

Integrating Model-Based Testing in the Space Industry

Support to LEIRIOS Technologies

Lars Wedin & Philippe Chevalley

ESA/ESTEC

Software Engineering and Standardisation Section



Outline

- ❑ Presentation of the Company
- ❑ State of the Practice in Functional Testing
- ❑ LEIRIOS Test Generator
- ❑ ESA Support to LEIRIOS
- ❑ Share of Activities
- ❑ Test Generation Process
- ❑ Technical Assessment Results
- ❑ Service Assessment
- ❑ Problem areas

Presentation of the Company

Commercial Aspects

- ✦ Spin-off from a CNRS & INRIA laboratory
- ✦ Recently Created (2003)
- ✦ Personnel (25):
 - 15 R&D Engineering
 - 6 Support & Services
 - 4 Sales
 - 6 Administration
- ✦ Location:
 - Besançon (R&D Centre)
 - Paris (Commercial)
 - Munich (German Market)

Field of Expertise

- ✦ Expertise in:
 - Model-Based Testing
 - Automatic Testing
- ✦ Leirios Test Generator
 - Formal B Models
 - UML Models
- ✦ Applications:
 - Smart Cards
 - Automotive
 - ...
 - Space ?

State of the Practice in Functional Verification

Verifying the compliance of a piece of software to its specification...

How to:

- Specify the tests (objectives)
- Master the complexity (generate **efficient tests**)
- Master the **number** of tests (stopping rule)
- Optimize the **functional test coverage**
- Manage **specification changes**
- Minimize **empiricism**



*Automated Test Generation
from a Model of the Specification*

LEIRIOS TEST GENERATOR

Challenges

Towards a fully automated test process...

- **Detection** of design/implementation faults
 - Automated generation of efficient test cases

- **Inputs:** requirements specification
 - Import UML models from widely used tools

- **Outputs:**
 - Test scripts generation to any execution environment
 - Traceability from requirements to test cases
 - Coverage reports

ESA Support to LEIRIOS

- ❑ Provide **expertise** in the applicability of ECSS Space Software Standards (ECSS-E-40, ECSS-Q-80)
- ❑ Apply the LEIRIOS Test Generator on a representative space software (**case study**)
- ❑ Provide feedbacks for improvement, empirical results on the **relevance of model-based testing** for the Space Industry.

Share of Activities

ESA



LEIRIOS Technologies

- ❑ Selection of the case study (AOCS software of the PROBA 2 mission)
- ❑ Design of the UML model
- ❑ Generation of test cases
- ❑ Evaluation of the effectiveness of the technology and dissemination of results

- ❑ Provide the technology (LEIRIOS Test Generator for UML/OCL)
- ❑ Provide dedicated training, support, and consultancy
- ❑ Provide feedbacks on results and implement modifications in LTG

Permanent cooperation between ESA and LEIRIOS to reach the study objectives

Test Generation Process

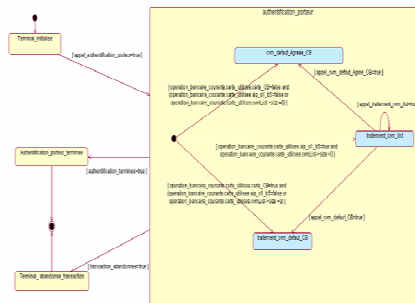


Functional Requirements

Functional Modelling



UML Model with OCL



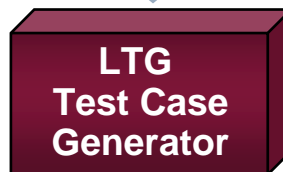
Model Validation



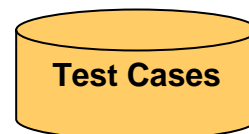
LTG Model Animator

LEIRIOS Test Generator™

Test Generation Criteria



Test Case Generation



Technical Assessment Results

Corrective Improvements

- Corrective maintenance (bug removal)
- Better user interface
- Better documentation (user manual)

New Functionality

- Support of various modelling tools (for UML)
- Floating-point variables
- Concurrency (reactive systems)



Such technology can be used to automate the verification process of space software

Service Assessment

- Value of the Support Provided to LEIRIOS
 - Evaluation of the tool for space application
 - Acquaintance with requirements of space systems.
 - Insight to the Space Market Arena

- Total cost incurred to ESA:
 - ~0.7 man*years (~0.5 man*year as actual support, and ~0.2 for building-up expertise).

Problem areas

- ❑ Administrative delay
 - ~3 months delay for establishing a contractual agreement
 - impact was mainly on ESA internal resource allocation.
- ❑ Lack of structured documentation on:
 - the technology to be assessed
 - modelling framework
 - information had to be obtained verbally.
- ❑ Underestimate of expertise requirement for applying the technology (steep learning curve)
- ❑ Confidentiality issue:
 - ESA to LEIRIOS flow of information related to the real specifications and test API was limited.