

**International Workshop
on Strategic and Economic Methods for
Assessment of IV&V Activities**

-Monograph-

In conjunction with HICSS-38

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**International Workshop on Strategic and Economic Methods for
Assessment of IV&V Activities
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1. Outline of Workshop

International Workshop on Strategic and Economic Methods for Assessment of IV&V Activities was held on 3rd January, 2005 in HAWAII sponsored by NASA (National Aeronautics Space Administration) and cosponsored by JAXA (Japanese Aeronautics Exploration Agency), JAMSS (Japan Manned Space Systems Corporation), and University of Hawaii (UH) in conjunction with HICSS-38.

Mr. Nelson Keeler, Director of NASA IV&V facility and Mr. Kazumi Okuda, Director of JAXA ITC Center made Opening Remarks, and they pointed out important of workshop and our future collaboration.

Intent of Workshop

The intent of the workshop is to get key “players” in the IV&V world together, to identify key issues and areas of concerns and/or focuses, and to identify opportunities to work together. At the same time, the discussion of the workshop and the outcome of the workshop is expected to be reviewed by more practitioners and public.

Background of Workshop

The background of the workshop is that NASA, JAXA, JAMSS, and UH have discussed sharing information on IV&V approaches, methodologies, and lessons learned. Specific discussions were the result of continuous self analysis on how we can do IV&V “better”?, what this means?, and what we need to do for this occur?.

The Attendees are:

Invited members

| | | |
|-----------------|-----------|--------------------------|
| Ned Keeler | NASA IV&V | nelson.h.keeler@nasa.gov |
| Kazumi Okuda | JAXA ITC | okuda.kazumi@jaxa.jp |
| Kjeld Hjortnaes | ESA | kjeld.hjortnaes@esa.int |

| | | |
|-------------|-----------------------------------|----------------------|
| Tim Menzies | Portland State University | tim@menzies.us |
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| Rick Kazman | University of Hawaii | kazman@hawaii.edu |

Observers (on-Site Registered)

| | | |
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| Ed McComas | Boeing | edward.w.mccomas@boeing.com |
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Organizers

| | | |
|-----------------|----------------------|----------------------------|
| Christina Moats | NASA IV&V | Christina.d.moats@nasa.gov |
| Daniel Port | University of Hawaii | dport@hawaii.edu |
| Masa Katahira | JAXA IV&V | Katahira@computer.org |
| Haruka Nakao | JAMSS | haruka@jamss.co.jp |

2. Position Papers and Presentations

As the result of reviews, the following 8 position papers attached in Appendix I were accepted. Their authors were invited for their presentations, and made their presentations in the following order.

Table -1 Accepted and Presented Position Paper Title

| | Title of position paper | Author(s) | Affiliation |
|-----|---|--|---------------------------------|
| 1-1 | ISV&V process and practice - Position paper European Space Agency | Kjeld Hjortnaes | ESA |
| 1-2 | Strategy to enhance IV&V activity in JAXA | Masa Katahira Kazumi Okuda | JAXA |
| 1-3 | Return on Investment as a Measure of the Value of Independent Verification and Validation | James B. Dabney | UHCL/Titan |
| 1-4 | A Bi-fractal Lognormal Model for Estimating Independent Verification and Validation Effort Requirement for Software Development | Robert W. L. Thomas | EG&G Inc./ PRC Inc./ NASA |
| 2-1 | IV&V is not V&V so how does that change things? | Tim Menzies | Portland State University |
| 2-2 | Success criteria and key points for successive IV&V outcome | Haruka Nakao Hitoshi Mamiya | JAMSS |
| 2-3 | The Need for Strategic Assessment of IV&V Activities | Rick Kazman Daniel Port | Univ. of Hawaii |
| 2-4 | IV&V Challenges for COTS-based Safety Critical Systems | Daniel Port Haruka Nakao Masa Katahira | Univ. of Hawaii |

3. Summary of Discussion

After the presentations were given, the attendees collectively brainstormed topics of particular interest and importance to discuss.

These were as follows:

- (1) What are the IV&V cost drivers?
- (2) What IV&V data should we be collecting and sharing (and the restrictions thereon); what are the standards for IV&V data
- (3) Can IV&V planning be integrated with developer SQA without affecting independence?; collaboration between IV&V and development teams
- (4) IV&V standards/guidelines
- (5) Who is the customer for IV&V?
- (6) When to do IV&V? when to stop? success criteria? how do we show that IV&V is effective?
- (7) Areas of cooperation/synergy among international members

- (8) Certifying (software intensive) systems and the role of IV&V
- (9) How important is uncertainty in IV&V, in particular with regards to benefit estimation
- (10) Is there anything special about IV&V for (manned) space missions
- (11) Does anyone use the Lewis textbook?
- (12) Do blind spots (i.e. missing things due to inability to focus on areas outside of particular development) matter?
- (13) Fixed versus variable cost IV&V
- (14) What is the validity of cost models in terms of their duration?
- (15) Success criteria

After the above list was generated, a discussion period ensued. Not all of the above topics were elaborated during the discussion period. Often discussion of one topic would include discussion of several others. Below is a summary of the major discussion points that were elaborated (note that the discussion categories are more general than those listed above):

Cost estimation

How to estimate cost and benefits of IV&V is a topic of considerable interest. There is a considerable difference between predictive ROI and realized ROI. Both depend on reasonable cost estimation models. However, an acceptable and practical definition and measure for IV&V ROI remains elusive (several researchers are pursuing this though). It is difficult to measure the tangible benefits of IV&V. How different it is from cost-effectiveness?

Another lively discussion was on what might be the cost drivers for an IV&V cost estimation model. Some of the candidates include:

- Language of implementation
- Personnel capabilities and experience
- Criticality of system failure
- Call-graph/branching complexity
- State/availability of documentation
- Quality of requirements
- Development environment
- Level of code reuse
- Performance (and, in general, QA) requirements
- Process maturity; Existence of an internal QA group; peer reviews; inspections

- Number of partners (software development; integration; hardware; etc.)
- Use of NDAs and access to proprietary data

The question of how analogous these are to COCOMO cost drivers was discussed. No conclusion was reached, however many similarities were noted (Bob Thomas is considering a COCOMO like IV&V cost model). Naturally the question of how to “size” an IV&V effort arose. The consensus was clear that SLOC is likely a poor size indicator, rather, is a cost factor. What about function points? Perhaps better, in particular because they include complexity adjustment factors. However, it is unclear exactly what functions points to count (e.g. COTS and reused code?). Another possibility is requirement size.

Several attendees advocated the need for a cost “rule of thumb” such as “IV&V should cost 10% of the software development cost” (Lewis?). This was controversial with several attendees arguing for and against such a heuristic (e.g. does it make sense to have a fixed percentage for all systems?).

Lastly, the entire idea of the practical use of cost modeling was questioned. Specifically it was stated that cost is of practical importance since we cannot have an arbitrary IV&V budget (especially with limited personal resources). As such, cost estimation is not as important as identifying critical areas and finding the most effective means of addressing them with the resources at hand.

Assessment methodology

The issue of assessment methodology was seen as an area in need of evaluation, sharing of information and research. There are many open questions such as “How early should IV&V (or can IV&V) be done?” (e.g. currently IV&V is primarily used as “insurance” rather than integrated as part of development process), “Can IV&V planning be integrated with developer SQA without affecting independence?” and “Can IV&V and development teams collaborate to produce better, cheaper, faster results and still attain high-assurance?”

In terms of current assessment practice, the three major IV&V organizations (NASA, JAXA, ESA) would like to be more aware of what the others are doing. There is a need to share current practices (as above) and learn from each others failures and successes. This brought up several related issues such as, how can we determine the effectiveness of methodologies? What is an effective (or wasteful) use of tools? How can continual improvement of practice be institutionalized? Should

IV&V be part of training and certification? How can we deal with the “blind spot” issue? How to choose what to assess and how much to assess to make optimal use of resources? How to identify critical areas?

Sharing of data

Further progress on IV&V research and improvement of practice is dependent on acquiring and analyzing good data. However, what data is needed? We should collect whatever we can, and have a budget for sanitization

- Minimum: Project artifacts + quality statement of the artifacts
- E.g. code + defect levels; requirements + defects
- To get ROI estimates we also need: Effort; Cost; Benefit
- What should the data be used for?
 - Estimating budgets for an IV&V program (better than saying “give me 10%”)
 - Estimating schedules from effort estimates
 - These numbers are only useful if there is a standard process, standard set of terms and definitions (a data dictionary)

Perhaps there is no “standard” set of data to be collected...

How to deal with proprietary issues (effort to sanitize data often not practical). What about export license problems? One suggestion was to just make available what data is already available and work from there (e.g. do not generate new data just for research, have results on existing data drive need for future data collections [delivering useable results now to encourage more data collection in the future]). What public data is already available (e.g. COCOMO I)? NASA’s IV&V facility has created a metrics DB; sanitized data from 5 projects; projects have been given the data and told that they can use it but they aren’t doing it. Creating a research database that could be shared among agencies would be useful, but perhaps impractical. Incentives to collect data? It was noted that the projects that collect the best data also have the best IV&V ROI. Is this enough to get organizations to collect more data?

How much is enough IV&V (making best use of resources)

This was seen as a very important and necessary topic. Some of the major questions in this area are:

- When to start doing IV&V?
- When to stop?
- What are the “success criteria” for completion?

- How do we show that IV&V is effective?
- If you find no problems, are there no problems or is your IV&V process faulty?

Not too much is known in this area just now. Some concepts discussed were:

- Simple effectiveness metric: number of different kinds of IV&V products/percentage of project budget spent on IV&V
- Look for a project to be within a nominal range
- Prioritize the assessment activities

However, this brought up the points that to optimize IV&V effort, you must first have trust in methodology, confidence in the results, and have a meaningful definition of “enough” IV&V. The overall goal seems to be, given constraints on resources (which there always are), how to achieve high assurance?

COTS and reuse

The topic of COTS and IV&V was raised. Despite concurrence that COTS indeed complicated IV&V efforts, it was said that reuse perhaps even a more relevant (although similar in trouble to COTS) due to the prevalent practice of uncontrolled code reuse in space systems. While it is clear that IV&V could be involved in the COTS assessment and selection (if possible), with code reuse this is not practical at present. Developers reuse code assuming that it was already assured. IV&V often does not have the tools and skills needed to properly assess reused code. Furthermore, often times insufficient time and budget are allocated to perform IV&V on reused code under the risky assumption that it has previously been assessed and thus requires less IV&V.

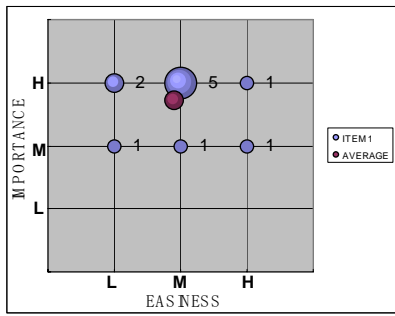
Common language

After a great deal of stimulating discussion on the above issues, it was stated that progress could be enhanced if a dictionary of terms, set of standards, and common work breakdown structure were created and used among IV&V practitioners.

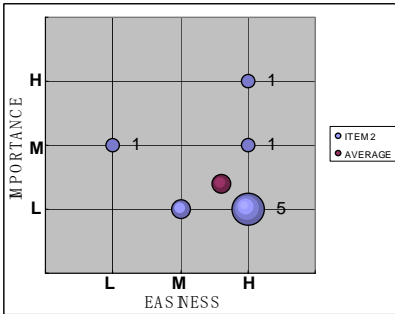
4. Ranking of Concerns

The discussions raised many interesting and important issues. In an attempt to provide leadership and focus, the issues were prioritized. The attendees each rated the issues terms of importance and easiness to pursue (on a scale of high, medium, and low for each of these attributes).

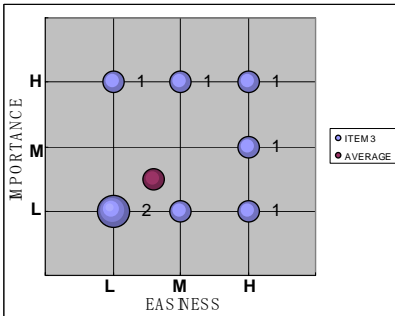
In order to select highest prioritized items from the listed concerns, the voting was done by all attendees. Each vote consisted of an evaluation (High, Medium, Low) for Importance and Easiness. A “High” rating for Easiness indicates that the issue is easy to pursue (data and or relationships exist) while a “Low” rating indicates a significant challenge. The item by item results of voting are drawn in Figure 4. All figures are indicated with Importance(H,M,L)/Easiness(H,M,L).



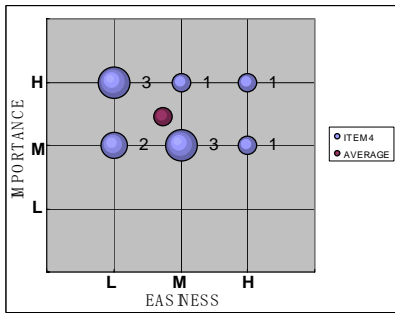
(1) What is IV&V cost drivers



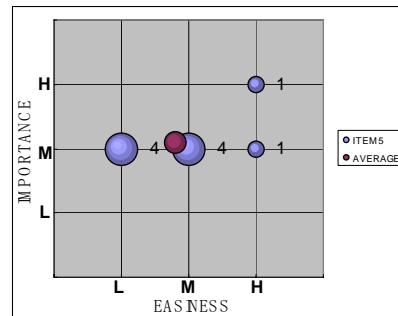
(2) Is IV&V for manned space missions special?



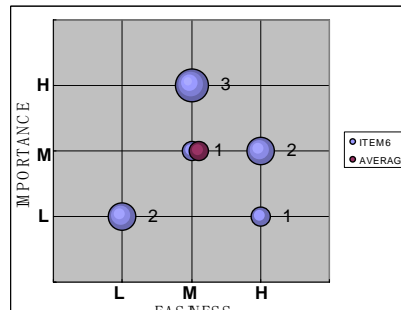
(3) Does Lewis 10% rule hold



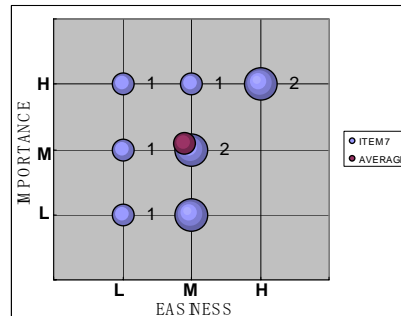
(4) Do blind spots matter?



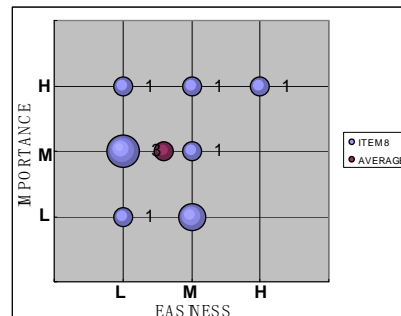
(5) What Data correcting and share



(6) Can IV&V planning be integrated with development SQA losing independence?

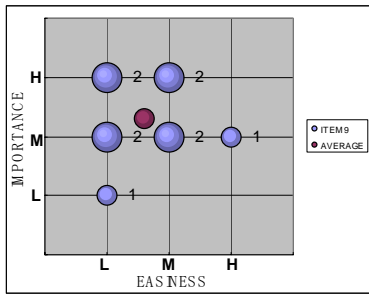


(7) Fixed vs. variable cost

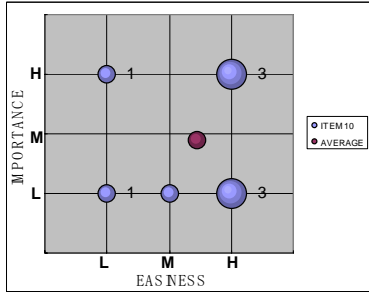


(8) How important is uncertainty on IV&V benefit

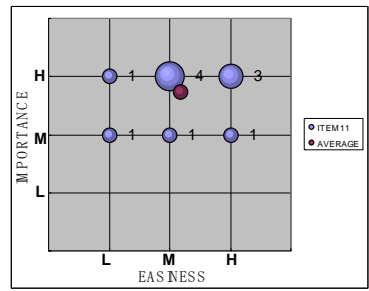
Figure -1 Priority for each issue (1/2)



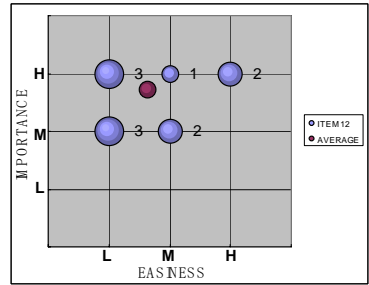
(9) Validity of cost models



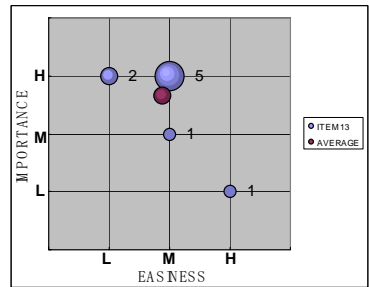
(10) Customers for IV&V



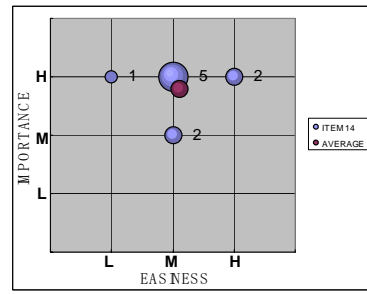
(11) When to do IV&V, when to stop



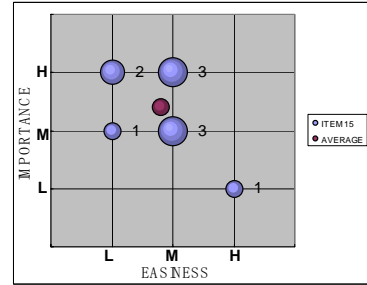
(12) Effectiveness of IV&V



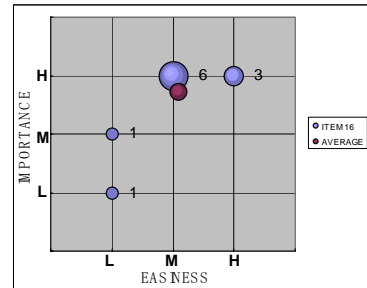
(13) COTS/ Reuse



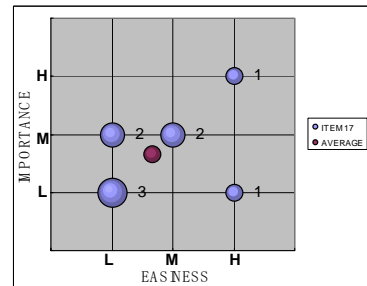
(14) Area of cooperation



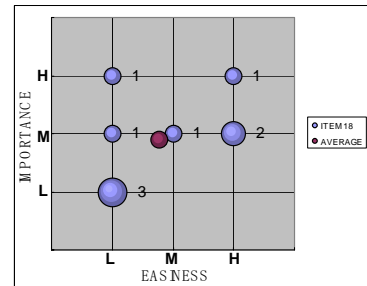
(15) IV&V standard/ guideline



(16) Success criteria / How to identify critical area



(17) Certification? (IV&V one element of certification process)



(18) Standards for data collection

Figure -2 Priority for each issue (2/2)

As a result of voting, 5 highest issues in order of importance and easiness are selected as follows:

(16) Success criteria / How to identify critical area

(14) Area of cooperation

(11) When to do IV&V, when to stop

(1) What is IV&V cost drivers

(13) COTS/ Reuse

5. Outcome of discussion

Concerning above issues, opportunities for cooperation were discussed and concluded as follows.

As for (16) and (11),

- The community shall compare each agency's assessment methodologies.
- Each agency shall identify working groups to compare.
 - (NASA will identify by the end of Jan. 31 2005.)
- Working group shall be established for ESA, NASA, and JAXA.
- Working group will catalog each approach.
- Working group will generate working paper (heading towards research proposal).
- Case studies are requested to contribute to Tim and Dan.

As for (14),

- Continuous investigation will need for dealing with export control and proprietary data issues.
 - o It is not easily addressed by this group
- Joint IV&V project under research area will be considered

As for (1),

- ESA and JAXA will consider whether they could provide the COCOMO data or not for further research based on Tim Menzie's information regarding which parameters are useful and necessary to his work

As for (13),

- COTS IV&V workshop at ICCBSS 2005 in Spain will be held.

- Especially reuse is indicated as an important common issue among all attendees.

6. Commitment

After the Workshop concluded, the Directors from ESA (Mr. Kjeld Hjortnaes), JAXA (Mr. Kazumi Okuda), and NASA (Mr. Nelson Keeler) met to further discuss the resulting workshop priorities.

Commitment of Directors:

The meeting resulted in the following agreements:

- (1) Each organization will each appoint a representative to coordinate group interface activities.
- (2) The selected representatives will create an agenda for and participate in regular IV&V Technical Interchange Meetings (TIMs). These TIMs will be coordinated in conjunction with JAXA's Workshop on Critical Software (WOCS), NASA's Software Assurance Symposium (SAS), and ESA's Software Workshop, which are established annual events. After the January 2005 WOCS, JAXA will try to hold it in the November in the future; SAS is scheduled for late June or early July; and ESA's workshop will be scheduled sometime in the Autumn.

The Directors will support their own meeting and will jointly attend one meeting annually on a rotating basis. HICSS-38 will count for NASA hosting the 2005 Directors Meeting, so next yearly meeting will be combined with either the JAXA or ESA workshop.

The intent is to have one TIM and one Directors meeting per year.

- (3) The next TIM will be planned in conjunction with the ESA Software Workshop in the autumn.
- (4) Through the TIMs, the group will jointly work on (a) IV&V Guidelines, (b) IV&V Dictionary, (c) assessment methodologies.
- (5) The use of video conferences will be explored to reduce travel demands.
- (6) Work will begin to establish an Exchange Program where mid-level government engineers will work on-site for 3 months. The focus of these on-site activities will be research and joint TIM

objectives. Each organization will review existing agreements to determine if they are sufficient to support this exchange program. If current agreements are not appropriate, new agreements will be pursued through each respective international affairs organization. It is expected that one exchange will occur per year with each organization and that the home organization will fund all of their representative's activities.

7. Next Step

We continue research collaboration together for practical and verifiably effective methods for the optimization of IV&V assessment activities. The first challenges we are going to do is developing taxonomy of attribute and techniques for each system domain and finding estimation rules. We have one case study applying strategic assessment to IV&V practice. It is important to apply it to other projects for getting more precise data.

The next step is testing the assessment methodology based on defined taxonomies and rules in real project. We estimate risk reduction and cost benefit before IV&V started and get their result after IV&V finished. We will be able to achieve more precise assessment approach by repeating feedback cycles of applying some projects. It is also important to compare our strategic assessment methodology with other assessment methodologies for effective IV&V practice.

“How much is enough IV&V” should be researched. We have to find out detail cost-benefit stopping point according for operational risk (e.g. Risk of catastrophe profile, Risk of Ruin profile).

We will hold next international workshop of strategic and economic methods for assessment of IV&V practice together. The result of strategic IV&V assessment will be contained. We also find the capability to improve our assessment at the next conference and meeting.



Appendix I

Contents:

- Position Paper
- Presentation sheet

| | Title of position paper | Author(s) | Affiliation |
|-----|---|--|---------------------------------|
| 1-1 | ISV&V process and practice - Position paper European Space Agency | Kjeld Hjordnaes | ESA |
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