

Verification and Validation People Can Be More Than Technical Advisors

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A verification and validation (V&V) organization (whether independent of developers or not) is normally described in technical terms, e.g., how V&V can verify that a developer's processes are technically sound. Some companies and government agencies (federal and state) are recognizing the benefits V&V can extend to non-technical areas such as project management, resource management, finance, and scheduling.

Several books [1, 2, 3], articles [4, 5, 6], and standards [7, 8, 9] address verification and validation (V&V). To some, the V&V descriptions are too narrow and restrictive of the V&V abilities. As shown by the above, publications usually relate to technical areas of V&V and rarely address non-technical V&V, e.g., evaluation of project resources and schedules.

However, a customer (i.e., who V&V reports to, not a product customer/client) could expand V&V's normal scope of work. For example, V&V could assist a customer in identifying non-technical risks such as, "Are a developer's change request schedule and cost estimates reasonable?"

In some cases an organization may not have a fully qualified Project Management Office (PMO) – a group of people dedicated to help a project manager oversee a project by handling the project's schedule, budget, deliveries, etc. In this situation, V&V can be used to coach the PMO or provide limited direct support. For some projects, this arrangement can work as long as everyone understands that V&V can only make recommendations and not provide direct or contractual direction. This point must be remembered while reading the rest of this article.

Several times a reader may say, "This is not V&V work." That is yesterday's mode of thinking. If V&V can become involved with contractual work, requirements identification, etc., even prior to contact award, the benefits could pay the V&V cost by preventing problems, reducing risks, and having an improved contract, statement of work, etc. This does not mean V&V can identify all the requirements, etc.: It can help, as a normal V&V function, an organization ensure the requirements are testable, real, etc. As needed, a project manager may assign some of the V&V efforts mentioned in this article to other organizations for efficiency or to minimize duplication of effort.

The rest of this article provides a quick overview of V&V and its relationship with other groups, and then addresses how V&V can help in non-technical

project areas. The following additional notes pertain to this article:

Note 1: For this article, unless needed for clarity, V&V is used as a convenience, even if a reader prefers use of the term Independent V&V (IV&V). In addition, software V&V is assumed even though many of the points apply to non-software V&V. In either case, this article assumes V&V is a group of people rather than a pure process. Except for Note 2, how V&V fits within an organization is ignored.

"In a well run, quality-oriented organization, V&V is not a separate group but an integral part of an organization's operation."

Note 2: In a well run, quality-oriented organization, V&V is not a separate group but an integral part of an organization's operation. Where this does not exist, because the risks are very high or there is a requirement for an independent group (e.g., safety within nuclear power plants), a unique group can be formed or contracted to perform what is known as IV&V. Reference [6] provides more detailed explanation on the technical differences between V&V and IV&V, e.g., amount of financial and managerial independence.

Note 3: The following applies to this article:

- Verification is the process of ensuring the outcome of each life-cycle phase/activity satisfies the requirements of that phase/activity and can support the next phase/activity.

- Validation is the process of ensuring a set of requirements is satisfied, i.e., the product satisfies the requirements.

V&V Overview

As indicated in [7, 9], V&V is totally independent if it has no financial, technical, or management link to a developer. As illustrated in Figure 1, V&V can be viewed as a systems engineering process employing a rigorous methodology for evaluating the correctness and quality of a product throughout a life cycle [10]. Some groups believe V&V should be restricted to testing, to duplicating a developer's efforts using a different approach or set of tools, or to only verifying/validating a developer's technical approach to produce a useful product for a client. Some groups believe V&V should concentrate on high-risk areas by performing one or more of the following:

- Defining risk levels in project-specific terms associated with cost, schedule, and performance.
- Identifying initial project risks.
- Analyzing project risks for impact and likelihood of becoming a problem.
- Identifying possible mitigating actions.
- Prioritizing risks based on return on effort.
- Implementing selected mitigation actions.
- Evaluating risk mitigation progress.
- Continually reassessing risks and actions.

Since formal V&V can be very costly, V&V is usually only involved with risky, costly, or very complex efforts. Much of the V&V cost is related to the experience level a client is paying for, especially if the development effort is very specialized, e.g., nuclear power or advanced space/aerospace technology. When not properly structured with other project groups, V&V can be costly due to duplication of effort, i.e., roles and responsibilities between groups are not well defined.

V&V and Quality Assurance

Many people believe V&V is not needed if

a project has a quality assurance (QA) group. QA and V&V play distinguishable and important roles in systems. Even if QA is independent of a developer, V&V and QA do not normally perform the same functions. As with V&V, QA works best when it is oriented toward preventing problems rather than finding problems.

While QA and V&V are concerned with quality, their perspectives are different. V&V usually focuses on ensuring the requirements are being met, the overall project is focused on the correct objectives, and risk is being managed by the PMO. QA on the other hand, is focused on the day-to-day aspects of a project and is used to determine if procedures are followed. For a project consisting of QA and V&V, QA may witness testing while V&V may measure the adequacy of a test and its associated processes, e.g., test procedures. As a result, QA and V&V can work together to ensure a system is built to meet its requirements, to meet the development standards, and to ensure that risks are minimized. [10]

QA consists of development experts to ensure standards and processes are followed, and to ensure other groups identify and resolve problems. As stated by Roger Fujii, "Following process does not necessarily ensure that the product correctly solves the user's problem" [11]. Normally, QA is involved in:

- Evaluations of processes.
- Audits of events to measure compliance with processes.
- Product quality – product satisfies the quality requirements.

If there is no V&V, QA activities may include:

- Testing.
- Test witnessing to ensure that test procedures are followed.
- Predicting system reliability.

Because V&V can capitalize on the existence of QA, V&V is normally involved in:

- Risk identification, i.e., part of the project risk management effort.
- Assessments, forecasts, and trend analysis to support management decision-making.
- Requirements analysis assessments.
- Traceability of requirements to design and testing, and traceability of design to code.
- Traceability of given/business requirements to derived requirements.
- Evaluation of technical issues.
- Technical evaluations of technical plans, approaches, or methodologies.
- Testing.
- Evaluation of how well a product satisfies the requirements.

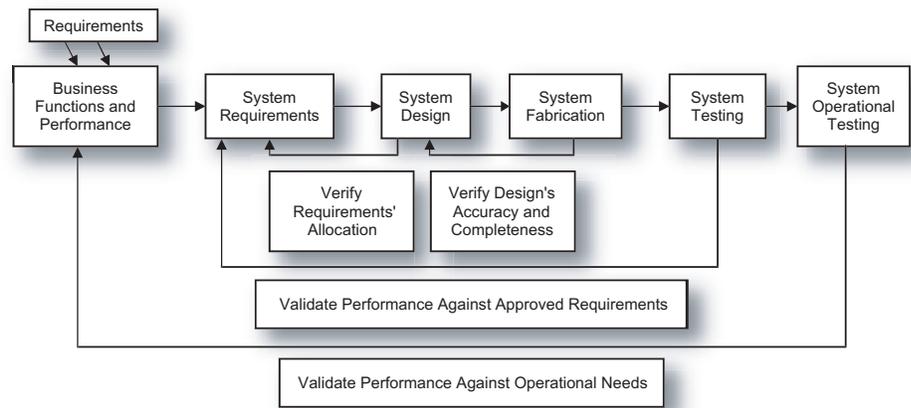


Figure 1: Summary of V&V's Role in Development

Some development organizations have a testing group, i.e., not part of development or QA. Other organizations use V&V as an independent testing group (in fact, testing may be the sole function of V&V). Some organizations use V&V to review a test group's test plans and test cases, or to develop test plans independently.

If an organization does not have its own QA, and it does not have confidence with a developer's QA, then it can combine product V&V with process V&V to address any certification needs. For instance, they can assess whether the processes, requirements, design, and tests satisfy the software, hardware, or system security needs.

V&V Non-Technical Activities

In addition to the technical activities, organizations can use V&V for non-technical areas to help manage a project. This includes the following:

- Evaluating a developer's project schedule and management plans.
- Evaluating a developer's product to determine if the contractual requirements are satisfied and then perhaps recommend if payment should be made.
- For an independent client organization, evaluating how well a client is performing on a project.
- In terms of determining a project's budget, schedule, and constraints, helping an organization to do the following:
 - Modify an existing system or build a new system.
 - Use state-of-the-art or state-of-the-practice technology.
 - Use an evolutionary or an incremental development model [10].
- Helping prepare proposal evaluation criteria.
- Evaluating proposals and making recommendations.

- Evaluating developer's or client's processes for impact on product development.
- Performing periodic evaluation of client's or developer's resources to help determine if changes are needed.
- Advising a client on the impact of proposed developer's or client's changes to its management, policies, requirements, or procedures.
- Assessing how well risks, problems, issues, action items, change requests, etc., are being identified and addressed.
- Improving client's acceptance of a product.

The following items are not thought of as being part of V&V. Thinking *outside of the box*, however, V&V experience can be used to prevent problems by having V&V help an organization with the following:

- Prepare a Request for Proposal (RFP).
- Prepare a client's development contract.
- Develop a client's organizational structure and select project personnel.

The above are examples of an organization using V&V to supplement its staff. In some situations, an organization may not have enough, or the right, people available to ensure an effective and efficient project. To prevent any adverse affect on the freedom, independence, and investigative curiosity of V&V, it must not become totally integrated into a client's organization. A *close working relationship* is the best way to describe the necessary interaction, e.g., daily contact, near-total exchange of technical information, and frequent informal meetings or briefings. According to Robert O. Lewis:

One of the keys to a successful ... verification and validation ... program is how the [V&V] personnel interface with development personnel [1].

Since V&V may report directly to a client (usually via contract), this statement is also true of V&V's working relationship with other organizations.

Without written PMO permission, V&V may need to document and route its results, requests for data and documents, etc., to its customer and refrain from direct interaction or interface with other organizations. This is especially true if the developer and V&V are contractors. If the contracts permit and the inter-organizational relationships are good, direct interactions are preferred.

There have been attempts with V&V to use informal methods to advance a project. For instance, have developers verbally address V&V questions/concerns to ensure the V&V team understands a situation, or to have a minor concern resolved without making a documented, *federal* case out of a situation.

Sometimes this works, but eventually a developer or client's manager is concerned that this approach is bypassing his or her authority. Another reason to avoid an informal approach is that V&V may be a participant in a court case between a developer and a client. In this situation V&V needs documented evidence of what they identified as good points, problems, etc., and what V&V did to communicate and help resolve the situation. At the same time, V&V may have to show it did not provide any direction that violated a contract, or significantly interfered with the developers.

As an example of the above discussion about authority, V&V could participate in the evaluation (for technical feasibility, and reasonable number of hours and cost) of a developer's change requests based on contractual staffing rates, other documentation, and discussions with the developer. The proper authority could then take V&V's comments and recommendations, along with comments and recommendations from others, under advisement when making the final decision to accept or reject a change request.

There are situations where developers and clients try to restrict V&V's effectiveness by creating barriers, e.g., preventing timely access to people or data. As with QA, this can be overcome if there are clear sets of processes, roles, and responsibilities.

Based on [12], the following sections are examples of how V&V (e.g., without hiring another contractor) can assist project managers by providing independent assessments, recommendations, or comments.

Planning Processes

- Identifying contractual criteria to measure progress.
- Defining performance measurements.
- Identifying, assigning, and documenting specific activities needed to produce a product.
- Verifying the accuracy, consistency, or completeness of a published schedule.
- Identifying and documenting interactivity dependencies.
- Determining what physical resources (people, equipment, material) and what quantities of each should be used to perform project activities.

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- Independently developing an approximation of the cost and time needed to complete project activities, e.g., change requests.
- Determining a project's communications and information needs.
- Identifying initial project risks.
- Preparing documents to support solicitation.

Executing Processes

- As needed, providing *out-of-the-box* thinking and evaluations to help determine project progress, effectiveness, and reporting.
- Responding to information requests and providing information in a timely manner.
- Helping ensure a developer's performance meets contractual requirements.

Controlling Processes

- Providing evaluation of a project's overall change (e.g., changes in scope, schedule, cost, performance, or quality) control process.
- Identifying risks and evaluating a project's risk management process.
- Collecting and disseminating performance information, forecasts, and status or progress reporting.
- Evaluating if change requests are within scope.
- Helping determine if a change will be beneficial.
- Identifying influencing factors that are, or could create, changes in schedule, cost, or performance.

Conclusions

The biggest technical payoff in using V&V can be to have V&V parallel each phase of the development effort. This provides a thorough requirements and design verification aimed at preventing otherwise costly errors, omissions, and inadequacies from ever reaching the coding, testing, or acceptance stages.

Customers also need to understand the capabilities of a good (or better yet, an outstanding) V&V. As with any support group (e.g., QA, configuration management, data library), a properly used V&V can provide resources to help a PMO to make timely, correct decisions.

For complex projects, an effective V&V is composed of people with experience; in-depth technical expertise; and strong communications, management and planning skills.

Key objectives of V&V are to:

- Assure a successful project.
 - Improve management visibility into the project's processes and product usefulness.
 - Avoid system failures of high consequence.
- The following V&V activities complement these V&V objectives: [10]
- Provide a project manager/client with objective analysis of data to support project decision making by the following:
 - Identify project risks as early as possible.
 - Prioritize risks by impact and probability of occurrence.
 - Define mitigation actions and perform cost-benefit analysis.
 - Help a project manager perform trade-offs, e.g., manage limited resources.
 - Evaluate progress on resolution of risks and corrective actions.
 - Provide quick assessment of pro-

- posed changes and consequences.
- As requested, provide PMO-type assistance.

Thus, organizations should look at V&V as more than a group with only technical knowledge. This may mean expanding the next version of [7] to include a new definition of V&V by indicating where V&V can help projects with non-technical issues. Another suggestion is to have [7] provide a section on how V&V and QA are alike and yet different.

No matter how V&V is utilized, the best results can occur when a well-planned V&V effort is conducted throughout a full system development life cycle. ♦

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Additional Reading

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