Improving IV&V Methods based on Practical Data Analysis in JAXA's Spacecraft Projects

The 2012 IV&V Annual Workshop @WVU Erickson Alumni Center

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- Background
  - IV&V Lifecycle
  - IV&V Practical Data Analysis
- Analysis of IV&V Findings
- Analysis of Software Bugs
- Future Work
1. Background (1/3)

- IV&V Lifecycle

IV&V Optimization Framework based on Practical Data (Ideal)

1. IV&V Planning
2. Perform IV&V
3. IV&V Result Analysis
4. IV&V Improvement

IV&V Decision Making Criteria

IV&V Manual

IV&V Database

Improvement Based on Practical Data Analysis

- Software Bugs
- Nonconformance on orbit

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1. Background (2/3)

- Areas of IV&V Practical Data Analysis

System/Subsystem Level

- Factor Analysis of On-orbit Nonconformances
- Analysis of IV&V Findings
- Measurement of IV&V Effectiveness

Software Level

- Factor Analysis of IV&V-overlooked Bugs
- Analysis of Software Bugs In Software Test

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Discussion Point

IV&V Improvement Method based on the analysis and feedback regarding
(1) IV&V Findings
(2) Software Bugs* in Software Test

* Bugs overlooked in IV&V and detected in Software Test
2. Analysis of IV&V Findings (1/5)

- **Purpose**
  - To Analyze the IV&V method in the case of detecting **Effective IV&V findings**
  - To Feedback the Lessons Learned to IV&V methodology (IV&V manual, etc.)

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**Input** → **Analyze** → **Feedback**

- **Software Function**
- **IV&V Attributes**
- **IV&V Method**
- **etc.**

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**Effective IV&V Findings** → **Lessons Learned** → **IV&V Manual**

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2. Analysis of IV&V Findings (2/5)

- Analysis
  - Input
    - IV&V Findings of JAXA’s Past Projects (Satellite / Launch Vehicle / Ground System)
  - Analysis Method
    ① To Analyze Characteristics of IV&V Findings
      - IV&V Plan, Guideline, Method, Pre/Post Process
    ② To Analyze Most Effective IV&V Findings
      - IV&V Procedure, How-to-detect, Characteristics
2. Analysis of IV&V Findings (3/5)

- Result (1)
  - IV&V Work Efficiency of Code Phase is lower than other phases.

[Suggestion]
Work Efficiency of Code Phase should be improved.

![Effective IV&V Findings detected per hour](chart.png)
2. Analysis of IV&V Findings (4/5)

- **Result (2)**
  - IV&V Findings of Safety is few, however they could be most effective at a high rate.

[Suggestion]
It is necessary to increase the application of IV&V from the aspect of safety.

**IV&V Effective Findings**

<table>
<thead>
<tr>
<th>I&amp;V Attributes</th>
<th>Traceability</th>
<th>Completeness</th>
<th>Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>件数</td>
<td>250</td>
<td>200</td>
<td>150</td>
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</tbody>
</table>

**Most Effective Findings**

<table>
<thead>
<tr>
<th>I&amp;V Attributes</th>
<th>Completeness</th>
<th>Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>件数</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

**I&V Attributes**

- Safety
- Completeness
- Traceability

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2. Analysis of IV&V Findings (5/5)

- Conclusion
  - The analysis results not depending on subjective experiences of IV&V engineers were obtained by quantitative analysis.
  - Objective Improvement Suggestion to IV&V based on practical data became available.
3. Analysis of Software Bugs (1/5)

Purpose

- To analyze Causal Factors of Software Bugs* by both Software Developers and IV&V engineers
- To suggest the improvement of IV&V activities based on the analysis

* Bugs overlooked in IV&V and detected in Software Test

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3. Analysis of Software Bugs (2/5)

- **Analysis**
  - **Input**
    - Software Bugs in Software Test regarding JAXA’s Past Satellite Projects (62 items)
  - **Analysis Method**
    - **By Software Developers**
      - To analyze whether IV&V can detect the bugs or not from the aspect of the development background
      - To derive the reason why IV&V can’t detect the bugs
    - **By IV&V Engineers**
      - To analyze whether IV&V can detect the bugs or not from the aspect of the IV&V methodology
      - To derive improvement feedback to IV&V manual

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3. Analysis of Software Bugs (3/5)

- Result of Analysis by Software Developer
  - Analysis of Bugs which are difficult to detect in IV&V

[Example of Analysis Sheet]

<table>
<thead>
<tr>
<th>Context of Software Bugs</th>
<th>IV&amp;V Attribute</th>
<th>Difficulties to detect in IV&amp;V</th>
<th>Improvement Suggestion</th>
</tr>
</thead>
</table>

Detailed Information is shown at the Workshop
3. Analysis of Software Bugs (4/5)

- Result of Analysis by IV&V Engineer
  - Analysis based on IV&V manual

[Example of Analysis Sheet]

<table>
<thead>
<tr>
<th>Context of Software Bugs</th>
<th>IV&amp;V Attribute</th>
<th>Overlooking Factor in IV&amp;V</th>
<th>The Reason why IV&amp;V can’t detect</th>
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Detailed Information is shown at the Workshop

<table>
<thead>
<tr>
<th>Improvement of IV&amp;V Plan</th>
<th>Improvement of IV&amp;V Attribute</th>
<th>Improvement of Evaluation Item</th>
<th>Improvement of IV&amp;V Method</th>
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</table>
3. Analysis of Software Bugs (5/5)

● Conclusion

- Causal Factor of Software Bugs which are not described clearly in the Nonconformance Report can be derived by getting complementary information from Software Developer.

- The areas which are difficult to apply IV&V even if it is technically possible to detect bugs were identified.

[Improvement Suggestion]
Scope of IV&V should be discussed and agreed with Project Team in IV&V planning.
4. Future Work

- **Analysis of IV&V Findings**
  - More Detailed Analysis including effects between multiple attributes

- **Analysis of Software Bugs**
  - Constructing the Framework in IV&V Lifecycle that IV&V Activities are continuously improved based on the Analysis of Software Bugs
END