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# Ensuring VICTORY Compliance

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## ABSTRACT

*Standard specifications give programs the flexibility of developing large systems from smaller pieces that can communicate between one another in a standard fashion. This benefit is lost, however, if there is no way to verify that vendors successfully adhere to the standard in question. The Vehicular Integration for Command, Control, Communications, and Computers (C4), Intelligence Surveillance and Reconnaissance (ISR) Electronic Warfare (EW) Interoperability (VICTORY) standards aim to create interoperability across various C4ISR/EW and platform systems installed on military ground vehicles while reducing size, weight, and power (SWaP) and enabling additional capabilities. The VICTORY Compliance Test Suite (CTS) provides a method to test hardware and software according to the standard specifications to ensure interoperability between VICTORY compliant components.*

## INTRODUCTION

Standard specifications allow systems that are designed and developed separately to work together. They provide detailed instructions for how a system should function and define communication between systems so that they can interoperate.

A piece of equipment that falsely claims to properly follow the standard can cause issues with interoperability and may not work as expected. In order for a standard specification to provide the maximum benefit possible, there needs to be a way to evaluate and report compliance of prospective components. Compliance testing allows a program to fully vet incoming equipment to ensure the required standard specification is being implemented correctly.

## BACKGROUND

Vehicular Integration for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance/Electronic Warfare (C4ISR/EW) Interoperability (VICTORY) is an initiative led by the VICTORY Standards Support Office (VSSO), which is managed by the U.S. Army Program Executive Office for Ground Combat Systems (PEO GCS) Systems Engineering & Integration (SE&I) organization. The initiative has a broad scope in the Army ground vehicle and technology communities, receiving support (funding and participation) from and providing capabilities for many programs across the Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASAALT) and Army Research, Development, and Engineering Command (RDECOM) organizations. The customers of VICTORY are Army ground vehicle programs and programs that create products that are integrated with Army ground vehicles.

VICTORY addresses the issue of how electronic systems (automotive, weapons, C4, ISR, EW, etc.) have been traditionally integrated with military ground vehicles that leads to sustainment problems. New capabilities are integrated with a “bolt-on” approach, in which capabilities are implemented as kits that include hardware (processing, display, user interface devices, sensors, cabling). This results

in redundant hardware that has an ever-increasing size, weight, and power (SWaP) impact on the vehicles and increases the time and cost to integrate and maintain the systems. In general, the systems are not designed to interoperate (share data, controls, or health monitoring functions) with other systems. Where interfaces that provide for interoperability do exist, they are often proprietary. The effect of systems not interoperating is redundancy in functionality and sensors, lack of flexibility, and poor support for the soldiers using the systems. The goals of the VICTORY initiative include:

- Moving away from the current "bolt-on" approach for integrating Army ground vehicle electronics;
- Reducing the amount of redundant hardware associated with current capabilities;
- Reducing the cycle time and cost necessary to develop, integrate, test, maintain, and upgrade vehicles throughout their life-cycles;
- Enhancing capabilities of existing systems by designing systems to interoperate, and enabling innovation;
- Enabling new capabilities (systems) to be added more quickly and with less cost and SWaP impact;
- Sharing processing resources, as opposed to the current practice of dedicating computers and displays to specific C4ISR/EW systems, enabling new software packages to be added later to support new capabilities;
- Promoting the idea of hardware and software components being movable between vehicles by maximizing portability, allowing for common products across vehicle fleets;
- Ensuring that both current and future information assurance (IA) requirements can be met, including features such as Data-At-Rest Encryption, both single and multi-enclave designs, and Transport Layer Security (TLS) and IP Layer Security (IPSec);
- Providing an evolutionary approach towards network-centric C4ISR/EW, starting with interoperability with current systems, and providing a pathway for insertion of new capabilities and technologies.

The approach VICTORY has taken toward these goals is to define an open in-vehicle network (IVN) architecture and develop standardized open network-based interface specifications for sharing data; configuring, controlling, and managing the health of the systems and the IVN itself; and for sharing computing resources. The IVN provides an open framework for integrating current-force and future systems and can be extended gradually as new systems are developed.

The VICTORY Standard Specifications[1] are defined at the component type level, not at the system level. A component type is a collection of interfaces, such as data, management, and health publishing. The VICTORY Standard Specifications define a set of VICTORY Type (VT) tables, where each table represents a list of specifications that comprise a component type or an interface of a component type. An example of a component type VT table is shown in Figure 1.

**Table 22. Position Service <VT50100-V1.7>**

| Spec Title | Spec Tag | Applicability |
|---|---|---|
| Position Data Interface | VT50101-V1.6 | Required |
| Position Management Interface | VT50102-V1.7 | Required |
| Syslog-Based Health Publishing Interface | VT50103-V1.4 | Required |
| Auto-Discovery Interface | VT59930-V1.6 | Optional |

*Figure 1: Component Type VT Table*

A component type VT table identifies the interfaces that comprise a component type, along with whether the interfaces are required, recommended, or optional. The component type VT table also contains a list of interface VT tables applicable to the component type. An example of an interface VT table is shown in Figure 2.

**Table 23. Position Data Interface <VT50101-V1.6>**

| Spec Title | Spec Tag | Applicability |
|---|---|---|
| Common Data Interface Specifications | VT59901-V1.6 | Required |
| Position Data Specification | 20009–20120725, Pro | Required |

*Figure 2: Interface VT Table*

An interface VT Table identifies the collection of specifications that comprise an interface, along with whether each specification is required, recommended, or optional.

A system can be compliant with one or more VICTORY component types, meaning it implements all of the required interfaces of each of those component types. Platform integrators are responsible for identifying which, if any, recommended or optional interfaces/specifications are necessary for VICTORY compliance on their particular platform. It is unlikely a vehicle platform will integrate every component type covered by the VICTORY Standard Specifications, as not all component types are relevant for every platform.

## COMPLIANCE TEST SUITE

The VICTORY Compliance Test Suite (CTS) is a comprehensive set of resources that have been developed to help vendors and platforms implement and verify VICTORY compliant component types. The CTS consists of

Compliance Test Plans (CTPs), Compliance Test Reports (CTRs), and the Compliance Test Tool (CTT).

### *Compliance Test Plans*

A VICTORY Compliance Test Plan is a document constructed using the VICTORY Standard Specifications to test implementations of VICTORY component types. A CTP is developed in two phases. The first phase, called validation, is a process where the test plan author reads the specification and develops a test procedure in order to test the parameters specified. Care is taken during validation to examine the specification and account for "corner cases" in compliance. Once the validation plan has been tested against an experimental VICTORY service, the validation test plan is adapted into a CTP. In this second phase, each testable parameter will be verified with test steps using valid values, invalid values, or malformed requests. Typical parameters define a value range for a specific data type or the structure of a message. Each parameter in the specification has a set of messages that relate to the parameters. For example, a mutable data type might have a message to set the value and a message to get the value from the VICTORY service. The test steps in the CTP verify that the component type under test responds to the messages sent in the correct manner. For example, a request to set the value of a VICTORY data type is tested by setting the value to a valid parameter, examining the response to the request, then checking if the value was updated correctly. The test procedure also includes steps to test any specific error cases that are defined in the specification by creating the error conditions and verifying that the component under test responds to the error case correctly.

A test plan is comprised of tests for the VICTORY interfaces required by the component type under test. For example, the Position Service component type is split up into multiple interfaces. These include the Position Service Management Interface, the Position Service Data Interface, the Syslog-based Health Publishing Management Interface, and the Auto-discovery Interface. An interface section of a CTP may contain one or more tests. The author of the CTP determines which VICTORY specifications can be tested in the same test and organizes the procedures into separate tests as appropriate. Each test has a unique test identifier such as PSDIT1. PSDIT1 is an abbreviation that corresponds to Position Data Interface Test 1. A test lists the specifications addressed by the procedure and requirements for running the test including prerequisite conditions, supporting items, test inputs, and assumptions and constraints. Following the requirements and setup information, the test is broken down into test evaluation criteria and the test procedure. A test evaluation criterion is a statement created with intent to determine compliance of the corresponding VICTORY specification(s). Figure 3 shows a criterion in PSDIT1.

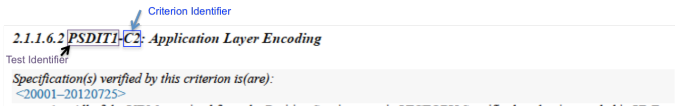


*Figure 3: CTP Criterion*

Each criterion lists the specifications it verifies and states the expected behavior for compliance. The criteria in PSDIT1 are labeled as PSDIT1-CX, where X is the criteria identification number, and PSDIT1 is the test identifier. Each criterion in a test has a unique criterion identifier. Each test step states the associated criteria that are to be used for verifying compliance for the step.

In order to verify overall compliance of the component type under test, test criteria are grouped together in order to test each specification applicable to the component type. This group is referred to as a test case. These test cases are compiled into a logic statement by representing each test case as an alphanumerical identifier. The logical operators used in the compliance statement are determined based on the applicability stated in the VT tables. An example of a compliance logic statement is shown in Figure 4.

**Table 36. Position Service Auto-Discovery Interface Compliance Logic <VT59930-V1.6>**

| Specifications | Test Procedure | Evaluation Criterion | Identifier |
|---|---|---|---|
| VT59930 Compliance Logic | 01044 | | |
| 01044 | Position Service Auto-Discovery Interface Test 1.2 | PSADIT1-C1 | A |
| | Position Service Auto-Discovery Interface Test 1.2 | PSADIT1-C2 | B |
| | Position Service Auto-Discovery Interface Test 1.2 | PSADIT1-C3 | C |
| 01044 Compliance Logic | A * B * C | | |

*Figure 4: Compliance Logic Statement*

A compliance logic table displays the VT tables and specifications in the "Specifications" column. The first row in a compliance logic table shows all of the VT tables and specifications required for compliance. As shown in Figure 4, this logic statement verifies the compliance of VT59930. This VT table includes only one specification, 01044. The criteria required for compliance of specification 01044 are specified in the test procedure and evaluation criterion columns of the table. The logic statement created with the criteria is provided in the "01044 Compliance Logic" row of the table.

### *Compliance Test Reports*

A Compliance Test Report encapsulates all of the results gathered from testing a component type against its corresponding CTP. The report contains the results of each test case, observations if a test case was marked as a failure, and a mapping of artifacts gathered during testing to test steps. Results from test cases are rolled up into a compliance statement for each specification, VT table, and finally for the

entire component type. Since not every specification or VT table is required for VICTORY compliance, based on platform integrator determination, the reports contain logic statements to determine compliance for each specification, VT table, and the component type.

Reports, in the form of an Excel spreadsheet, can be filled out manually while following the corresponding test plan by selecting "PASS" or "FAIL" in the document for each test case. All results are automatically rolled up as the report is filled out. The Compliance Test Tool can also generate completed reports by exporting the results of tests run using the tool.

### *Compliance Test Tool*

The Compliance Test Tool is a software tool that provides a variety of features. The main functionality of the CTT is to provide automated testing of the CTPs. It also offers a way to view the other documents that make up the CTS. Figure 5 shows the left half view of the CTT. The buttons on the left of the window allow the user to select the view shown in the main area of the user interface.

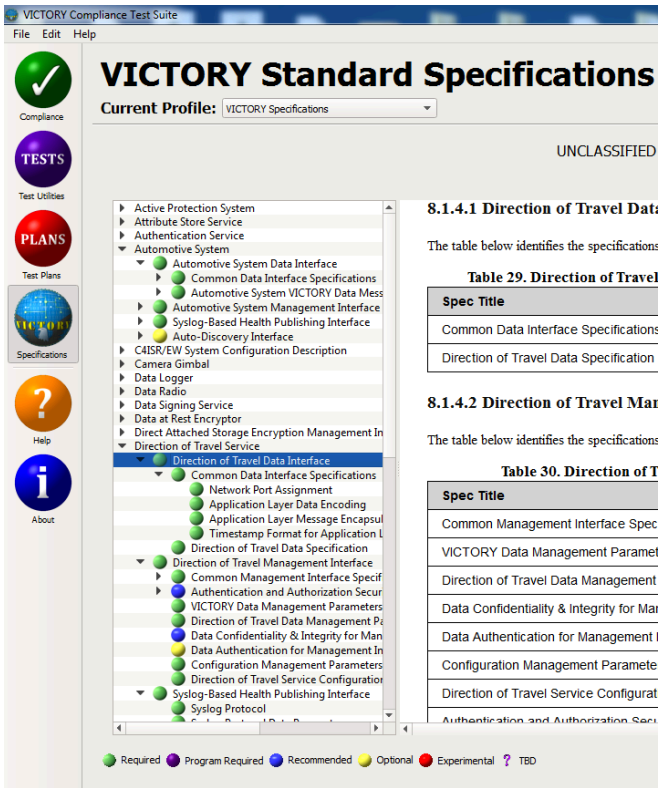


*Figure 5: CTT Specifications View*

The "Specifications" view, shown selected in Figure 5, allows the user to view the VICTORY Standard Specifications document along with a tree view in the left pane. The tree view contains all of the component types at the top level. Expanding a node in the tree displays the VT tables and specifications associated with that node. Each node has a color-coded orb that indicates the applicability, i.e., whether the table or specification is required for VICTORY compliance, is required by the program ordering the testing, is recommended, or is optional. These orbs also mark tables and specifications that are at the "Experimental" level of maturity. Clicking on any of the nodes will display the content in the pane to the right, which allows easy navigation of the specification document.

The "Test Plans" view displays the Compliance Test Plans in a user interface similar to the "Specifications" view. There is a tree view in the left pane that expands to show interfaces that can then be expanded to show individual tests. Each test can be expanded to show the criteria associated with the test. The nodes in this view can also be clicked to show the corresponding test plan section in the right pane.

The "Test Utilities" view is where a user can select tests to execute. A user can select entire component types or individual tests. Once the desired tests are selected, the user is taken to the configuration page, as shown in Figure 6**Error! Reference source not found.**.

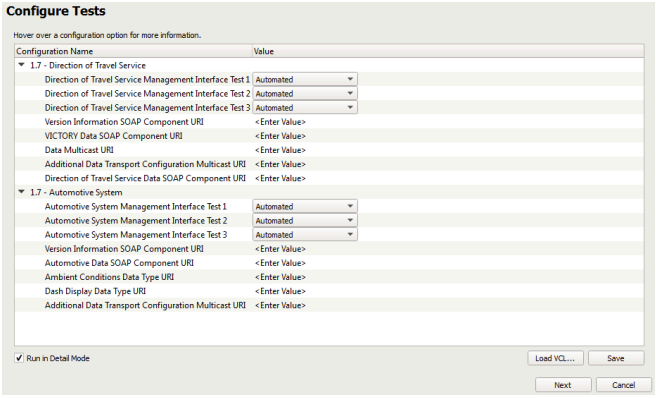


*Figure 6: Test Configuration*

The configuration page displays the selected tests and the configuration items required to run any automated tests. A user can also choose to run tests manually by selecting the manual option in the drop down menu next to the name of the test. Most configuration items needed for automated testing are URIs that point to the location of a component type's management interface or multicast addresses where VICTORY data messages (VDMs) are published. Configuration items can be entered manually by typing in the values, but most of the values can be filled out automatically by loading a VICTORY Configuration Language (VCL) instance document. This saves a significant amount of time when running a large number of tests. After

filling out the test configuration and clicking the "Next" button, the values are checked for validity. If all of the values are valid, testing begins.

Most tests can be run as either automated or manual. However, there are some tests, mostly limited to hardware components, that only allow for manual testing. If any manual tests are selected, they are run first. For manual tests, the CTT guides users through the test, step by step, and the user selects whether each criterion passes or fails. Artifacts and observations can be uploaded at the user's discretion. After any manual tests are finished, the automated tests are executed. Automated tests automatically record artifacts and observations that can help the user track down why criteria failed during the test.

Users are given the option to view and/or export the results after testing has completed. Exported results are saved as a CTR. The "Compliance" view displays test results, as depicted in Figure 7.

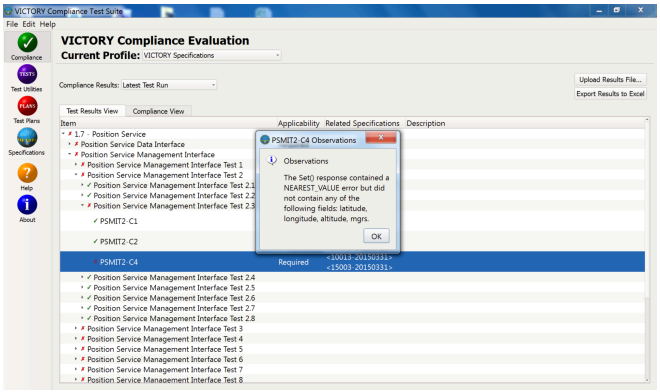


*Figure 7: Test Results*

Here the results can be viewed in two ways. They can be displayed at a test level, informing the user exactly what interface, test, step, and criterion passed or failed. This is very useful for debugging and isolating particular issues with an implementation. Results can also be viewed in a way that reflects the VICTORY compliance of the component type, taking into account the applicability of the specifications being tested, similarly to the way it is done in a CTR. Previously exported CTR files can also be uploaded and viewed on this page.

### *CTS as a Development Tool*

The primary use of the CTS is for programs that have required the use of the VICTORY Standard Specifications to test prospective hardware or software provided by vendors to ensure that the components in question do in fact implement VICTORY correctly. The CTS gives programs the ability to quickly perform automated testing against a CTS profile specific to the needs of the program and output the results in an easy to view format. While the CTS does not provide functional or performance testing, it does provide verification that a component complies with the VICTORY specifications. If the CTS successfully verified compliance, the program may allow this component into their final system. However, if the CTS reported an error, the program may deny the component and submit the report to the vendor as feedback. This ability to quickly and easily verify whether or not components are compliant with the VICTORY Standard Specifications is intended to make the inclusion of VICTORY in contracts easier to verify and support for programs.

The CTS can also be used directly by vendors themselves while developing hardware and software. The inclusion of the VICTORY Standard Specifications within the CTS provides easy access to the document. Reading through the Compliance Test Plans can provide clarification as to what is expected. Finally, being able to run the CTS against a component during development will give a vendor immediate feedback regarding problem areas that need to be addressed. Having observations that give detailed error messages on what caused a failure, along with having the artifacts from the test, will point a developer directly to an issue that needs to be resolved. The results also contain references that link back to the specification and CTP to add an easy means of reviewing the content if there is confusion on why a failure occurred.

## CONCLUSIONS

While the use of a standard can give a particular industry a common means of developing consistent and interoperable solutions, having a method by which to determine compliance against the standard makes the standard more useful to the community at large. For the VICTORY Standard Specifications, the Compliance Test Suite has been developed to 1) view the VICTORY Standard Specifications electronically, 2) provide a means by which to view the Compliance Test Plans for each component type, 3) execute either automated or manual testing of component types, and 4) generate Compliance Test Reports that provide detailed feedback after a test is run.

The use of the CTS enables programs to ensure that component types included in their final system will meet the specifications of VICTORY as required by the program and will also help minimize the time and cost of evaluating new equipment. The CTS also gives individual vendors the ability to perform the same testing during the development phase. This can help vendors quickly diagnose problems and areas of concern before the equipment is delivered to the program. Finally, the detailed observations provided during fail cases gives both programs and vendors information as to what caused the failure and lead to solutions that will help make the equipment VICTORY compliant.

## REFERENCES

[1] Vehicular Integration for C4ISR/EW Interoperability (VICTORY) Standard Specifications, Version 1.7, 15 February 2018.