Japan Aerospace Exploration Agency

NAIST

Cost Effective IV&V Planning Activity derived from Experiences on JAXA's Spacecraft Projects

ADCSS2008@ESTEC

Session : The ISVV Process Improvement

Topic : Improvement/revision to the ISVV process as defined in the ESA ISVV Guide

Tsutomu MATSUMOTO*1, Shinsuke MATSUMOTO*2

Hidetake UWANO*2, Akito MONDEN*2, Yuko MIYAMOTO*1

Shogo UJIHARA*1, Naohiko KOHTAKE*1, Masa KATAHIRA*1

*1 Japan Aerospace Exploration Agency (JAXA)

*2 Nara Institute of Science and Technology (NAIST)

31 October, 2008

Contents

- Current IV&V in JAXA
- Overview of Research
- Specific Question of Cost Effective IV&V
- Cost Effective IV&V Planning Activity
  - IV&V Planning Tool
  - Effectiveness Measurement
  - Summary and Future Work
- Empirical Evaluation Based on Defect History
  - Goal and Hypotheses
  - Proposal Method
  - Case Study
  - Summary and Future Work

Current IV&V in JAXA

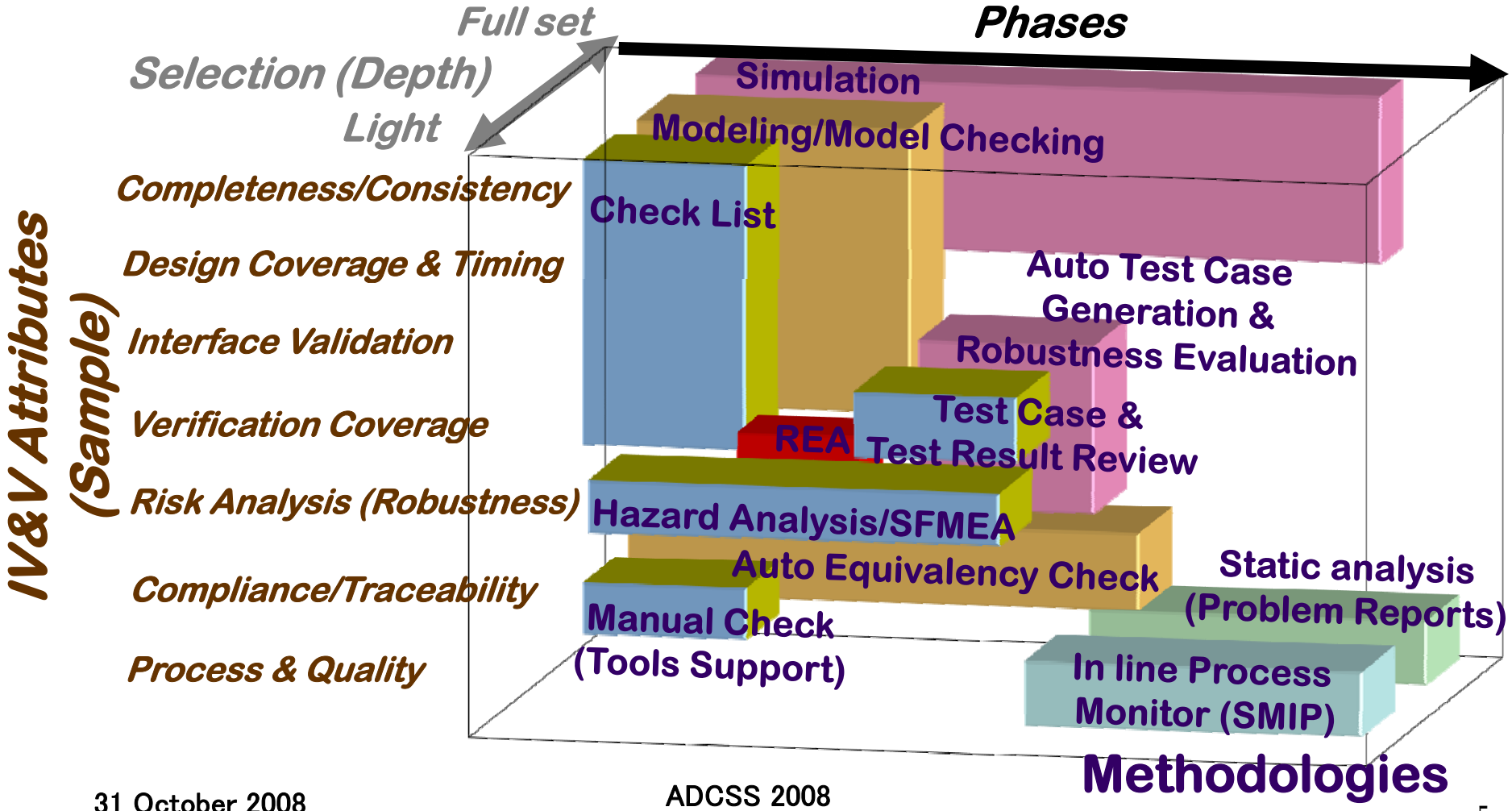
- Current Situation
  - Increase in IV&V needs from various projects
    - ◆ **Effective IV&V** should be tailored and performed for each project
  - Limitation of IV&V engineer, budget and schedule
    - ◆ **Effective IV&V management** should be applied
  - Increase in system and software complexity
    - ◆ **Effective IV&V techniques** should be developed and applied

Overview of Research

- Goal of Cost Effective IV&V
  - Rationale for IV&V planning as best solution
    - Selecting appropriate combination of IV&V techniques to achieve cost effectiveness:
      - Risk reduction
      - Cost performance
- Research Activity
  - IV&V planning method based on experiences
  - Empirical evaluation of IV&V techniques (collaborative project with NAIST)

Overview of Research

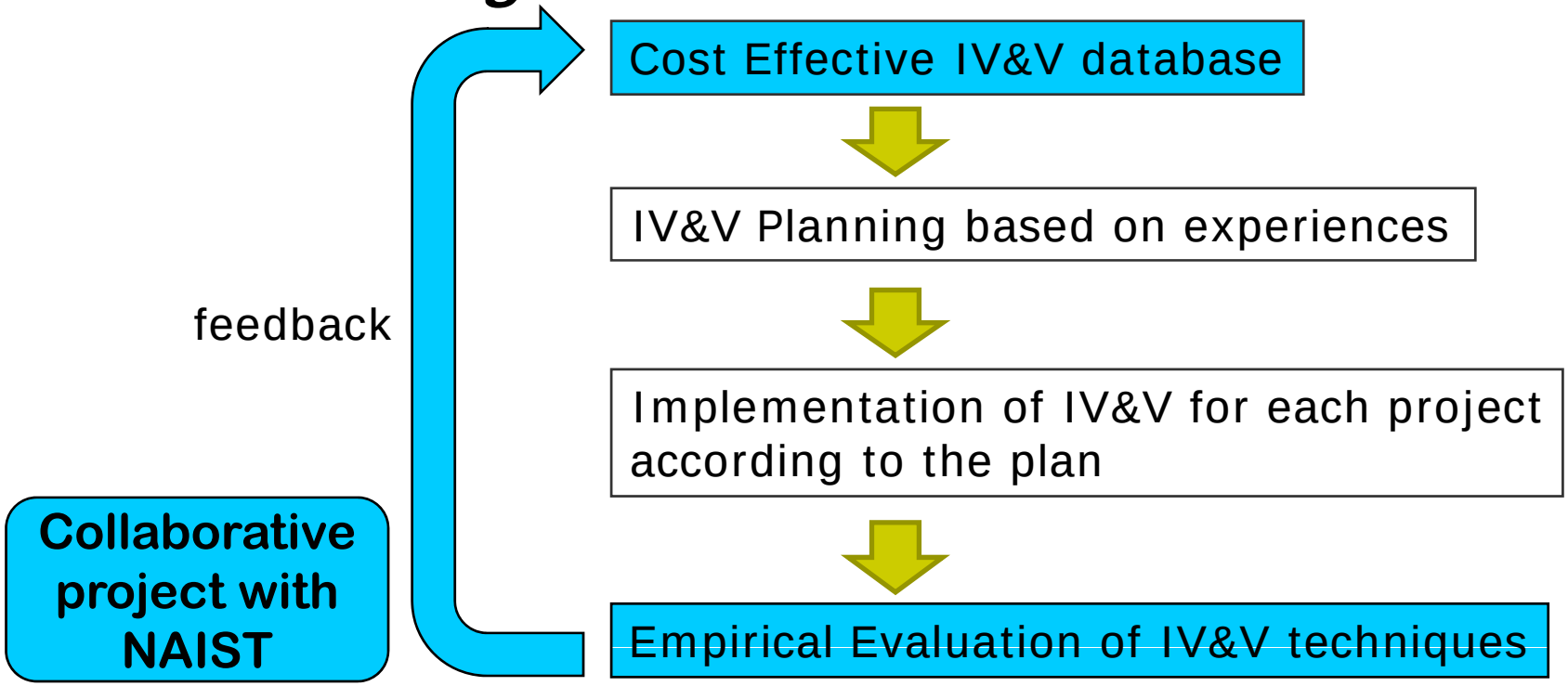
- IV&V techniques and combination



Specific Question of Cost Effective IV&V

- **Question**

  How to effectively feedback the experiences to the following IV&V activities



Cost Effective IV&V Planning Activity

- **Motivation**

  To perform IV&V by small group with low cost

- **Proposed Solution**

  To select appropriate combination of IV&V techniques for each project along a certain guideline

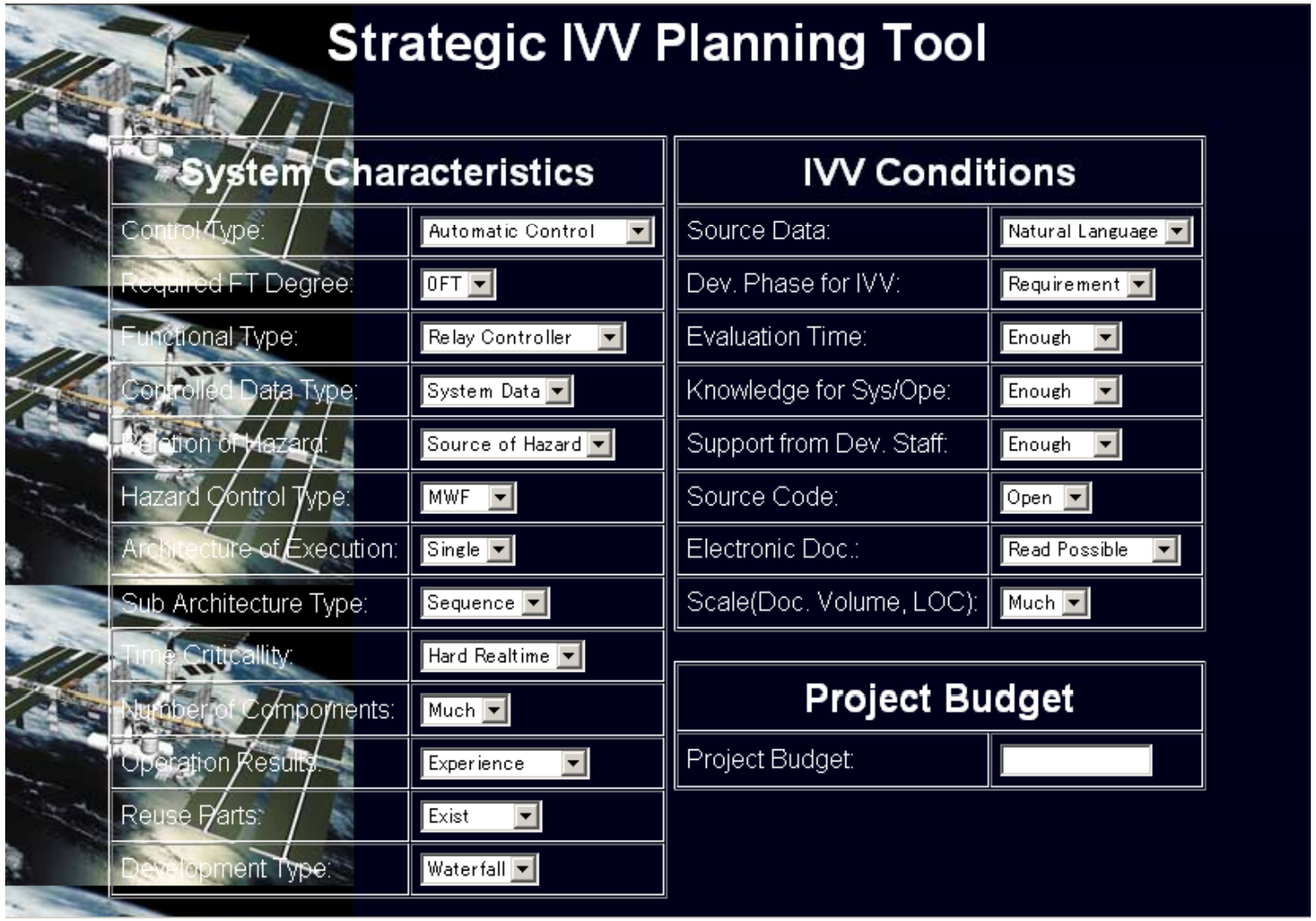
- **Research Activity**
  - Development of IV&V Planning Tool
  - Effectiveness Measurement of IV&V techniques

IV&V Planning Tool

- Planning concept
  - 1st Round: planning at concept design phase
    - Estimation of cost, expected risk, risk-reduction
  - 2nd Round: planning after S/W development start
    - Selection of appropriate IV&V techniques
- Development of IV&V Planning Tool
  - Input : e.g. system characteristics, project budget
  - Output: e.g. risk size, risk probability, cost
  - Needs to be improved :

    accuracy of effectiveness estimation

IV&V Planning Tool

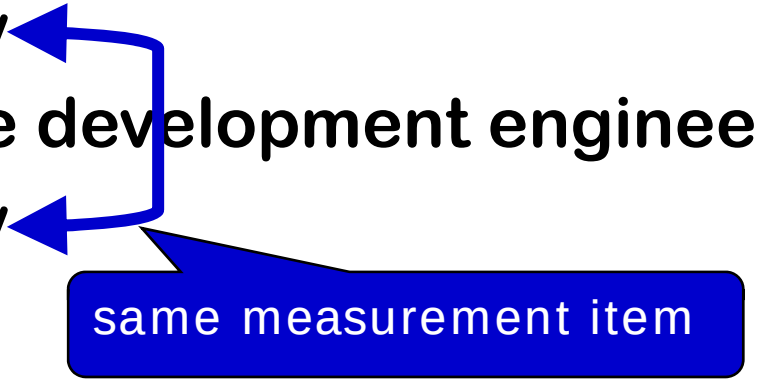


Effectiveness Measurement

- Measuring methods
  - Definition of metrics for each IV&V findings
    - e.g. priority, criticality, man-hours
  - Measured by both IV&V engineers and software development engineers
    - To improve the estimation accuracy by analyzing the difference between each values
- Current ongoing work
  - Trial measurement in some projects

Effectiveness Measurement

- Example : metrics in IV&V findings list
  - Measured by IV&V engineers for each finding
    - target function of the software
    - applied IV&V attribute and technique
    - man-hours to detect the finding
    - criticality and priority
  - Answer from software development engineers
    - criticality and priority



Summary and Future Work

- Summary
  - IV&V Planning Tool
    - Framework has been developed.
    - Estimation accuracy should be improved.
  - Effectiveness Measurement
    - Metrics has been defined.
    - Measurement will be put into practice.
- Future Work
  - Collect and analyze the IV&V process data
  - Feedback the result of empirical evaluation to Cost Effectiveness Database

Empirical Evaluation Based on Defect History

- Goal
  - Evaluate IV&V activities by analyzing detected defects
- Hypotheses
  - Good IV&V process can detect wide variety of defects
  - Good IV&V technique can detect “expected” defects
    - e.g. “traceability analysis” is expected to detect “inconsistency” between requirement spec. and design spec.

Approach

- Try to build the defect classification suitable for IV&V
- Identify expected defect classes for each IV&V technique (or perspective)
- Compare expected defects and actually detected defects on the classification map

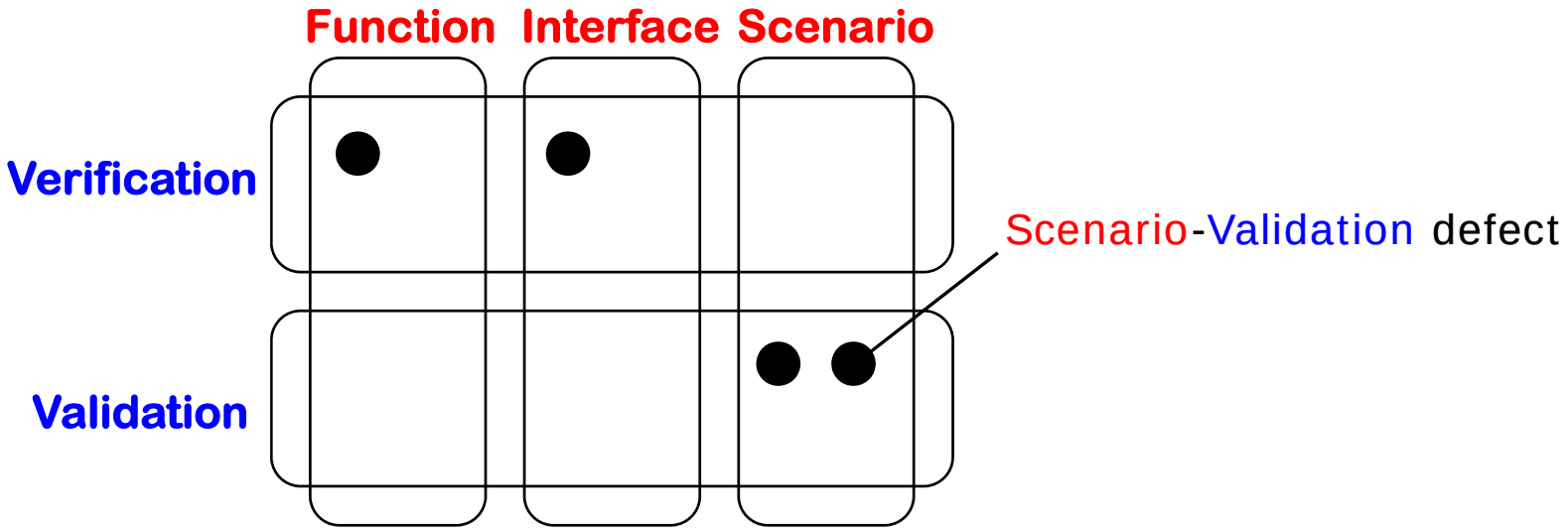
Related work

- Orthogonal defect classification (ODC)*
  - Commonly used in enterprise software development.
  - Classification categories:
    - *Function, Interface, Checking, Assignment, Timing/Serialization, Build/Package/Merge, Documentation, Algorithm*
  - Categories are not independent enough
    - This makes classification more difficult
    - Classification depends on person
    - 30% of defects are often classified as “others”
  - “Verification bugs” and “validation bugs” are not separated

*Chillarege, R. et al.: Orthogonal Defect Classification-A Concept for In-Process Measurements, *IEEE Transactions on Software Engineering*, Vol.18, No.11, pp.943–956 (1992).

Our Proposal Method

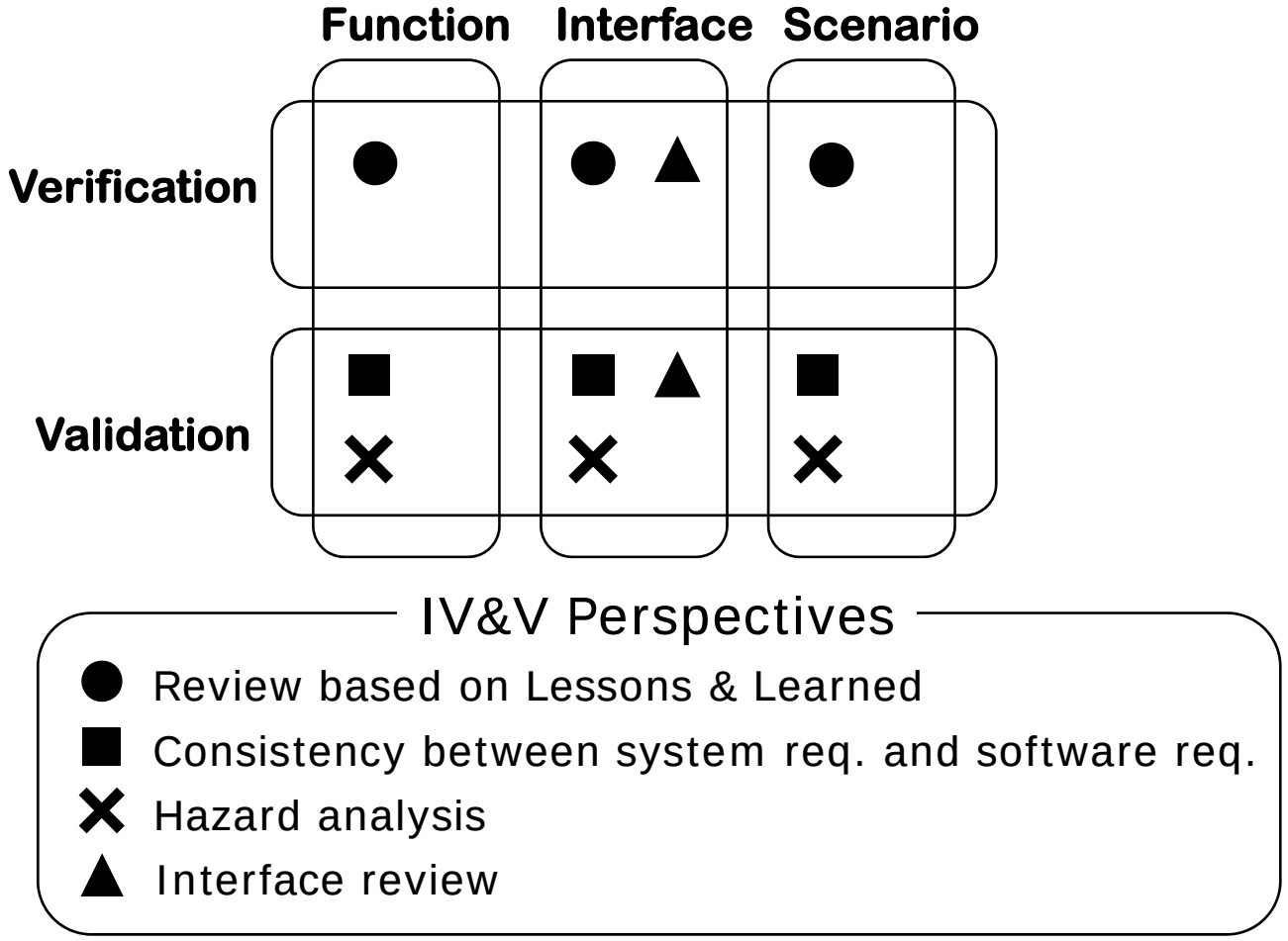
- Two viewpoints
  - Function / Interface / Scenario
  - Verification / Validation



- Simple but easy-to classify
- Evaluate both V&V activities

Expected Defects

- IV&V perspectives and expected defects



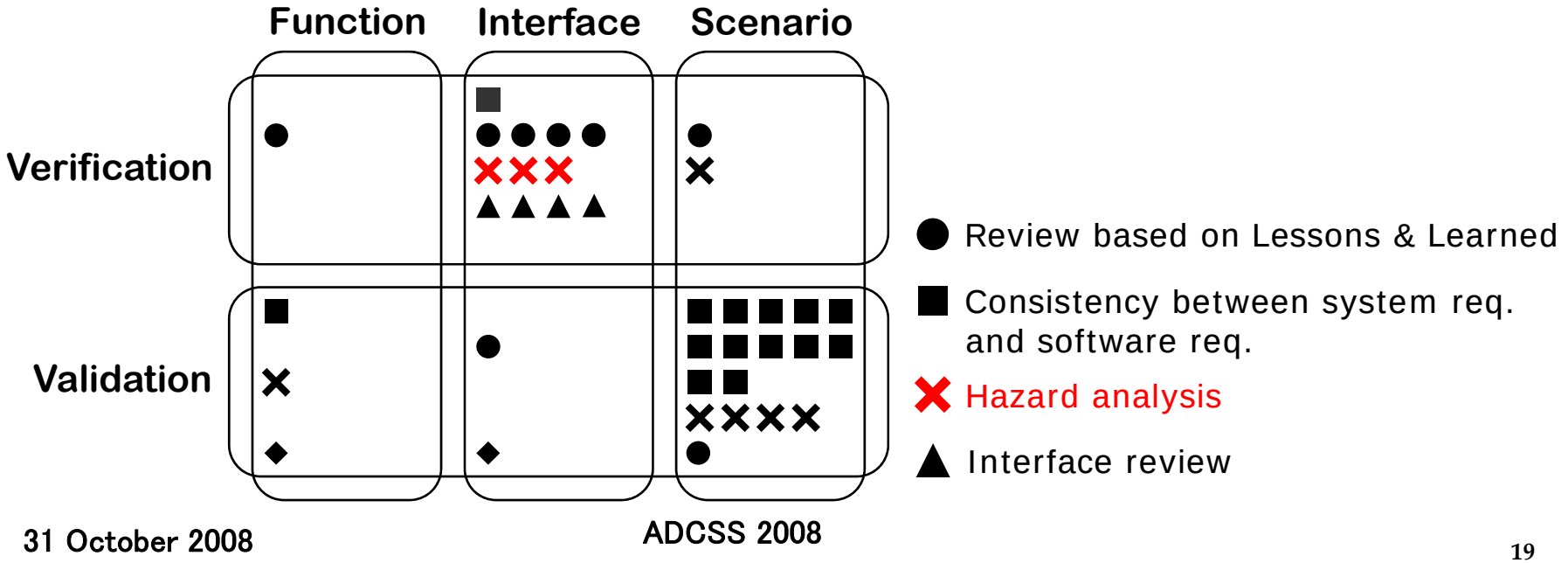
Case Study

- Target Data
  - 49 defects detected by IV&V activities conducted in a software req. analysis phase of a satellite system

- We compared expected defects and actually detected defects in each IV&V perspective

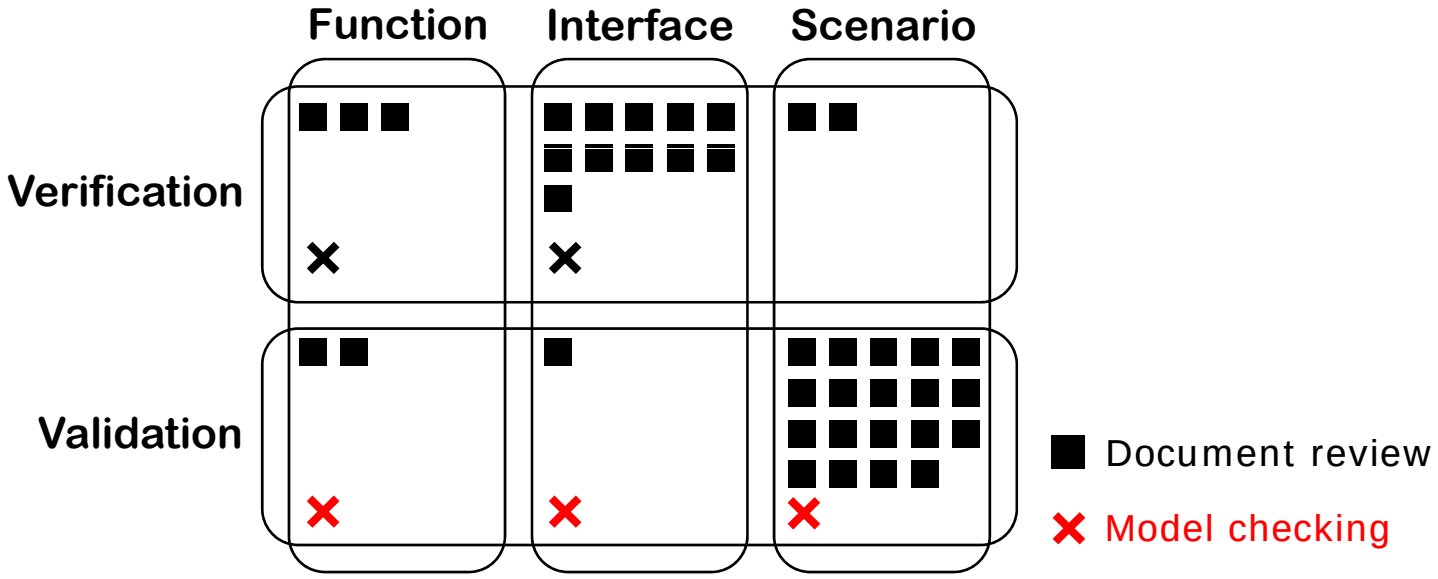
Result 1

- "Hazard analysis" detected "interface-verification" defects while it is expected to detect validation defects
  - These defects might be overlooked in "interface review"



Result 2

- "Model checking" detected "validation defects" as well as "verification defects"
  - Validation problems were found during model construction



Summary and Future Work

- Summary
  - We have built a defect classification to evaluate IV&V activities

- Future Work
  - Seek for a better defect classification
  - Compare detected defects among different IV&V phases (req. analysis, design, coding …) or among different systems