



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

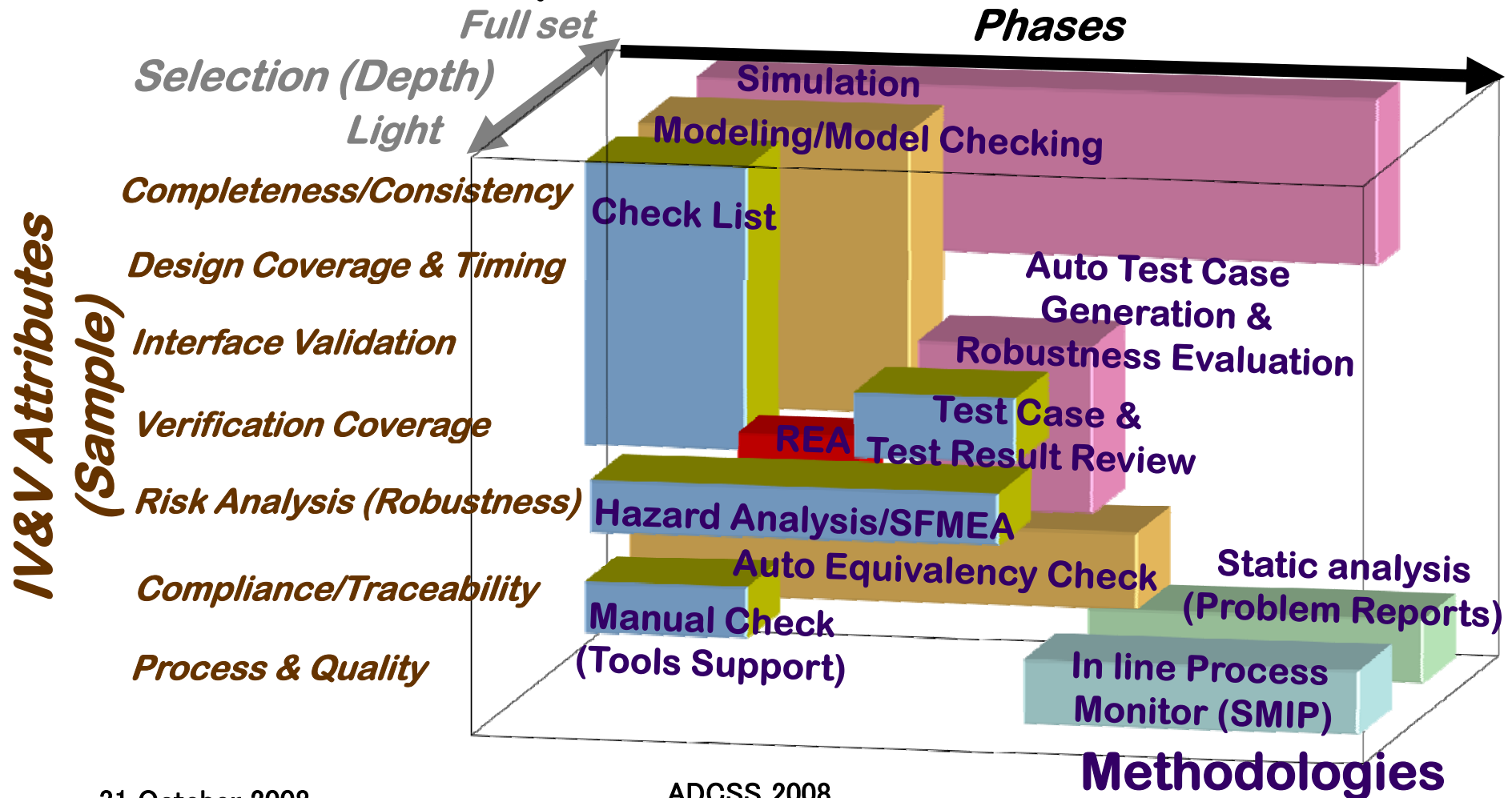
# Overview of Research



- **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

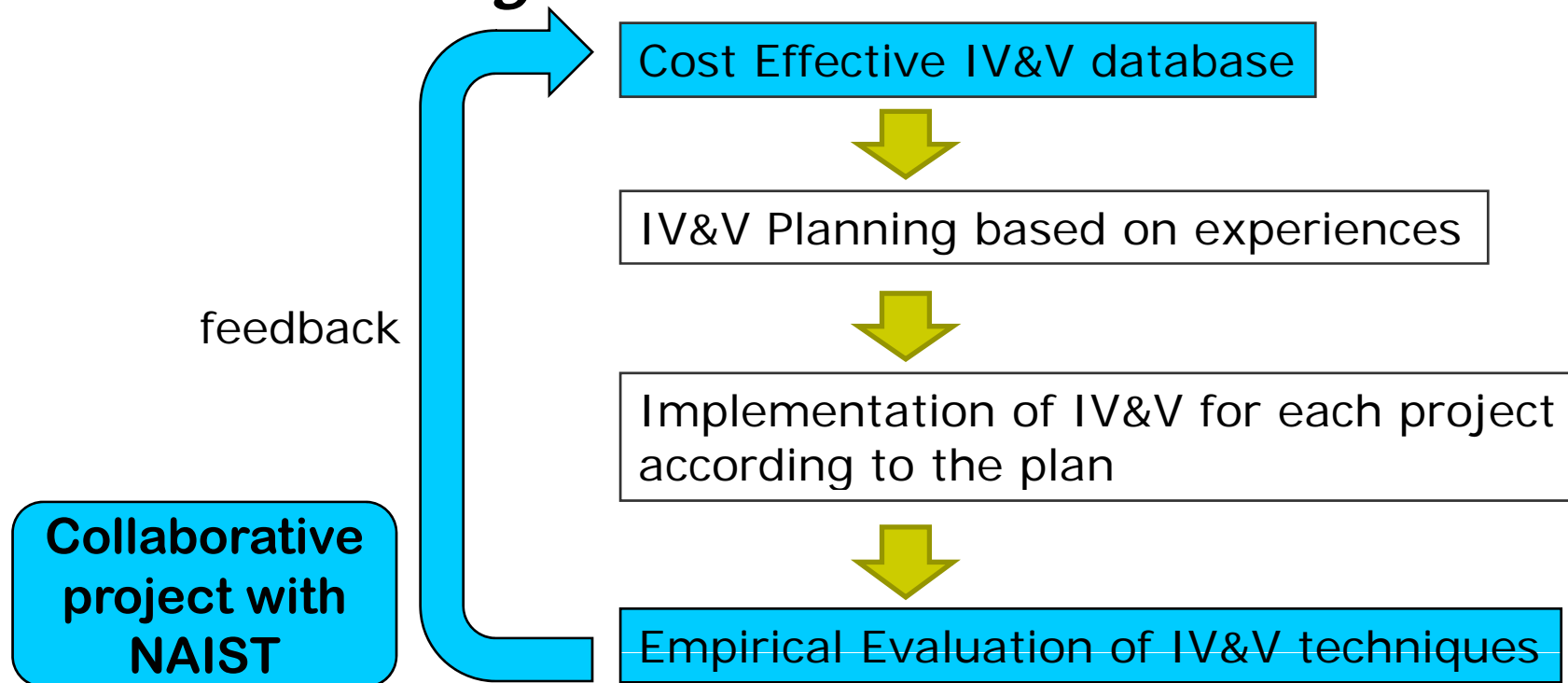


# Specific Question of Cost Effective IV&V



- Question

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



# Cost Effective IV&V Planning Activity

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- **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**
  - 1<sup>st</sup> Round: planning at concept design phase
    - Estimation of cost, expected risk, risk-reduction
  - 2<sup>nd</sup> 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



## Strategic IVV Planning Tool

System Characteristics		IVV Conditions			
Control Type:	Automatic Control	Source Data:	Natural Language		
Required FT Degree:	OFT	Dev. Phase for IVV:	Requirement		
Functional Type:	Relay Controller	Evaluation Time:	Enough		
Controlled Data Type:	System Data	Knowledge for Sys/Ope:	Enough		
Relation of Hazard:	Source of Hazard	Support from Dev. Staff:	Enough		
Hazard Control Type:	MWF	Source Code:	Open		
Architecture of Execution:	Single	Electronic Doc.:	Read Possible		
Sub Architecture Type:	Sequence	Scale(Doc. Volume, LOC):	Much		
Time Criticality:	Hard Realtime	<b>Project Budget</b>			
Number of Components:	Much			Project Budget:	<input type="text"/>
Operation Results:	Experience				
Reuse Parts:	Exist				
Development Type:	Waterfall				

# 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

same measurement item

# 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

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- **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

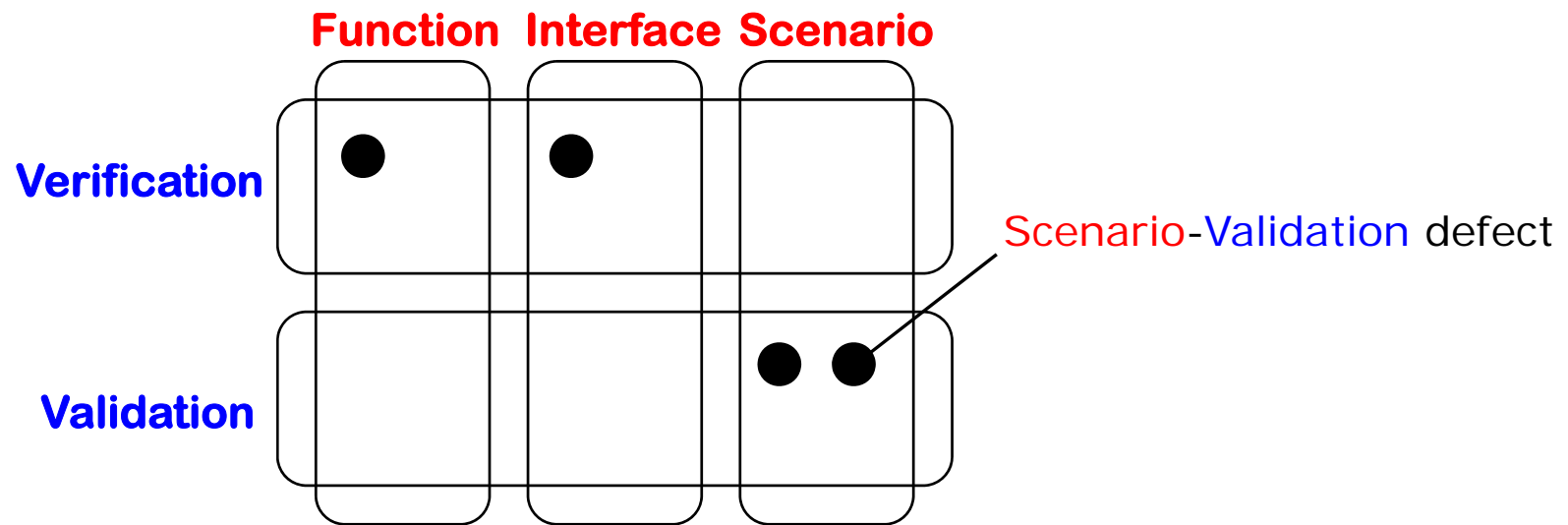


- **Orthogonal defect classification (ODC)\***
  - Commonly used in enterprise software development.
  - Classification categories:
    - *Function, Interface, Checking, Assignment, Timing/Serialization, Build/Package/Merge, Documentation, Algorithm*
  - Categories are not independent enough
    - This 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**

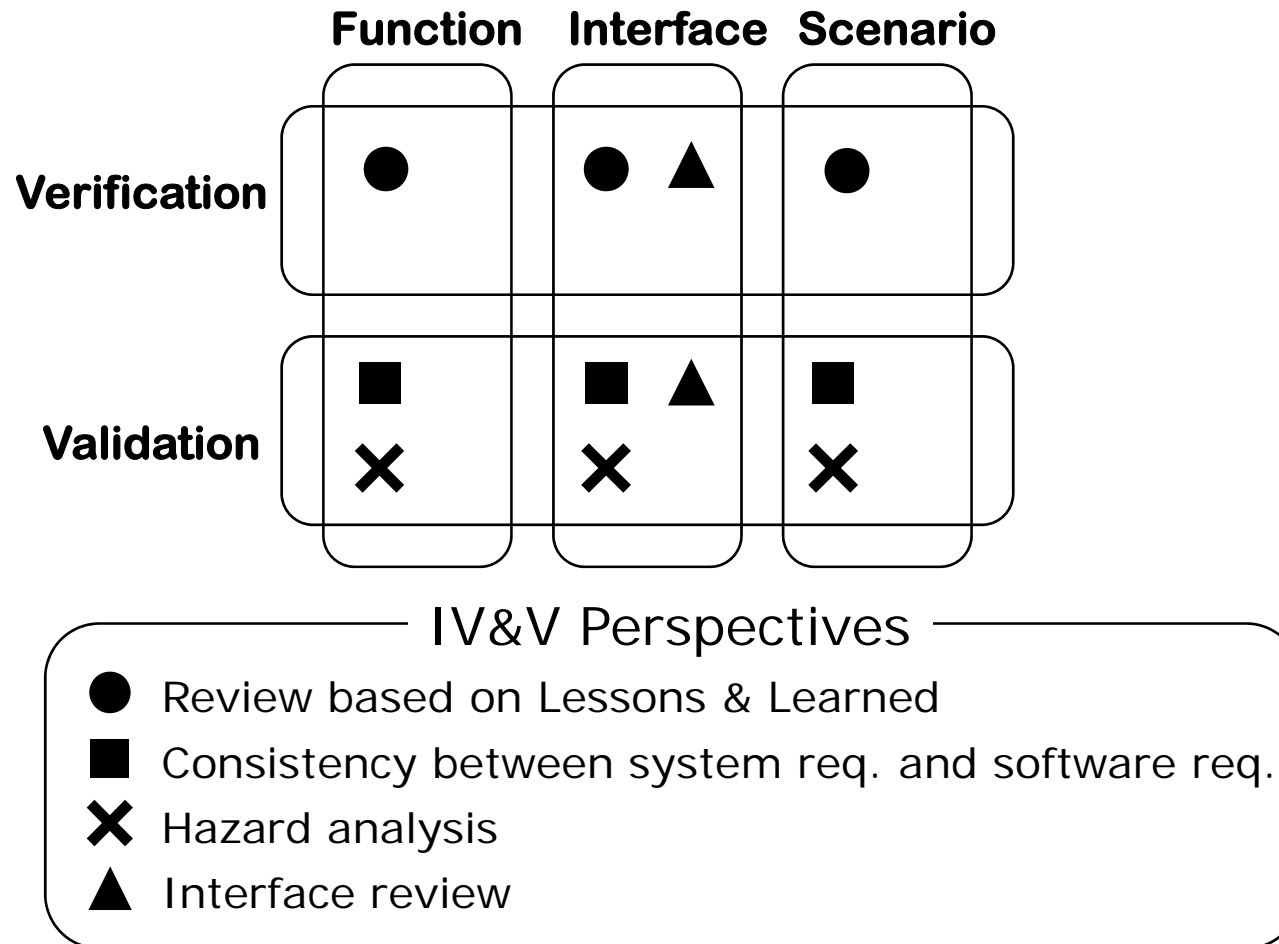


- Simple but easy-to classify
- Evaluate both V&V activities



# Expected Defects

- IV&V perspectives and expected defects



# Case Study

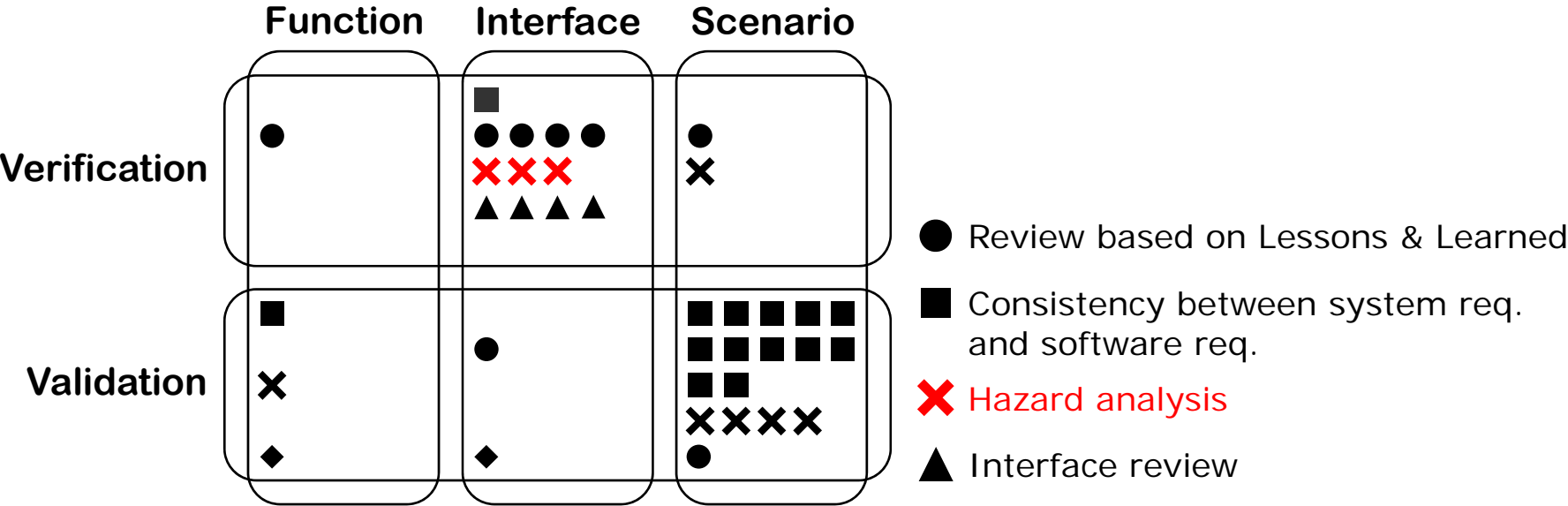
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- **Target Data**
  - 49 defects detected by IV&V activities conducted in a software req. analysis phase of a satellite system
- **We compared expected defects and actually detected defects in each IV&V perspective**

# Result 1

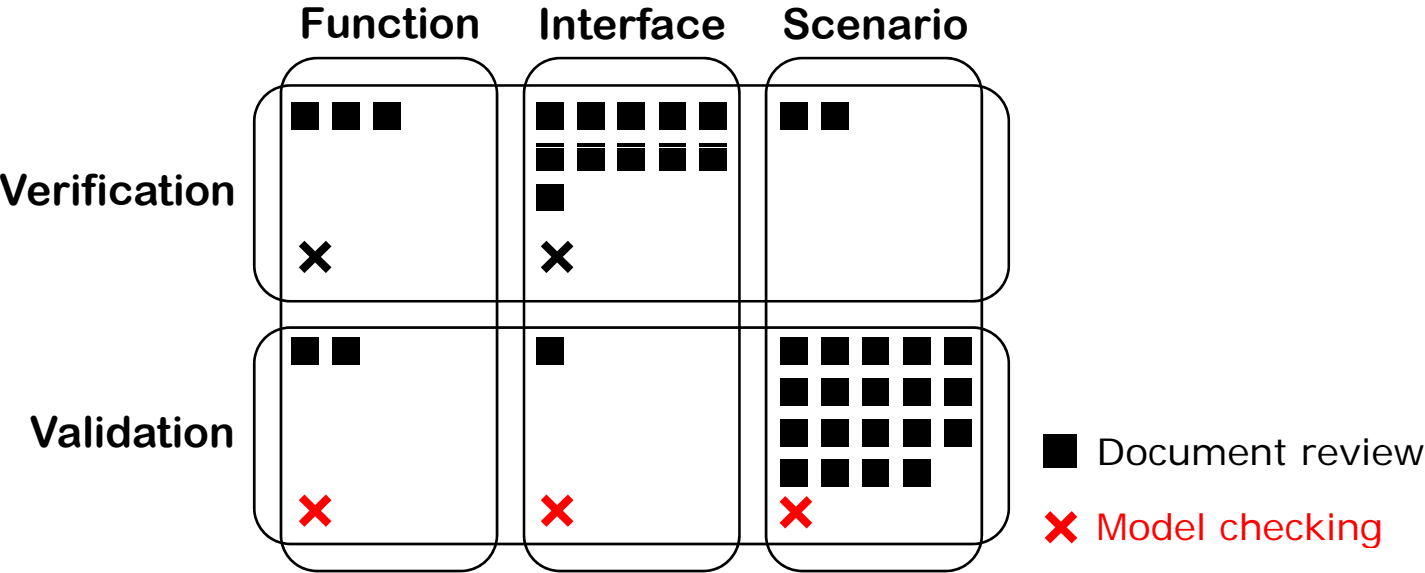
- “Hazard analysis” detected “interface-verification” defects while it is expected to detect validation defects
  - These defects might be overlooked in “interface review”



# Result 2



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



# Summary and Future Work

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- **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