



**INDEPENDENT VERIFICATION AND
VALIDATION (IV&V) WHITE PAPER**

Prepared by Adnet, Inc. February 2013

Executive Summary

Adnet is pleased to provide this white paper, describing our approach to performing Independent Verification and Validation (IV&V). Our goal is to partner with our clients to apply industry best practices for developing and deploying systems of the highest quality. We augment existing customer management methods and expertise and develop a program tailored to meet the customer's specific needs. We analyze existing processes, introduce standard methods built on the Software Engineering Institute's Capability Maturity Model Integration (CMMI version 1.3), mentor key stakeholders in the application of the benefits realized by applying standards, and develop and implement an efficient and effective IV&V program that includes the effective use of metrics to track and evaluate the status of the program. The Adnet's staff's plays a number of roles within our customer's overall team, as is appropriate when creating a true partnership, committed to overall program success. At times, we serve as catalyst, moderator, mediator, leader, observer, analyst, thinker, listener, independent doer, writer and educator. In all things, we are team players, working in concert to achieve our customers' goals. Adnet staff also possesses numerous technical and management certifications including Certified Software Testing Engineers, Microsoft Certified Software Engineers, and Certified Project Management Professionals. Adnet has successfully delivered Project Management Support, Quality Assurance and IV&V programs for many clients. These clients have realized the following benefits from our efforts:

Increased productivity and efficiency. Adnet facilitated communication between the management and technical teams to increase the visibility of obstacles encountered. Once obstacles surfaced, management cooperated in removing them, with the result that the technical teams learned they could trust management to help them reach their goals.

Precise project tracking and performance based on targeted metrics. Our Metrics program matured to the point of accurately identifying risk areas and the number of test failures per release cycle. This resulted in accurate scheduling of test and rework time, and consistent on-time delivery of releases.

Effective and reliable migration to an established open architecture. Application and use of industry-standard languages, databases, and development/maintenance tools provided the needed structure for the development cycle, from requirements generation to user acceptance testing—all to ensure a successful migration of the re-engineered systems. We now provide monitoring, quality assurance (QA), and testing of maintenance fixes, data changes and new function changes.

In the following pages, we describe the details of our technical approach to developing and delivering Independent Validation and Verification, quality assurance and other program management support services of superior quality.

The Adnet, Inc Systems Engineering Lifecycle Can Easily Be Modified to Fit Specific Needs.

1.0 IV&V Defined

IV&V is an integral part of the overall Lifecycle of any system development program. Adnet has developed a Lifecycle management process, based on industry best practices, that includes all elements needed to comply with major standards, including the Software Engineering Institute's Capability Maturity Model Integration, the International Standards Organization ISO-9000 standards, American National Standards Institute guidelines, MIL-STD-498 and other related MIL Standards. Figure 1-1 presents the elements of this process, and illustrates the difference between validation and verification (V&V) and independent verification within this model, V&V is an integral part of the overall life cycle, performed as part of the process that the development team uses to internally insure that they are on track, that they have fulfilled all of the requirements defined for the application being developed and that the system performs as expected. It is linked to other fundamental internal processes, such as quality assurance and control, configuration management and risk management.

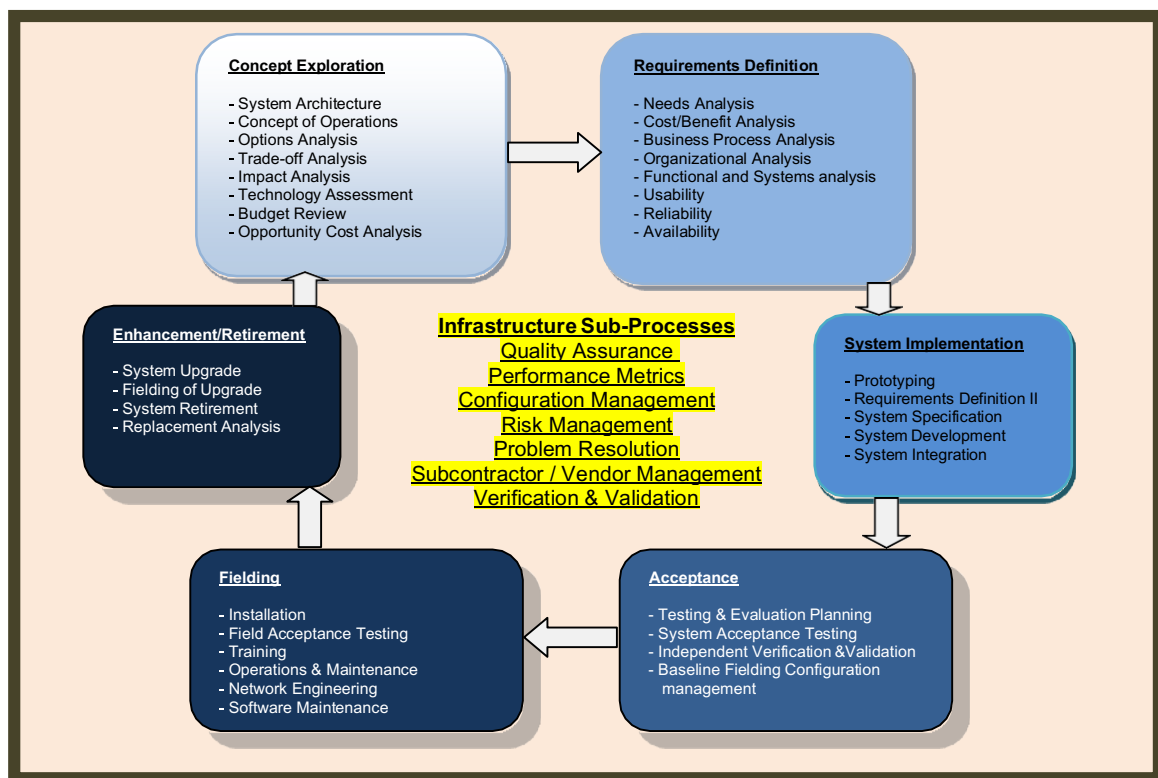


Figure 1-1 Adnet Systems Engineering Lifecycle Can Easily Be Modified to Fit Specific Needs.

IV&V is performed by an independent third party, and includes a review and evaluation of all of the elements within the program Lifecycle, with a focus on testing the product to ensure that it fulfills all of the defined requirements and performs as expected.

An IV&V team is a major risk-mitigation activity that the customer may use to ensure that the

development team (whether internal or another contractor) has indeed provided services as expected and the product that works as required.

2.0 Standards and Certifications

The Adnet staffs use a number of standards, selected according to the requirements of the individual program, when developing IV&V, V&V, QA, Metrics, Configuration Management and Risk Management processes. These standards are also at the core of our Adnet quality through Verification and Validation (QV2) methodology. Adnet has developed this methodology specifically to meet the needs of our IV&V customers and to guide our actions when developing comprehensive quality assurance programs in accordance with SEI CMMI Level 3 guidelines. Standards used include, but are not limited to:

- SEI CMMI Development
- MIL-STD-498 (Software Development)
- CMMI for Services
- MIL-STD-973 and MIL-STD-2549 Configuration Management
- MIL-STD-881 Program Management (Contract Work Breakdown Structure)
- ITIL version 3,
- ISO-9000-2008
- ANSI-9000 Quality Assurance
- J-STD-16 (Software Development)
- IEEE and EIA Configuration Management
- SEI Risk Taxonomy (Risk Management and Mitigation)
- ISO 20000 SMS

In addition, Adnet's testing staff holds discipline-related certifications in Microsoft, Novel Networks, ORACLE development and a wide range of other disciplines and specific development environments.

3.0 Quality Assurance

There is a fundamental difference between quality control and quality assurance. Quality control is always product oriented — “does the *product* perform as expected?” It attempts to find and eliminate defects before reaching users. Quality assurance is process oriented — “does the *process* support the mission and goals of the organization to prevent defects?” Traditionally, IV&V testing and quality control have been events that occurred as part of the release process for a new product or modular update to an existing application. The focus of quality control and IV&V testing is on the results of the process (the work product) and is at the core of *Product Assurance*. The role of testing and quality control has been to identify and correct defects in the program at the modular and/or integration level(s) so that the product reaches an acceptable level of reliability. V&V is a part of the overall quality assurance process. The focus is always on effective *Process Assurance*. It assumes that if you control a process, the outcome of that process – the product – becomes predictable. We therefore perform V&V and quality assurance as mechanisms to gain insight into the processes, refine our control over the processes, and improve the predictability and reliability of the results of those processes. Over time, the processes stabilize and, through training, the use of consistent documentation, and implementation of established methodologies and techniques becomes consistent, duplicable and repeatable. When this occurs, the process moves from the simple quality assurance in the context of continuous

improvement. Therefore, quality assurance is an integral part of the overall Lifecycle, begins on Day One of any effort and continues until the overall project is completed and retired. Key elements of the Process Assurance approach defined by our QV2 methodology and refined over the past 15 years Include:

Walkthroughs **or Technical Reviews** of the product include its requirements, design and code implementation. Our analysts participate in the reviews/walk-through as scheduled and conducted by the development team. The requirements review ensures that the software requirements are correct, consistent, complete, unambiguous and testable as documented in the requirements specification. The design review ensures technical integrity and validity of the design as documented in the preliminary design and any design updates. Code reviews ensure that the code is free from logic errors and complies with coding standards and conventions as documented in the development plan. The results of the evaluation are documented in an inspection report and include any recommendations for improvement in the design, implementation or testability of the product. Walkthroughs can be conducted by the development team, by individuals from the organization who are not currently working on the project but are familiar with the organization's processes and procedures, or by the customer or third-party reviewers who are conducting a formal inspection on behalf of the customer. Depending upon the circumstances, these reviews may be identified by different names.

Peer Review or walkthrough is conducted by individuals who are employees of the developing organization, are familiar with the development methodology and procedures being used, and provide internal feedback on the progress of the development project.

In Progress Reviews are normally conducted by the customer or their designated representatives to evaluate the progress of the development activity and to provide course corrections early enough to minimize serious problems at acceptance testing.

Formal Inspection or Review is performed at the conclusion of the development project, along with both modular and system acceptance testing. All documentation is reviewed, including requirements, configuration control, risk management, internal testing, previous walkthrough reports, error detection, and other information. Normally, acceptance testing is conducted to demonstrate that every functional and technical interface and security requirement is fulfilled. Stress testing may or may not be included in the formal inspection and review process.

Quality Audit can be conducted by either internal or independent quality auditors to ensure that the metrics and other quality measures used to evaluate the progress of the development effort are being gathered according to the defined processes, that the processes are monitored as defined by the quality plan, and that the program is performing to the quality performance standards defined in the quality plan.

Quality Assessment is normally conducted by independent evaluators to determine if the processes and procedures used to manage key process areas within the overall development effort are sufficient to provide appropriate levels of insight into the processes used, provide consistent

and repeatable performance, and serve the stated objectives of the organization.

4.0 Test Engineering

The Adnet staffs are familiar with all aspects of test engineering. Typically, we establish a test laboratory, which includes the creation of a tested environment that replicates the operating environment to insure the integrity of the existing systems. The test laboratory also allows us to deploy a variety of automated testing tools, such as probes, automated message generators, other stress test tools, and a variety of automated testing software tools that are appropriate to the specific project. For example, most CASE tool deployments have automated code testing routines that we frequently use, as well as automated code configuration documentation tools. Our staff members have extensive experience in all aspects of test engineering, including V&V, test plan development, test case development, creation of test databases and the generation of structured test reports for each phase of the development lifecycle. We have regularly used benchmark test cases drawn from nationally established benchmarking sources such as the National Benchmark Clearing House in Austin, Texas, and the U.S. Army and National Institute of Standards benchmarks for specific military and other performance standards. The selection of standards and benchmarks to be used is based on the choice of development model (e.g. agile, waterfall, bootstrap, JAD/RAD, Information Engineering) and on the development platform and environment. In all cases, we exercise strict code control and release management as part of the configuration management function and, when using COTS products or third-party providers, we exercise structured and measurable supplier control. Media control is implemented to facilitate the deployment of multiple platforms and to manage backup systems when providing disaster recovery capabilities.

5.0 Metrics Collection and Analysis

Adnet reviews all existing metrics collection schemas to ensure that selected metrics meet project needs. We then gather and evaluate the selected metric data and subject it to systematic scrutiny in order to provide useful management information. We also assess the need for additional metrics that may provide meaningful measures concerning the development status and progress of the project. Examples of metrics we often use include:

- **“Percent completion”** (comparison of WBS tasks and schedule) used to monitor task progress (based on the concept of earned value);
- **“defects found during design review vs. code inspection”** (defects per lines of code or per 100 function points), used to monitor effectiveness in understanding and translating user requirements; and
- **“Cost of change,”** used to quantify the schedule slippage and added expense involved when changes to the requirements are contemplated. Other metrics can be adopted to assess development process efficiency; effectiveness of code inspections; IR generation as a measure of coding efficiency; aged problem reports; change requests as a measure of program stability; and end-user satisfaction.

Other metrics can be adopted to assess development process efficiency; effectiveness of code inspections; IR generation as a measure of coding efficiency; aged problem reports; change requests as a measure of program stability; and end-user satisfaction. Metrics based on the developmental software and hardware environment and defined at the beginning of the project or task can provide early indications of potential software development Problems. Adnet's analysis of metrics has been used successfully to detect and understand internal program consistency, traceability, consistency within requirement documents, appropriate sizing and timing, and conformance with standards. Our approach is designed so that our clients are able to apply a proven and consistent methodology in managing the application development process. The earned value concept and the use of a work breakdown structure (WBS) have become two of the premier tools used in successful projects today. They provide a structured and visual methodology to account for all efforts required for the project. In addition, earned value provides a measure of the efficiency of the work being accomplished and gives warnings of potential problems before they become insurmountable. Used judiciously, the WBS and the earned value concepts can help ensure a smooth development process with sufficient oversight and no surprise. When Adnet is functioning as an IV&V contractor, all errors and problems are documented and reported to the customer and the development team. Depending on the severity of the problem, the Adnet's IV&V staff may then retest the specific function after the development team has made corrections or it may retest the entire module or application to ensure that the correction was made properly. When Adnet is performing V&V, the test engineer documents and reports the defect to the development team and may participate in correcting the problem. In all cases, the process is continued until all functional testing can be performed without error.

6.0 Configuration Management

Software CM is the process by which, during the development process, the project team identifies the software items that will be included in the baseline, manages and controls that baseline in terms of changes, and audits and reports the status of the project software baseline. Configuration management is a key function that, like quality assurance, is established at the beginning of the project and continues until the application is finally retired from use. Our approach complies with the EIA CM standards, and is in alignment with the IEEE definition of configuration management: A discipline applying technical and administrative direction and surveillance to: Identify and document the functional and physical characteristics of a configuration item; Control changes to those characteristics; Record and report change processing and implementation status; and Verify compliance with specified requirements. It includes the four key elements defined by the IEEE as critical to effective CM, and conforms to SEI CMMI recommendations for effective CM. When appropriate, we conform to the current Adnet IV&V White Paper, prepared, MIL-STD-973 and MIL-STD-2549, the EIA standard, and the IEEE standard, shown below.

Configuration Item Identification	An element of configuration management consisting of selecting configuration items for a system and recording their functional and physical characteristics in technical documentation
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Change Control	An element of configuration management consisting of the evaluation, coordination, approval or disapproval, and implementation of changes to configuration items after formal establishment of a baseline configuration items.
Configuration Status Accounting	An element of configuration management consisting of the recording and reporting of information needed to manage a configuration effectively. This information includes a listing of the approved configuration identification, the status of proposed changes to the configuration, and the implementation status of approved (or disapproved) changes.
Configuration Audits	The process of verifying that all required configuration items have been produced, that the current version agrees with specified requirements, that the technical documentation completely and accurately describes the configuration items, and that all change requests have been resolved.

Our experience in large, complex system configuration management provides our customers with an inimitable tool with which to perform appropriate CM oversight. Adnet will review and recommend processes for the following areas, because they are vital to the development of a mature and effective CM process:

- Baseline and Release Management, including identification of the individual software items (modules, functions, database descriptions, tables, etc.), cataloguing the configuration items, and documenting versions.
- Change and Version Control, to permit parallel development through branching in the main Configuration line. Version control allows continued and concurrent development while a development line is frozen for validation testing. Additional tools include file comparison, and file merging functions.
- Document management, including management of the requirements, design, and user documentation that represents the foundation of the end product. Documentation is often the first task forgotten and the last task accomplished. We establish procedures to ensure that each requirement, change, screen, and module is adequately documented using impact assessments.

7.0 Project Cost and Risk Management

Adnet reviews all existing plans, and typically develops a Project Management Plan for each IV&V project identified by our customers. We ensure that the format and content are consistent with our customer's documentation requirements and define how the plan can be applied to future projects. The Project Plan defines the project schedule, WBS or CWBS (contract work breakdown structure) in accordance with MIL-STD-881, if required, and metrics to be used in assessing progress against the schedule and WBS. The WBS structures the way in which the

work is to be performed and will reflect the way project costs and resource data are reported. The WBS is product-oriented with subdivisions of hardware, services and data required. The project schedule is developed from the identified work packages for the WBS so that earned value metrics can be generated and reported during the life of the project.

Adnet has based its Risk Management methodology on the Software Engineering Institute's Risk Taxonomy Methodology to identify and manage task-specific risks. We have become thoroughly familiar with this formal process, which identifies and prioritizes program risks, focuses management attention on them, and develops and implements plans to mitigate them. Our consistent use of this process has significantly improved our ability to deliver products and services on time and within budget. Upon identifying the risks specifically associated with each project, we prioritize those risks and develop mitigation plans to manage them. The overall result is a high degree of reliability in our performance of the required tasks, and a correspondingly high degree of customer satisfaction. Once the plan is developed, risk management becomes a strategy that compels the project team to continually address potential risk areas throughout the life of the project. The plan outlines risk identification methods and tools, analysis techniques used to quantify the identified risks in terms of probability and consequences of the occurrence, and risk response or mitigation techniques used to reduce or control the impact of the risk. Risk status is reported concurrently with project technical, cost, and schedule status. An example of risk assessment is shown below.

Priority	Risk Event	Occurrence Probability	Impact	Response
3	Reduced funding	0.4	high	Work with sponsors to seek additional funding. Reduce technical requirements additional funding
1	Interface conflicts with legacy systems	0.6	high	Conduct complete interface requirements definition Conduct both modular and system interface testing

8.0 Automated Tools

Adnet has researched, evaluated, recommended, and standardized the use of many types of software packages for current projects. In particular, tools for Configuration Management and Quality Assurance, CASE (Computer-Aided Software Engineering), Metrics tools, Data Modeling and Data Flow Diagramming are in use on many projects. Adnet's employees also work with other organizations with ongoing and previous software evaluation programs, and acquire and evaluate benchmark software for testing compilers. By applying our expertise with CM/QA tools, such as the PVCS, Rational Suite, and QVCS, we can significantly enhance the processes within current organization.

9.0 Documentation

Adnet includes all documentation as configuration items. Documents created include, but are not limited to:

<ul style="list-style-type: none"> • Requirements Traceability Matrix and related requirements documentation 	<ul style="list-style-type: none"> • Walkthrough and Review Reports and Recommendations
<ul style="list-style-type: none"> • Detailed Design and Data Mapping 	<ul style="list-style-type: none"> • High Level Design
<ul style="list-style-type: none"> • Coding Standards 	<ul style="list-style-type: none"> • Test Plan
<ul style="list-style-type: none"> • Quality Audit Reports 	<ul style="list-style-type: none"> • Quality Evaluation Report
<ul style="list-style-type: none"> • Status Report 	<ul style="list-style-type: none"> • Acceptance Testing Plan
<ul style="list-style-type: none"> • Acceptance Test Report 	<ul style="list-style-type: none"> • Quality Plan
<ul style="list-style-type: none"> • Test Scripts 	<ul style="list-style-type: none"> • Test Database
<ul style="list-style-type: none"> • Testing Reports 	<ul style="list-style-type: none"> • Defect Report

These documents are maintained electronically, with controlled access and version control so that both the current version and previous versions (where applicable) are available for review. In addition, the Adnet staffs is skilled in preparing and presenting materials to support customer use, including administrative and user training documentation, course materials, and briefings. We consider these to be a normal part of the documentation requirements when we are performing development services, and part of the materials under review when conducting IV&V functions. From following best practices in developing products and providing services, Adnet has been successfully appraised, certified in CMMI L3, ISO 9001:2008 and ISO 20000.

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