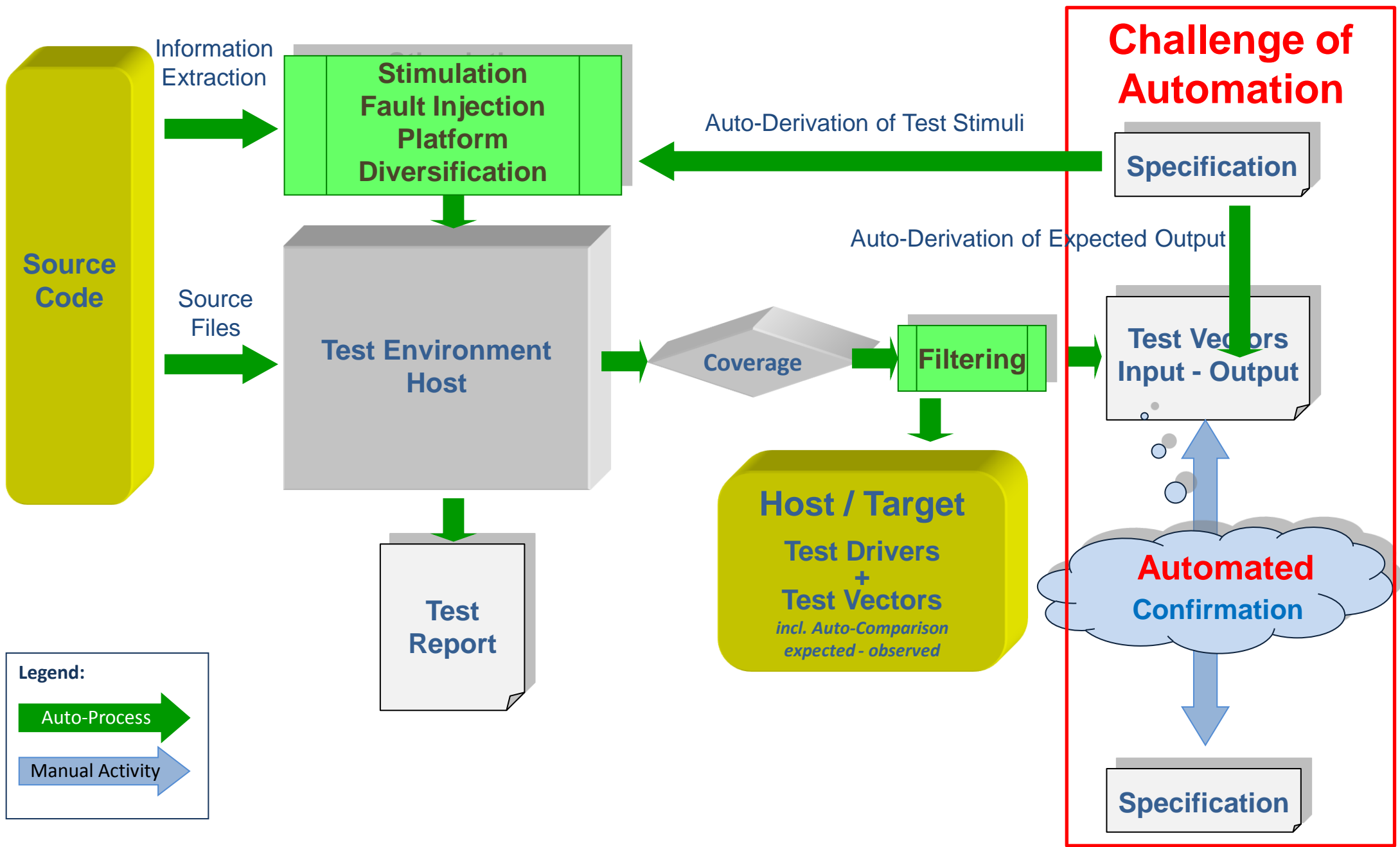
³ SCISYS UK Ltd
Bristol, UK
E-Mail: Allan.Pascoe@scisys.co.uk
Glenn.Johnsom@scisys.co.uk

Contents

- Introduction
- Current Status
- Considerations on Verification
- The Future ?
- Conclusions

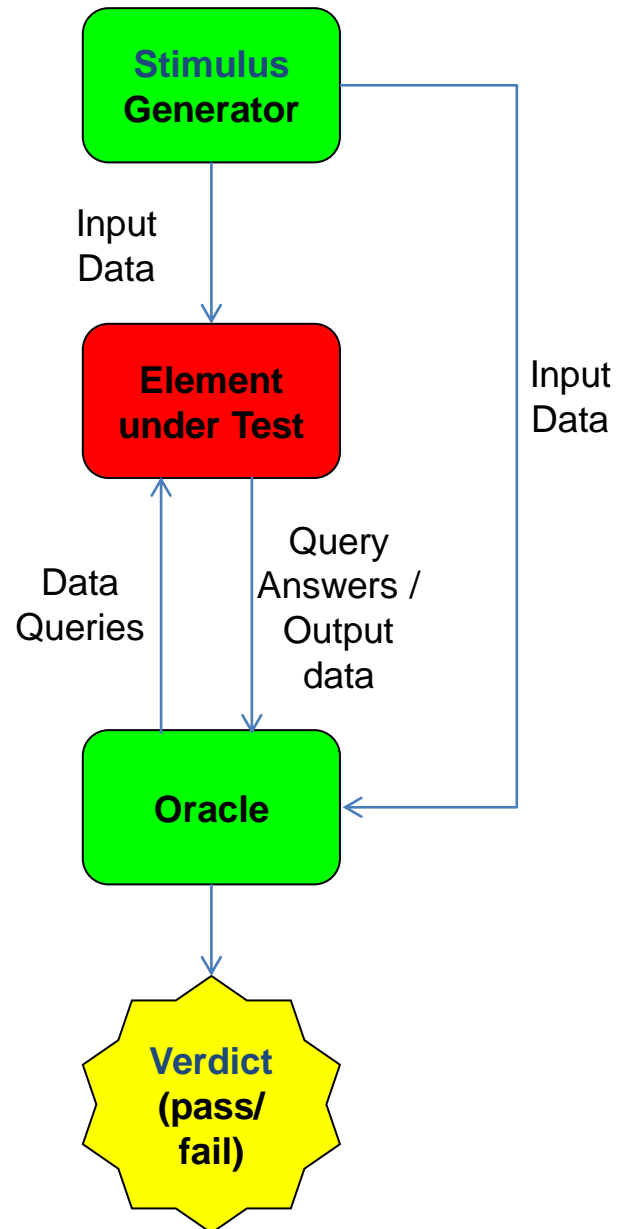
Introduction

The FAST Test Process and RQBT Flow-Optimized Source-code-based Testing



- Verify that software is compliant with the requirements!
 - ❖ Functional
 - ❖ Non-Functional: Robustness, Resource Usage, Timing, ...
- More systematic derivation of test cases from RQs?
 - ❖ What does a RQ represent?
 - ❖ Functional? Non-functional?
- Requirement Coverage?
 - ❖ When is a requirement covered?
 - ❖ By one test case? By multiple test cases? (n:m relationship)

Principles of S/W Test Automation



- Select stimuli
- Determine expected behaviour
- Execute
- Compare

Extract Required Information

Requirement:

Upon receipt of the "XYZ" TC the Nominal Mode SW shall route the TC to GPS in accordance with the format and procedures defined in [REF_ICD].

Process:

1. Read natural language requirement
2. Parse and understand natural language!
3. Build Stimulus Generator and Oracle from formal requirement
4. Profit! 😊

A task not yet solved reliably!

Let's focus on the content!

Use Extracted Information

Requirement:

Upon receipt of the "XYZ" TC the Nominal Mode SW shall route the TC to GPS in accordance with the format and procedures defined in [REF_ICD].

- **Condition/Trigger:** *Upon receipt of the "XYZ" TC* ← How/
Where?
- **Subject:** *the Nominal Mode SW*
- **Activity:** *route to the GPS* ← How can we
check that?
- **Object:** *the TC*
- **Qualifier:** *in accordance with the format and
procedures defined in [REF_ICD].* ← How can we
check that?

Current Status

Statistical Overview of Analysis

RQ-Class	Description	No. of RQs	No. of RQ-Groups
FUNC	Functions	46	10
HK	Housekeeping	8	8
COMM	Communications	19	7
MON	Monitoring	7	7
TM	Telemetry Generation	3	3
TCH	TC Handling	3	3
Total		87	39

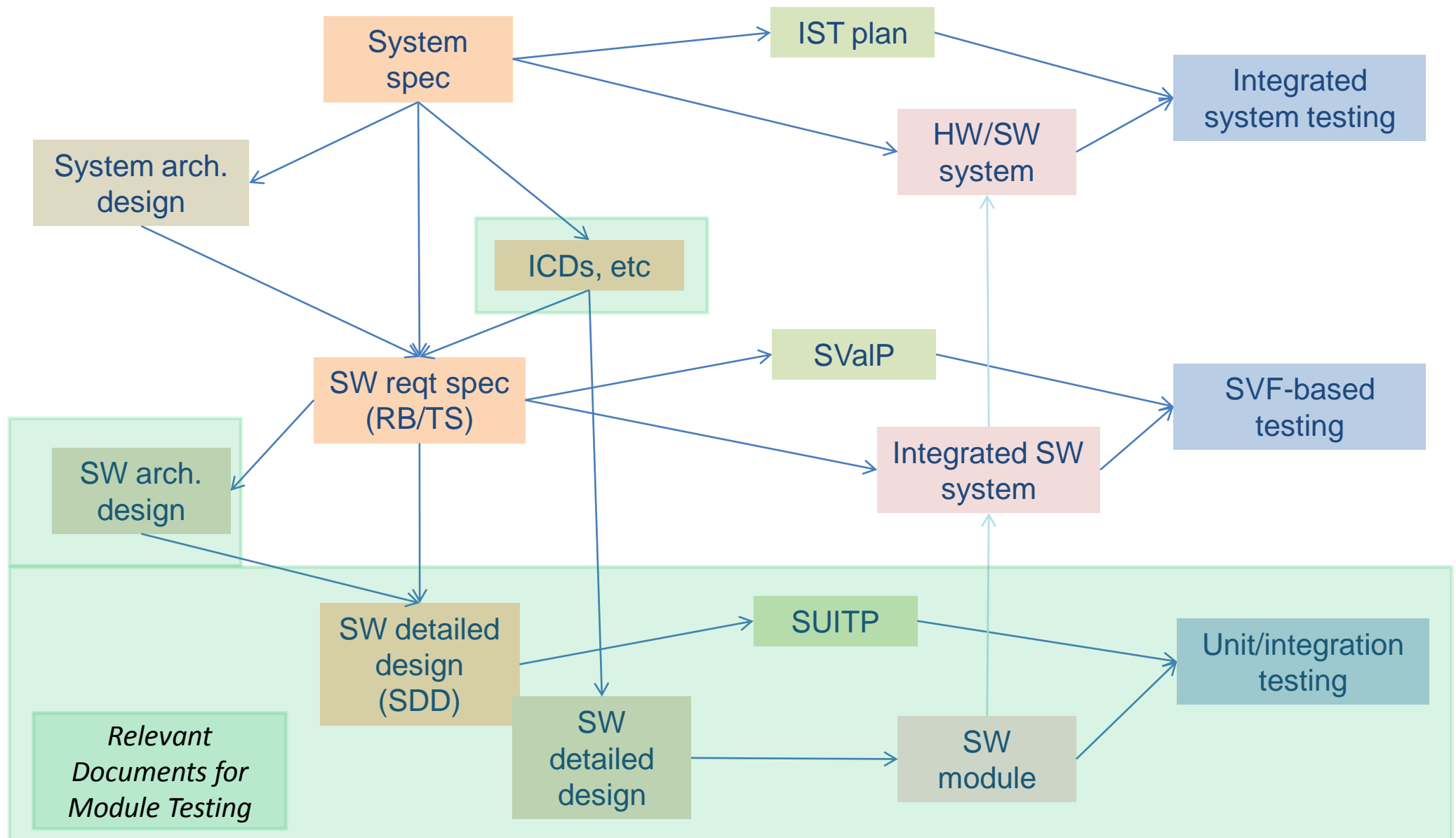
Example Requirements

Level	Class	Text	Testing Approach
High	COMM	It shall be possible for the Nominal Mode SW to command both the nominal and redundant GPS units providing they are switched ON (as defined by the current satellite configuration vector).	This requirement is violated if it is impossible for the Nominal SW to command GPS units which are switched on.
		Upon receipt of the "XYZ" TC of [TC_REF] the Nominal Mode SW shall route the TC to GPS in accordance with the format and procedures defined in [REF_ICD].	Proper conversion can be checked, e.g., by back-conversion and comparison with the original.
	HK	The data contents of the following GPS TM packets shall be stored within the system data pool: GPS Message TM, Primary Message TM	These requirements can be violated by not storing the data from the respective TM packets in the system data pool or not storing them separately.
Low	FUNC	This function process_GPS_data processes the raw GPS data. Its interface is summarised in Table xxx.	The detailed description of the algorithm can be used to provide a <i>reference implementation</i> which can be used as an oracle.
		<p>This function GPS__navigation_function shall generate the position and velocity in the inertial J2000 reference frame for the current time for the following cases:</p> <ul style="list-style-type: none"> • ... • ... • ... <p>It will be called at n Hz in modes A and B. Its interface is described in Table yyy.</p>	

- **(Sub-)System Level Requirements**
 - ❖ addresses interfacing, external view
 - ❖ in many cases sequence-based
 - ❖ no correlation with a code function possible on this level
 - ❖ no stimuli and expected values are visible

- **Implementation-Level Requirements**
 - ❖ in part pseudo-code or mix of text and pseudo-code
 - ❖ identification of code function may be possible, but manual
 - ❖ manual establishment of reference oracle possible

Typical OBSW Development Approach



- Spec / RQs:
 - ❖ Describe, *what* is to be done
 - ❖ Need to be sufficiently abstract in order not to constrain design
- Design
 - ❖ Answer to Spec: Describe, *how* it is to be done
 - ❖ Breakdown to code elements (functions, data, types)
 - ❖ Should the SDD be a low-level RQ document?
 - ❖ Should the SDD make testable statements?

Verification Considerations

How to test Function requirements

This function `process_GPS_data` processes the raw GPS data. Its interface is summarised in Table xxx.

Further Requirements specify the exact steps of the function in prose or pseudo-code.

Test approach

- Generate input according to parameter spec
- Use specification (pseudo code) as reference implementation run on same input
- Compare output of real and reference implementation

The Future ?

Example: Low-Level RQ

At 8Hz set the validity flags for the GPS Validity monitors to true if the corresponding GPS unit is active and the AOCS mode is Mode1, Mode2 or Mode3.

The GPS_monitor_func shall

do

*If the GPS_unit_X.status == active and the
AOCS_mode == (Mode1, Mode2 or Mode3)*

then

GPS_X_validity_monitor = true

end

enddo

- **Condition/Trigger:** *8Hz period timer expires &&
GPS_unit_X.status == active &&
AOCS_mode == (Mode1, Mode2 or Mode3)*
- **Subject:** *the GPS_monitor_func assign*
- **Activity:** *assign true*
- **Object:** *GPS_X_validity_monitor*

Condition

Function

Action

Variable

Clearly Specified

Implementation of Automated RQBT

```

If the GPS unit X is active and the AOCS mode is Mode1, Mode2 or Mode3
  GPS_X_validity_monitor = true.
end
  
```

RQ

Automation(?)

irrelevant on UT level, issue on system level

8 Hz

Test Case	Input			Output	Oracle
	Status	Mode	validity	validity	
1	active	Mode1	False	True	Q1
2	active	Mode2	False	True	Q2
2	active	Mode3	False	True	Q3
4	active	Mode4	False	False	Q4
5	non-active	Mode2	False	False	Q5

Flag changed

Automation

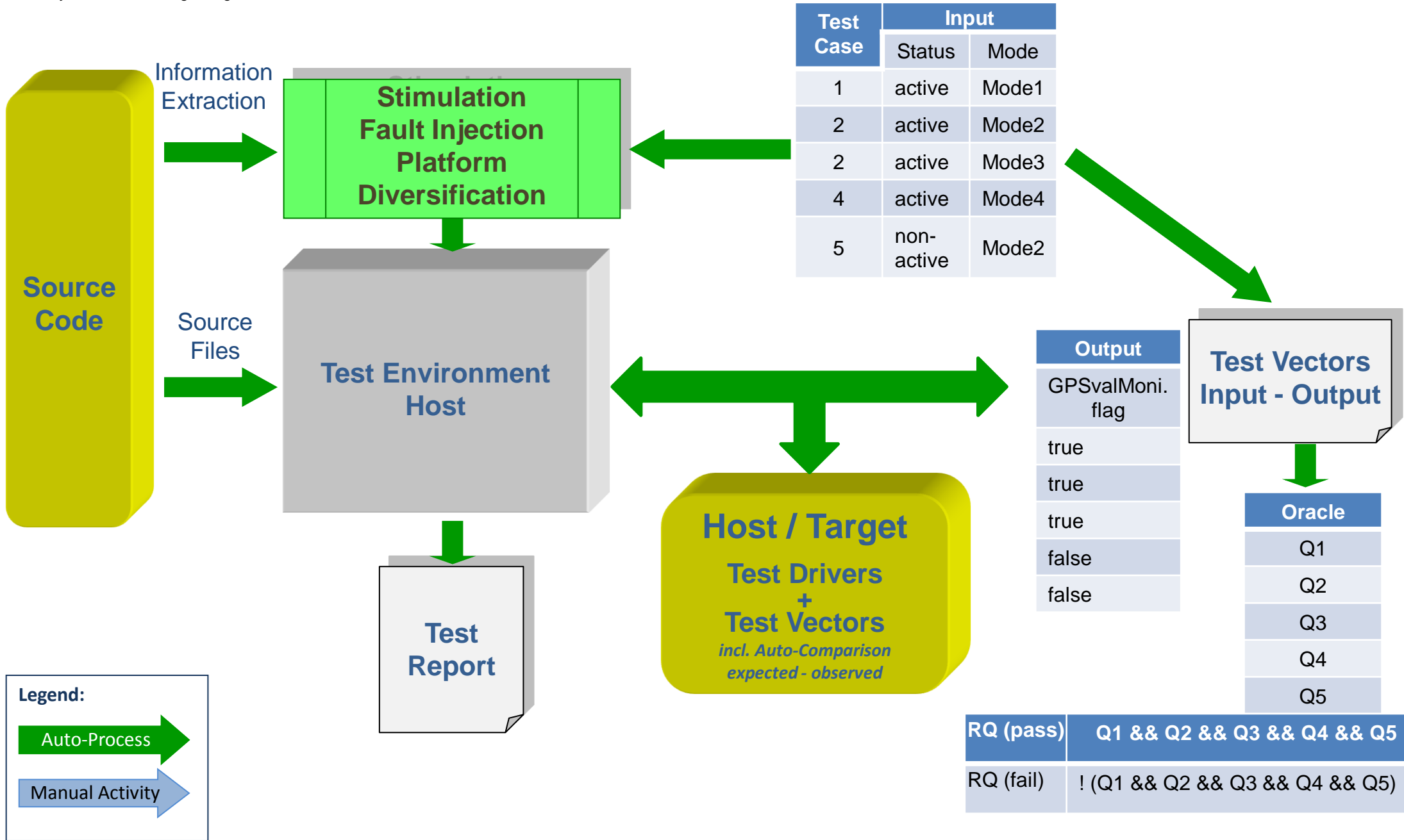
Flag unchanged

Precondition

Oracle	
RQ (pass)	Q1 && Q2 && Q3 && Q4 && Q5
RQ (fail)	! (Q1 && Q2 && Q3 && Q4 && Q5)

*Separation of Concerns:
System (high) and UT (low) level*

The FAST Test Process and Automated RQBT



Conclusions

- **Two different classes of RQs**
 - ❖ high-level: SVF-based testing
 - ❖ low-level: unit/integration testing
- **RQ-structure**
 - ❖ information distributed across a number of documents
 - ❖ not well structured:
 - condition, subject, activity, object, qualifier
 - ❖ ambiguities due to natural language
 - ❖ traces are not continuously established top-down

Where to go now?

- **Improved process, more formalization required**
- Is this feasible at all?
 - ❖ Is there a common schema? Schemas for sub-domains?
 - ❖ Tooling? Standardisation?
 - ❖ Engineer acceptance?
- But: strong need for automation due to increasing complexity
- Expected Benefits
 - ❖ improvement of understanding and quality
 - ❖ massive increase of test cases without increase of costs
 - More test cases ⇒ higher confidence in test results
 - Less effort for test case generation ⇒ decrease of cost
 - ❖ Possibly: auto-coding from requirements ⇒ improved code quality

Thank you for your attention!

Questions?

*The project was funded by
ESA GSTP Programme
under Contract No. 4000 116 014*