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Executive Summary

This report is written from the perspective of the National Institute of Standards and Technology (NIST). It is a deliverable against the 1992 Computer-aided Acquisition and Logistic Support (CALS) Statement of Work NIST has with the CALS Evaluation and Integration Office (CEIO). It contains both tutorial information and issues associated with the various types of testing activities under the purview of the CALS initiative. Others may benefit from this report since it additionally provides general tutorial information about the various types of testing activities and associated terminology, and summarizes conformance testing activities for several national and international standards.

The four primary testing activities discussed in this report are: standards testing, component testing, conformance testing, and acceptance testing.

Standards testing determines whether the national, international, or military standards (and specifications) are viable and implementable.

Component testing is conducted to verify the implementation of the design for one software element (e.g., unit, module) or a collection of software elements.

Conformance testing tests the extent to which an implementation under test is a conforming implementation.

Acceptance testing determines whether a software system satisfies its acceptance criteria and enables the user to determine whether to accept the system. This includes the planning and execution of several kinds of tests (e.g., functional, interoperability, performance tests) to demonstrate the implemented software satisfies the user requirements.

Where two or more people are gathered to discuss the topic of "testing," there are usually as many definitions of testing as there are people in the

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1 The opinions and recommendations of this report are not necessarily those of the CALS Executive or the CALS Evaluation and Integration Office Management.
- Should the CEIO fund the development of a conformance testing service for the FIPS and associated military specification?

- Even if conformance testing services existed for all the CALS military specifications, how does the CEIO guarantee enterprise users will take advantage of such services?

For each issue, alternatives are provided, pros and cons considered, and recommendations drawn.
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I. INTRODUCTION.

A. Content of this Report.

If the CALS initiative is to be successful, government and industry have to attain a high level of confidence that the CALS specifications and standards are adequate to satisfy the requirements for digital delivery of technical data supporting user applications. Equally as important, both government and industry must be satisfied industry implementations can deliver this technical data according to a set of specifications and standards. For this to happen, CALS has to influence testing in three areas: standards, conformance, and acceptance testing [JCMO91].

The content of this report covers those testing activities which have been or are funded by CALS, by DoD services, or by industry to support CALS. Although specific activity descriptions may be limited to the CALS community, the types of testing activities generically described in the following pages, the author believes, satisfy most enterprise users' application requirements.

B. Scope of this Report.

The audience of this report includes: the CALS Executive and supporting CALS Evaluation and Integration Office (CEIO) managers; CALS/CE Industry Steering Group (ISG) participants, particularly those who have invested in testing activities relative to CALS; suppliers of CALS implementations; and enterprise users responsible for implementing CALS solutions into their logistic support life cycle processes.

C. Structure of this Report.

The body of the document is divided into nine sections with additional supportive appendices. The following is a brief description of each section:

1. Introduction. This section introduces the need for testing realized by the CALS Evaluation and Integration Office.
II. TERMINOLOGY.

Where two or more people are gathered to discuss the topic of "testing," there are usually as many definitions of testing as there are people in the room. Add personal expectation to the formula, and one is left with a nebulous understanding of what "testing" provides. To emphasize this bedlam, a few key testing terms are highlighted below.

Certification.

There is a discrepancy in the use of the word "certification" between DOD-STD-2168:

"a process, which may be incremental, by which a contractor provides objective evidence to the contracting agency that an item satisfies its specified requirements" [2168]

and ISO/IEC (International Organization for Standardization / International Electrotechnical Commission) Guide 2:

"procedure by which a third party gives written assurance that a product, process or service conforms to specified requirements" [2-91].

DoD's definition primarily applies to the quality of software to be purchased and meeting the enterprise user's specific requirements, i.e., acceptance testing. The ISO/IEC Guide relates to the formal process for judging conformity of a product, process, or service, primarily used in reference to conformance testing. The ISO/IEC definition is reinforced by a similar conformance testing application in American National Standards Institute (ANSI) Z34.1-1987's definition:

"the procedure by which written assurance is given that a product or service conforms to a standard or specification" [Z34.1].
A last definition on the word validation also supports a conformance testing type of activity and comes from FIPS 11-3, Guideline: American National Dictionary for Information Systems [FIPS11-3]:

"(1) tests to determine whether an implemented system fulfills its requirements. (2) see data validation [(1) a process used to determine if data are inaccurate, incomplete, or unreasonable; the process may include format checks, completeness checks, check key tests, reasonableness checks and limit checks. (2) the checking of data for correctness or compliance with applicable standards, rules, and conventions.]

Since there is so much double entendre in using the word "validation," one must define the use applicable to the document. This report is primarily addressing the validation activities associated with standards and conformance testing; therefore, the two relevant definitions, which apply to these testing phases, have been defined in the glossary.

**Verification.**

DOD-STD-2167A:

"the process of evaluating the products of a given software development activity to determine correctness and consistency with respect to the products and standards provided as input to that activity" [2167A],

and FIPS PUB 132:

"the process of determining whether or not the products of a given phase of the software development cycle fulfill the requirements established during the previous phase" [FIPS132]

are consistent in referring to an evaluation process applied to software during its development cycle---component testing.
III. BACKGROUND.

A. Standardization and Implementation Process Flow.

The explosion of technology standards in the last decade has brought the issue of conformance testing to the fore. Through standards, we have arrived at the dawn of the age of Open Systems, where one can employ configuration components from disparate vendors to achieve cost and operating efficiencies.

Multi-vendor systems without conformance testing, however, are a scourge upon the landscape, as they almost certainly will fail to operate in a heterogeneous product environment. Although standards have unlocked the door to openness, they can be ambiguous, occasionally irrational and imprecise; standards are almost always implemented in a manner somewhat unique from someone else's implementation. This often leads to operational failure unless testing is performed beforehand [JC90].

Figure 1 is a modification of a diagram developed by the CALS/CE Industry Steering Group Ad Hoc Testing Committee. This interpretation of their figure presents an example of the overall structure within which standards are developed (step 1), tested (step 2), implementations built (step 3), conformance testing performed (step 4), high level acceptance testing done (step 5), and finally, at a more detailed level, the output data sets of the implementations verified (step 6).

There are specific expected outputs from this diagram in order to meet the enterprise user's requirements. At the culmination of step 2, an international, national, federal, or military standard or specification is created. Step 3 culminates in an implementation of that standard in off-the-shelf supplier offerings, and step 4 qualifies the supplier's implementation against the standard. Step 5 is the integration of the supplier's implementation into the enterprise user's installed base. Step 6 checks data integrity, and concludes with acceptable data sets.
accomplished by the supplier. Oversight of step 4 is the responsibility of NIST; however, actual conformance testing processes may be delegated to other agents acting on behalf of NIST, or performed as a supplier's declaration. In step 5, an enterprise user may optionally choose to perform interoperability testing prior to the remaining high-level acceptance testing activities, e.g., performance testing, robustness testing. Interoperability as a first step of acceptance testing is particularly important if the enterprise user has a high investment in legacy systems. Steps 5 and 6 are typically performed by the enterprise users of the standard implementations [TEST2]. Although interoperability is ultimately the responsibility of the enterprise user, suppliers may optionally perform interoperability assessment among themselves. An example of such a practice occurs for GOSIP implementations, where an online system is available for access by suppliers.

In general, an enterprise user is an organization or person who builds, uses, maintains, or disposes of information generated from an implementation. It is important to recognize two different enterprise users benefitting from the output of steps 5 and 6: the systems integrator or a government agent. If the buying government agent recognizes and approves the requirements which a systems integrator must meet when performing system and data acceptance, then, although the agent's acceptance testing task may not be complete, the workload for evaluation is minimized. The CALS Evaluation and Integration Office (CEIO) could propose a consistent method for defining the requirements which the systems integrator must meet when assessing the supplier's implementation for a potential government acquisition.

An introduction to the various levels of standards, which play a role in CALS, seems necessary in order to understand the implication on testing activity.

**International Organization for Standardization (ISO).**

In 1946, national standards organizations from 25 countries formed the International Organization for Standardization (ISO). The U.S. representative, American National Standards Institute (ANSI), is the sole U.S. representative to ISO. ISO develops, coordinates, and promulgates
"Improve the life-cycle efficiency and effectiveness of federal information technology resources;
facilitate the competitive and economic procurement of systems, components, and services;
improve the portability of data, software, and technical skills across systems;
protect systems and networks against unauthorized access, manipulation, abuse, and protect information from unauthorized modification or disclosure;
reduce waste, errors, and unnecessary duplication in the application and use of systems; and
increase the productivity of the federal work force" [FIPS91].

Military Standards and Specifications.
Military standards (MILSTDs) establish engineering and technical requirements for processes, procedures, practices, and methods that have been adopted as a standard. Military specifications (MILSPECs) are prepared specifically to support defense acquisition. They are intended to clearly and accurately define essential technical requirements as well as define that those procedures necessary to determine requirements have been met [DOD 4120.3M]. Specific to CALS, the purpose of MILSTD-1840 is to standardize the format and information structures of digital data files used for the transfer and archival storage of digital technical information [1840]. The MILSPECs 28000, 28001, 28002, and 28003 identify requirements for specific applications using the Initial Graphics Exchange Specification (IGES), Standard Generalized Markup Language (SGML), Raster, and the Computer Graphics Metafile (CGM), respectively.
"Tailoring" standards for unique requirements, while still maintaining technical attributes from the standard, is a potential occurrence, given the generation of standards at the international, national, federal, and defense levels. For example, given the existence of an ISO standard, ANSI can:

- Accept it in total.
- Delete portions unnecessary to achieve United States objectives.
technology is established and implementations are developed. For the
development of STEP, a different approach was chosen. Building on
research and development (R&D), but not on vast implementation
experience, STEP is being designed through the visions of many
individuals. Without reference implementations developed during
standards testing, which may be used to pass quality judgement on the
concepts, the result may be a product data exchange standard that is (1)
not implementable or, if implementable, (2) does not solve the functional
requirements the enterprise user community initially expressed. Hence,
"validating" the standard is necessary prior to its adoption.

The CALS military specification testing was founded on a similar need.
These specifications were written to minimize the flexibility usually
found in consensus-built national or international standards, and add any
additional requirements specific to the CALS initiative. No
implementations of these military specifications existed prior to their
adoption, and the concept of requiring computer standards for the
exchange of weapon system data was relatively new. Given this
Conformance testing is the testing of a candidate product for the existence of characteristics required by a standard. Its primary activity is to ensure specified behavior of implementations. Additional benefits include: clarifying the standard for guiding future implementation, producing a feedback loop to the standards-making bodies for improvements to the standard, encouraging commercial development by supporting a baseline for commonality in all products, and providing greater confidence on the part of the potential enterprise user. Conformance-tested implementations increase the probability these same implementations will be able to interoperate, but provides no guarantee. Figure 3 portrays the activities of conformance testing.

In the formal conformance testing process, the client is the organization or individual seeking recognition that a product complies with the standard. Upon completing conformance testing, the client obtains a conformance test report. This test report may enhance a commercial client's selling power to bid on a government contract or show a potential system's integrator or commercial user the product has been tested under a controlled environment by an unbiased testing laboratory using approved test methods. This formal process improves the competitive edge for the client against those suppliers who have not undergone the same process. It is also important for a government developer to undergo conformance testing of its implementations to ensure conformity prior to use.

An alternative to this formal process is the supplier's declaration. This is where the supplier performs its own testing, generates a test report, and makes a "declaration" of conformance for a given implementation against a given standard.

Although conformance testing provides a means to evaluate syntactic and semantic alignment of an implementation to a given standard, it does not measure fitness for use in a particular environment. The enterprise user is interested in a systems approach. Enterprise users must provide their own way to measure robustness, performance, interoperability, or data integrity of an implementation and the system under which it operates. These activities are known as acceptance testing. Basically, the burden falls to the enterprise user to perform acceptance testing, since it is defined for a particular functional requirement in the context of a
Appendix B is a list of directives and guidelines of general value to the testing continuum, as well as those of specific value to the CALS initiative. Although the list is not exhaustive, it should impress upon the reader the many interested domains that have given thought to testing activities.
IV. TESTING ACTIVITIES.

A. General Description of Primary Participants.

Before describing a particular testing activity performed by a specific organization, it seems appropriate to introduce the three primary participants within the CALS community: the CALS Test Network (CTN), the National Institute of Standards and Technology (NIST), and the CALS/CE Industry Steering Group (ISG). All have some level of activity across the breadth of testing under the CALS initiative.

1. CALS Test Network

The CALS Test Network (CTN) is a confederation of over 300 industry and 30 government organizations that have agreed to evaluate and demonstrate the interchange and functional use of digital technical information using CALS standards. This is accomplished through a collaborative multi-service effort. Test beds in support of the CALS Test Network Office have been established by each of the DoD Services, Defense

![Figure 4: Representative CTN Test Bed Hardware Configuration](image-url)
B. Standards Testing Activities.

1. National PDES Testbed (NPT).

The goal of the National PDES Testbed (NPT), located at the National Institute of Standards and Technology (NIST), is to provide technical leadership and a testing-based foundation for the complete development of STEP. Meeting the objectives associated with several processes is necessary to validate the viability and implementability of the International Organization for Standardization (ISO) Committee Draft (CD) for STEP:

Model Scoping and Construction. Identify and model an application use of the draft STEP specifications.

Test Definition Tool. Define test scenarios for evaluating STEP models.

Test Case Generation Tool. Convert real world product data into STEP structures.

Test Execution and Evaluation Tool. Run test, analyze results, and produce final reports [4417-90].

Of the many technical threads pursued within the NPT, those related specifically to CALS standards testing include:

- Testbed Initiation Activities. Establishing the operational testbed facility, coordinating efforts with outside organizations, performing initial technical studies, developing prototype systems, and performing preliminary testing of the draft STEP. (These initiation activities were completed in fiscal year 1990.)

- Validation Test System. Developing a system for testing and evaluating the application protocols which are defined as standardized parts of STEP. (NIST released a version at the end of
DoD-owned systems [JUN91]. The CALS Test Network has been requested, on occasion, to evaluate implementations of CALS specifications which are already procured under contract by one of the services or DLA. Their first activity of this nature was to ascertain CALS-compliance for the raster compression software (Type I) on the DSREDS, EDCARS, and EDMICS systems.


Computer users and the computer equipment, software, and services industries receive support from NIST in the form of standards and technical methods. These standards and technical methods are applied to advance the effective use of computers and related telecommunications equipment. One aspect of this support is the issuing of Federal Information Processing Standards Publications (FIPS PUBS). NIST has responsibility for providing conformance testing programs for FIPS PUBS where a need has been identified and resources are available. Under the CALS initiative, the conformance testing responsibilities of NIST have been expanded to include conformance testing against the CALS military specifications.

NIST's approach to CALS conformance testing has been: (1) establish a conformance testing service for the FIPS if warranted and (2) adapt the FIPS conformance testing service to meet CALS requirements as specified in the military specification 28000 series. The formal policies and procedures to define a conformance testing service for either a FIPS or a military specification are similar.

With the exception of Mil-D-28000, based on the Initial Graphics Exchange Specification (IGES), the CALS military specifications require FIPS compliance. A proposed FIPS for IGES is now under consideration. The FIPS for CGM (FIPS PUB 128) is being modified to include the full functionality of MIL-D-28003. Once this process is complete, FIPS CGM conformance testing and MIL-D-28003 conformance testing will be synonymous.
testing laboratory includes an on-site assessment by a team technically competent in the standard and testing tools for which the laboratory is being accredited. The testing laboratory's accreditation is based on the on-site assessment reports, actions taken by the testing laboratory to correct deficiencies, results of proficiency testing, and information from any monitoring visits which may have been performed.

<table>
<thead>
<tr>
<th>PROGRAM</th>
<th>ANNUAL AD/TECH SUPP. FEE(1)</th>
<th>INITIAL APPLIC. FEE(2)</th>
<th>ON-SITE ASSESS. FEE(3)</th>
<th>PROFICIENCY TESTING FEE</th>
<th>TEST METHOD FEE (each)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer/GOSIP</td>
<td>$5,600</td>
<td>$500</td>
<td>$2,100</td>
<td>$0</td>
<td>$300</td>
</tr>
<tr>
<td>Computer/High Level Protocols</td>
<td>3,500</td>
<td>500</td>
<td>1,300</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>Computer/POSIX</td>
<td>3,600</td>
<td>500</td>
<td>3,000</td>
<td>0</td>
<td>150</td>
</tr>
<tr>
<td>Computer/X.25-Blacker</td>
<td>3,500</td>
<td>500</td>
<td>1,300</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>ECT/MILSTD-462</td>
<td>3,550</td>
<td>500</td>
<td>3,000</td>
<td>200</td>
<td>30</td>
</tr>
</tbody>
</table>

(1) The Administrative/Technical Support Fee is assessed annually, regardless of a laboratory's accreditation status.
(2) One time per program only. This fee not paid if a renewal application.
(3) The On-Site Assessment Fee is due every other year. This fee paid only in the year in which notification is received that an on-site assessment will be performed.

Table I: NVLAP Fee Structure [1144K]

   Besides the standards testing activities mentioned above, the National PDES Testbed has also been funded by the CEIO in the past, to actively participate in the development of the STEP conformance testing standards
- Place all software vendor offerings that have completed the certification process on the Validated Products List (VPL)\textsuperscript{6} [ISG92].

D. Acceptance Testing Activities.

1. CALS Test Network.

As an overall tasking, the CTN Office is responsible for government user application, interoperability, and other related testing. All of the test beds perform interoperability testing to the level of the test bed capability, i.e., test bed system hardware and software available. The Army test bed has been designated the lead service specific to data acceptance testing. Particularly, CTN Test Report 91-028 presents models that define the entities and attributes related to the acceptance of CALS-conforming digital data for technical manuals. These models are expandable as the CALS specifications mature.

2. CALS/CE Industry Steering Group Committee.

The CALS/CE ISG Acceptance Testing Committee developed a report for industry and the CALS Office to:

- Recommend approaches which may be applied to assure successful data exchange for near term CALS deliverables.

- Recommend approaches which may be applied to ensure successful access to and use of information which resides within the Contractor's Integrated Technical Information Service (CITIS) for its intended purposes.

- Provide, for any given type of CALS deliverable, a framework for determining: what the evaluation method options are, what the acceptance criteria should be, what constitutes contractual

\textsuperscript{6} The Validated Products List is an internationally-recognized document which publishes results for several conformance testing services. It is available through the National Technical Information Service: subscriptions, phone: 703/487-4630; individual copies, phone: 703/487-4650; ordering number PB91-937300.
V. TESTING ISSUES ASSOCIATED WITH CALS INITIATIVE.

The following issues have been raised and were highlighted in the previous text (sections I through IV), and are gathered here for further elaboration. After each issue is raised, alternatives are offered, the pros and cons for each alternative listed, and a recommendation made. The author is providing only recommendations; The CEIO has to consider DoD flagship program priorities, adaptation with other defense initiatives such as CIM (Corporate Information Management), and budgetary constraints when determining the most appropriate alternative. In some cases more than one alternative may be selected since the alternatives are not always mutually exclusive. The order of presentation is not meant to reflect a priority.

A. Should the CEIO Allow the Systems Integrator to Perform Acceptance Testing?

The CEIO could propose a consistent method for defining the requirements which the systems integrator must meet when assessing the supplier's implementation for a potential government acquisition. Since acceptance testing is a responsibility associated with each procurement, it can often be very expensive.

Issue. Whether the CEIO should recognize any acceptance testing performed by the systems integrator prior to government procurement.

Alternative 1. Prior to obtaining a system, the government user performs full acceptance testing.

Pros.
- Ensures the highest level of confidence for the government user that the system meets the requirements.

Cons.
- Expensive and repetitive for each and every government user, especially when buying systems which meet similar requirements of other earlier procurements.
- Provides a consistent means of measurement across procurements.
- Diminishes workload of government user to establish means of measurement for each procurement.
- Leverages what is usually performed by the systems integrator anyway.

**Cons.**
- Government user still left with some acceptance testing.
- A predefined measurement of the systems integrator process may have to be tailored for each systems integrator or each standard.
- The systems integrator may believe the government has no business assessing the way it conducts business in-house.

**Recommendation.** Alternative 3: The government user applies predefined requirements which the systems integrator applies in-house, and the government user accepts the results.

Support of such a recommendation would require the development of the requirements for this level of acceptance testing. Time and cost could be reduced if some of the acceptance tasks were performed by the systems integrator prior to the government user's assessment. There are too many unique requirements associated with any given procurement to develop one grand scheme for acceptance testing. Developing a definition of the requirements would create a controlled yet flexible environment. The CTN staff would be appropriate resources to assist the CEIO to develop such requirements since they have a combination of technical expertise in the testing arena, as well as an understanding of DoD requirements.

**B. How Should CEIO STEP Validation Funds be Apportioned?**

**Develop a system for testing and evaluating the application protocols which are being defined as parts of STEP.** Should the CEIO invest in a system for testing and evaluating the STEP application protocols as they are being drafted? Is such a testing system necessary?

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7 Within the STEP community, standards testing, as defined in this report, is commonly referred to as STEP validation.
- Early participation in the standardization process increases NIST understanding of the technologies for global federal agency application.
- NIST can better harmonize DoD's requirements and priorities with other federal agencies and the international community.
- NIST has strongly established relationships with other STEP-supporting organizations, e.g., PDES, Inc.
- The physical location of the National PDES Testbed is centrally located along with the office of the National Product Data Exchange Initiative.

Cons.
- STEP expertise is not being developed within DoD.
- Hardware and software investment is not at a DoD site.
- NIST may not understand DoD requirements as well as DoD.

Alternative 3. Instead of the CEIO investing in hardware, software, and test bed environmental support resources for the development of STEP, it should invest in additional technical human resources.

Pros.
- Funding levels can more easily fluctuate because not impacted by hardware, software, site maintenance costs.
- Provides more participation at technical working group level when developing the standard.
- Human resources could be split between DoD and sponsored agency participation to balance objectivity with understanding the requirements.

Cons.
- CALS less in control of influencing implementable content of STEP, since other test beds (e.g., European and Asian activities) would drive the standard's content.
- Potentially less implementable APs as output, since specification text would be written on assumption that it was implementable.
- When human resources move on, no retention/record of corporate knowledge occurs.
**Alternative 1.** Under the sponsorship of the CEIO, NIST should provide conformance testing services for the CALS military specifications.

**Pros.**
- NIST has conformance testing service experience.
- Military specification-level conformance testing services could be harmonized with FIPS conformance testing services.
- NIST participates in the international efforts; therefore, can best maintain international harmonization.
- NIST is an objective agent; no vested interest in outcomes.
- Service could be used by other DoD programs with similar needs, e.g., CIM; therefore, cost sharing could occur.

**Cons.**
- Military specifications are application-specific, and tend to support only one federal agency--DoD.
- DoD expertise would not be built if NIST provided the full services.
- NIST may prefer providing conformance testing services at the FIPS level only, since FIPS benefit multiple government agencies.

**Alternative 2.** Under the CEIO authority, a DoD site, e.g., the Joint Interoperability Test Center (JITC), could be designated to provide conformance testing services for the CALS military specifications.

**Pros.**
- More easily controlled by CALS.
- Facility could be used by other DoD programs with similar needs, e.g., CIM; therefore, cost sharing could occur.
- Potentially one-stop-shopping site for all the testing needs: standards testing, conformance testing, acceptance testing.
- Builds DoD expertise in-house.

**Cons.**
- May not be attractive to other federal agencies who have adopted the CALS military specifications.
- Depending on commercial testing laboratory interest, could potentially place the government in competition with the
Issue. Accreditation of testing laboratories is often viewed as an expensive overhead both in actual dollars required to initiate and time required to establish such a program. Should the CEIO invest?

Alternative 1. Provide testing laboratory accreditation for first, second, and third party testing laboratories through NVLAP. The upper part of Figure 5 shows the general process for accreditation.

![Diagram showing the general process for accreditation]

**Figure 5: Testing Laboratory Acceptance**

**Pros.**
- Better ensures the quality and accuracy of test data.
- Provides some assurance of the technical proficiency and competence of a laboratory to assess an implementation's conformance to a set of prescribed standards [4576-91].
- Better opportunity for international harmonization.
- Ensures consistent test methods and test tools are being employed during the evaluation process.
Pros.
- No up-front cost to CALS.
- Marketing claims are robust, painting successful progress of CALS initiative.

Cons.
- No consistent set of test suite/tools or procedures for comparison.
- Not performed by objective, unbiased party.
- Assurance for conformance only as good as trust in supplier.
- Often quality assurance or acceptance testing (e.g., performance, robustness, data set testing) versus conformance testing practices performed, forcing conformance testing analysis on each buying enterprise user as part of acceptance testing.
- Practice not commonly recognized internationally for information technology standards' implementations.

Alternative 4. CEIO could recognize specific testing tools or test suite only, making them commercially available through National Technical Information Service (NTIS).

Pros.
- CEIO, suppliers, and enterprise users would not be faced with additional costs associated with accreditation.
- Allows cheaper testing for repeated in-house use.
- Provides something for use to the supplier quicker than waiting for an accreditation program.
- Assists supplier during implementation development and component testing.

Cons.
- Does not ensure the application of such tools would be consistent between enterprise users; therefore, could not ensure consistency of results.
- Results would not be recognized internationally.
- Depending on selection of CEIO testing tools or test suite, results may not be recognized by other federal agencies using the military specifications.
- Better prediction of time required to test each implementation in the standards testing environment against the CTN test suite.
- Reduces time required to process a given implementation.
- Allows more time for more volunteer supplier participants.

**Cons.**
- More administrative costs since a new test report would be generated each time an implementation was tested in a different environment.
- Preparatory time and cost would have to be repeated each time the same implementation returned for more testing.

**Alternative 2.** Offer CTN services for both standards testing and interoperability testing at once (status quo).

**Pros.**
- Program manager gets his bottom line: interoperability.
- Reinforces that CALS specifications work in multiple environments.

**Cons.**
- Interoperability performed on two, not necessarily conforming, implementations requires more time since no common ground is established.
- Much redundancy in testing occurs from implementation to implementation; therefore, more expensive.
- CEIO paying for what the individual program manager should pay for.
- Interoperability testing subtracts manpower from standards testing.
- Sends a message to program manager that interoperability is not a program manager's issue; the CEIO will always concern itself with the government user's interoperability requirements.
- Enterprise user may not bother with conformance testing since interoperability is often the greatest concern.

**Alternative 3.** Offer CTN services for only standards testing.

**Pros.**
- More cost effective for CEIO.
- Less system maintenance and manpower required.
F. Should the CTN Acclaim CALS Compliance?

To affirm CALS compliance only for DoD-owned systems. In addition to its scope for standards and interoperability testing, the CTN was given authority to affirm CALS compliance for those implementations already on a DoD system. This has created a perception in the CALS community that any client participating in the voluntary CTN program is, in effect, undergoing conformance testing and can make such claims.

Issue. Whether the CTN should affirm CALS compliance only for DoD-owned systems.

Alternative 1. Allow CTN test beds to claim CALS compliance for those implementations already on DoD systems.

Pros.
- Provides complete continuum of standards testing, conformance testing, and acceptance testing (interoperability testing aspects) for the DoD user.
- Provides in-house DoD user service.

Cons.
- Presents an "uneven playing field." Only those suppliers who are already on DoD systems have an opportunity for such evaluation.
- Such an evaluation is occurring AFTER the product is purchased and DoD is already financially committed.
- Creates public image of confusion as to who is responsible for conformance testing of products.
- Negatively impacts competitive procurement for those requests for proposals which specify "must be CTN-approved."
- CEIO continues to fund (forever?) service requirements for testing.
- Measurement of conformance by CTN may not be consistent with other conformance testing programs established by NIST.
- Does not allow same service for other federal agencies using the military specifications.
- Such complete coverage of all testing activities by one organization does not allow for a checks-and-balances system.
Cons.
- Could not predict workload, therefore may adversely impact standards testing.

Recommendation. Alternative 3: Focus CTN activities on acceptance testing, complements the previous recommendation for separation of standards testing from interoperability testing.

The following issues were not raised in the previous text, but are also some questions facing the CALS community.

G. Could the CEIO Use Supplier-Developed Testing Suites/Tools?

Software and testing tools developed to accomplish component testing by the supplier may be an asset to the CALS initiative if they were made available to accomplish specific testing to CALS requirements. Tools for a commercial conformance testing service are very expensive to develop. Industry also faces a corporate overhead cost.

Corporate development of proprietary testing tools to evaluate the "goodness" and "conformity" of their implementations is usually done in-house. It is costly for the corporation to invest in such testing, but it is deemed worthwhile for such testing to take place. Since this testing is most always done in isolation of other corporations, the cost to develop and implement such testing in tool development and test bed maintenance is high. Such costs are ultimately passed onto DoD through procurements of the implementation itself.

Issue. Should the CEIO try to leverage industry's test suite and tool development resources to benefit conformance testing and reduce industries' investment costs?

Alternative 1. Such proprietary testing tools could be made available to a CALS conformance testing program for: (1) use if complete or (2) adaptation if incomplete.
- Industry-driven/developed test suite/test tools may be biased toward consortium participants' implementations.

Recommendation. Alternative 1: Such proprietary testing tools could be made available to a CALS conformance testing program for: (1) use if complete or (2) adaptation if incomplete. Past experience has shown little cooperation by industry to provide testing tools the supplier has already developed to perform its internal component testing. Such development work is expensive, and most suppliers see little benefit in sharing their internal testing tools. There have been a few exceptions to this, however, where test cases or tools have been provided. Although work is usually required to modify or complete such donations of software for conformance testing, they have served as a foundation.

H. Should the CEIO Invest in the Development of Conformance Testing Services?

In order to establish commercial off-the-shelf (COTS) implementations of CALS military specifications and standards, conformance testing services have to be available. ("Conformance testing services" in this context include everything necessary to establish such a service for a given standard: the development or assessment of a test suite/test tool, establishing the accreditation criteria, and writing the policies and procedures for the conformance testing service.) The CEIO faces continuing budgetary restrictions which affects the priorities. NIST may or may not establish conformance testing services for those FIPS on which the military specifications are based. Even if a FIPS conformance testing service was being established, it may not meet the requirements for CALS specifications. Often there are preliminary syntactic and semantic requirements in the FIPS which the military specification assumes; however, the military specifications impose additional constraints on the application of the FIPS in a DoD environment.

Issue. Should the CEIO fund the development of a conformance testing service at either the FIPS or associated military specification level?
- If a conformance testing service were established independently of CALS, coordination with a FIPS conformance testing service or other international activity may be lacking.
- May not be recognized by other government agencies, therefore forcing suppliers to undergo multiple assessments.

**Recommendation.** Alternative 1: CEIO should fund conformance testing service development at both the FIPS and associated military specification. Unless some other federal agency has identified a strong enough interest in the FIPS to support the development of a FIPS conformance testing service, such a service may not be established. By supporting first the development of a conformance testing service which covers the FIPS, then the military specification, the CEIO can:

- Assess whether further investment in the military specification level is appropriate and efficient.
- Stay harmonized with industry and other government agencies for those FIPS which are based on national and international standards.
- Ensure a conformance testing service will be established which will meet their requirements.

I. How Should the CEIO Ensure Conformance Testing Becomes Part of the Way of Doing Business?

Even if the CEIO establishes conformance testing services, the requirement has to be instilled into both the Defense community and the supporting industry. There are a lot of misunderstandings with terminology, what a specific testing activity provides, and the advent of receiving digital versus hard copy data. Both the enterprise user and the supplier may not appreciate the full value-added in requiring and participating in conformance testing activities.

Even though CALS is funding various conformance testing activities and services, the ultimate measure of success is: whether the procuring enterprise user requires conformance-tested implementations in contracts and whether the supplier is motivated to apply for conformance testing without a request for proposal requirement. The CEIO needs to
Pros.
- Provides primary source of reference for enterprise users.
- The Validated Products List has international recognition as a source document on implementations which have undergone conformance testing.
- Government user's job is made easier when writing requests for proposals (RFPs).
- Creates a more consistent way of doing business.
- Relatively easy to develop policy and guidelines.

Cons.
- Ineffective unless conformance testing readily available.
- May be difficult to enforce policy and guidelines.
- Since the Validated Products List is only published quarterly, it still requires the prompt issuing of a hard copy certificate for a conforming implementation which has successfully undergone conformance testing.
- Adoption of Validated Products List requires CEIO comply with NIST acceptance of test suite/tools, testing laboratory accreditation procedures, and means of reporting test results.

Alternative 3. CEIO provide funding to establish and ensure conformance testing services exist for each of the CALS specifications.

Pros.
- Ensures policies and guidelines are meaningful.
- Ensures the CEIO that testing laboratories will always exist for conformance testing of their military specifications.
- "Tailors" conformance testing services to meet CEIO requirements. (In the case of SGML, other industries [i.e., Aerospace Industry Association] have their own requirements for ensuring conformance testing tools exist specific to their industrial application.
- CEIO can control their budgetary priorities and focus on some standards over others to meet flagship program requirements.

Cons.
- More expensive.
- Face timing constraints given a limited budget.
Alternative 4: Leverage existing commercial efforts and any commercial demands for conformance testing. The automobile industry both here in the United States and abroad, has recognized the benefits in using standards. As an example, IGES, a U.S. national standard, already has supporting conformance testing services offered in the United Kingdom for any application, as well as in Germany for the automotive industry. Electronic publishing and the use of SGML have also brought conformance testing requirements to the forefront in Europe.

In order to "ensure" conformance testing becomes part of the CALS infrastructure, the CEIO should invest time and resources into all of the alternatives; any one alternative will not give the CALS initiative full benefit.
VI. CONFORMANCE TESTING STATUS OF CALS STANDARDS.

The following provides a status of conformance testing programs of standards already adopted under the CALS initiative, as well as those which are related and may be necessary to support CALS applications. Where appropriate, a distinction is made on the status of conformance testing programs at the military specification, federal, national, or international levels. For selected standards, a detailed description of the supporting test suite, test tools, or conformance testing process is provided.

A. CALS Military Standards and Specifications.


The CALS Evaluation and Integration Office (CEIO) is examining the requirements for a conformance testing service for MILSTD-1840.


The only commercial conformance testing service offered for IGES is located at the CAD-CAM Data Exchange Technical Centre (CADDTC) in the United Kingdom. CADDTC has been formally accredited by their national accreditation body to perform conformance testing for IGES. In addition, there are several U.S. and international suppliers that offer proprietary software tools to test IGES data files of implementations. There is also a public domain library of executable test suites developed by the IGES/PDES Organization Test Case Design Committee. None of these tools has been independently assessed for its capabilities and completeness.

For the proposed IGES FIPS (expected publication by end of 1992), there is no commercially available service available. NIST hopes to evaluate those executable software tools and test suites available as a preliminary step to establish a conformance testing service for IGES FIPS.

There is no commercial conformance testing service available for the Digital Representation for Communication of Product Data (Mil-D-28000).
FIPS150; however, there are a few proprietary and public domain executable test suites which have undergone a technical assessment for quality and completeness. Initial focus of this assessment has been Raster Type I. Procedures for running a conformance testing service have been beta-tested under the sponsorship of the CEIO and are published as NISTIR 4848, Raster Graphics Validation. Upon completing enhancements to the selected conformance testing suite, a conformance testing service for Type I is expected to be ready at NIST by the end of 1992. Results will be published in the Validated Products List. An accreditation program is currently under consideration to transfer testing laboratory responsibilities from NIST to accredited first, second, and third party testing laboratories. NIST is also in the process of evaluating Type II conformance testing tools.

Figure 6 shows the raster conformance testing process steps of a client's Implementation Under Test (IUT) as follows:

- Client submits the Raster Graphics Request for Validation form to CSL. The client shall specify the testing environment and the type of encoding (Type I or II) to be tested.

- NIST instructs the testing laboratory to assemble and send to the client a conformance test package consisting of instructions, forms, and two sets of test cases formatted in accordance with MILSTD-1840 and MIL-R-28002. The first set (or document) will consist of uncompressed, binary bitmap images of various sizes and contents. The second set will consist of images of various sizes and similar (though not identical) contents to the first set but will be encoded following FIPS PUB 150 (Type I and II) and FIPS "Raster DAP" (Type II only).

- Using the instructions and forms received from the testing laboratory, the client processes the test suite through the IUT. The set of bitmap images (set 1) is processed creating the client's version of the encoded files, and the set of laboratory encoded files (set 2) is decoded/decompressed creating the client's version of the bitmap files. Both sets of these client processed images will then be formatted by following MILSTD-1840 and MIL-R-28002. At the
The client sends the processed files to the testing laboratory for evaluation.

The testing laboratory will evaluate each of the returned set of files comparing them with the expected results to determine if the client's IUT produced the expected results. The client's encoded images from set 1 will be compared to the laboratory's encoded versions of the original binary bitmap images. The client's bitmap images from set 2 will be compared to the laboratory's bitmap images. This procedure verifies the correctness of the encoding and compression/decompression algorithm, as well as the information contained in the raster data file header records regarding the image orientation, dimension, and pel density. The results of this comparison will be evaluated and documented for inclusion in the Validated Summary Report. The evaluation is based upon only the stated system configuration and does not indicate what the system would produce under a different configuration.

The testing laboratory prepares a Validated Summary Report containing the results of the conformance testing [FS92].


A full conformance testing service is available at NIST to test an implementation's data files for conformance to the ISO CGM standard (which is adopted through FIPS 128), as well as the Digital Representation for Communication of Illustration Data: CGM Application Profile (MIL-D-28003). The results of such testing are published in the Validated Products List. To date (August 24, 1992), one conformance assessment has been completed, and two have applied for the service.

NIST anticipates offering a conformance testing program for CGM generators by the end of 1992. Generator testing will be comprised of the metafile conformance testing already offered plus additional steps.

Figure 7 shows the CGM conformance testing process for both a client's metafile and generator.
generates CGMs from the test script and test images. These CGMs are analyzed syntactically and semantically for completeness. The client is responsible to provide not only the metafiles, but a hard copy graphical representation of the metafile (if appropriate), and the client's internal format used to generate the metafile.

The same automated syntactical check occurs against the metafiles, as well as automated semantical visual and completeness checks. At the culmination of generator conformance assessment, a test report is prepared, and again, with the client's permission, the results are published in the Validated Products List.


Since CITIS is not yet an accepted military standard, no conformance testing service has been implemented.


NIST, in conjunction with the Joint Interoperability Test Center (JITC) at Fort Huachuca, Arizona, offers a U.S. GOSIP Register Database (GRD). This GRD provides the following up-to-date reference information relative to FIPS 146 conformance testing: U.S. GOSIP abstract test suites; assessed means of testing; NVLAP-accredited first, second, and third party testing laboratories; and conformance tested GOSIP products. Information about access to this GRD is published in the Validated Products List.

Figure 8 is the conformance assessment process overview for GOSIP IUTs. The conformance assessment process involves three phases: preparation for testing; test operations; and test report production.

The preparation for testing includes producing the system conformance statement, Protocol Implementation Conformance Statement (PICS), and Protocol Implementation Extra Information for Testing (PIXIT); choosing the appropriate abstract test method and abstract test suite based on the PICS and PIXIT; and preparing the SUT and means of testing.

The test operations phase involves a static conformance review, conducted by analyzing the PICS with respect to the relevant static

There is no conformance testing service available. Virginia Polytechnic Institute (VPI) and State University, Blacksburg, Virginia, has a proprietary executable test suite developed. Seven VHDL CAD suppliers provided funding for the initiative. Vantage, one of the participating CAD suppliers, also provided an initial test suite that was jointly developed by Vantage and Intermetrics under contract to the Air Force (AF Wright Laboratory, Solid State Electronics Directorate). The Vantage/Intermetrics test suite had high granularity tests. VPI designated test points at the paragraph level, then associated the test cases from the Air Force initiative, affecting the initial structure of the Vantage/Intermetrics test suite.

VPI's test suite software is free to universities and $2000 for non-universities. The VPI test suite tests primarily (85%) static semantics, and the remainder dynamic semantics.

The Air Force has assessed the VPI test suite and finds it the most complete in existence to date. The Air Force would like to find funding to build upon this test suite to make it more complete. There has also been preliminary discussion with the CEIO about taking over the VHDL standard and associated conformance testing service requirements [JA92], [JH92].


There is currently no formal activity in conformance testing of EDIF. The University of Manchester, United Kingdom, does have a reference implementation which has not undergone an independent assessment; however, if a supplier so chooses, the supplier may send EDIF files to the University of Manchester to be run against this reference implementation [RP92].

10. Institute for Packaging of Electronic Components (IPC) Standards.

There are several standards by the IPC 350 series. These include:

- Printed Board Description in Digital Form (IPC-D-350).
present and correctly defined in the output files; and a Manual view which
verifies presence and accuracy of features in photoplots and paper check
plots [IPC91]. Assessment of the required changes is made, and the
results reported to IPC. IPC issues a certificate of conformity for those
implementations meeting the requirements.

Although no work is underway to provide conformance testing services for
the remainder of the D-350 series, IEC is expected to embrace the other D-
350 standards as part of the IEC 1182 series. This adoption is expected to
promote further requests and incentive to develop conformance testing
services for the remainder of the D-350 standards [BD92].

11. Electronic Data Interchange (EDI) Transaction Set 841.

The EDI Transaction Set 841 is called out as an alternative transmission
in MILSTD-1840B. As mentioned previously, the overall conformance
testing requirements for MILSTD-1840 are currently being assessed.
However, since the national EDI standard is still under the status of "draft
standard for trial use," no known conformance testing activity or test
suite development is occurring.

B. Future Candidate CALS Standards.


STEP has not been adopted as an international standard to date; therefore,
no conformance testing service is available. Development of abstract test
suites to support STEP application protocols is underway, and initial work
on a conformance testing system is being funded by the Navy
Manufacturing Technology (MANTECH) Program. NIST is providing technical
and managerial oversight; the Industrial Technical Institute (ITI) of
Michigan is doing the major portion of the technical development. A
memorandum of understanding has been established between the National
PDES Testbed, ITI, and PDES, Inc., to collaborate on the development of an
ATS. Current activities in support of STEP include proposing the abstract
test notation for ATSSs and performing a requirements and capabilities
survey. A survey of existing STEP tools, which may contribute toward a
conformance testing system, has been completed. An additional
2. Database Language SQL.

NIST offers a conformance testing service for implementations which claim conformance to Database Language SQL FIPS 127-1 Level II (including the integrity enhancement feature). The results are published in the Validated Products List.

Figure 10 shows a system flow diagram for basic SQL testing. The system flow for testing the integrity enhancement is identical in structure. Running an SQL test suite consists of five steps.

**Figure 10: SQL System Flow Diagram** [SQL92]

In step 1, the schema files are processed in some implementor-defined manner, perhaps interactively.

In step 2, a program is run to insert values into six of the base tables. The contents of these six tables will remain unchanged throughout
A high-level view of the IRDS conformance testing system architecture is provided in Figure 11. The following are the components of the architecture:

![Diagram of IRDS System Architecture]

**Figure 11: IRDS System Architecture**

**Command Language Test Suite.** This is implemented as a set of text files corresponding to the test sets in the suite and is supplied by NIST. The format of each file is precisely that of a batch file of commands.

**Command Language Interface Driver.** This software component processes the Command Language Test Suite using the candidate IRDS. The organization of the test suite assumes that, as a practical matter, this processing is done on a test set by test set basis. For each command in the test set, the Driver echoes and executes that command; formats all direct output, including error and success messages and Output IRD and Output IRD Schema displays; and writes the results, in the required canonical format, to the Command Language Test Results File.
C. Candidate CALS Standards Contained in CIM Technical Reference Model.

1. Portable Operating System Interface for Computer Environments (POSIX).

As of mid September, 1992, over 70 implementations have been validated for conformance to FIPS 151-1. On a quarterly basis, validated POSIX implementations are listed in the Validated Products List. POSIX conformance testing is operated through accredited testing laboratories, of which there are currently eight. A NIST POSIX Electronic Mail File Service is available for on-line access to the most recent information associated with the POSIX conformance testing service. Via Internet, a system's user only needs to type "posix@nist.gov" at the mail level to access the POSIX Electronic Mail File Service. Current cost for the test suite (through NTIS) is $2,500.

The European Community under the Conformance Testing Services II (CTS2) initiative also has a POSIX conformance testing service. They chose the X/Open test suite VSX for the EC POSIX conformance testing services. Activity has been ongoing to harmonize the U.S. NIST and EC conformance testing services.

X-Open also offers their conformance testing suite and certification mark program to those suppliers desiring to perform their own conformance testing.


A conformance testing service was started at NIST October 1, 1992. This conformance testing service uses version 2 of the PHIGS Validation Tests (PVT). Both version 2 and its predecessor, version 1, were developed by NIST. Version 1 was made available in July 1990, but was used only for component testing by implementors. The NIST conformance testing service measures conformance of PHIGS implementations to PHIGS FIPS 153.

Figure 12 depicts the processes associated with the PHIGS conformance testing process. Semantic requirements are identified in the PHIGS
functions and data may or may not correspond to the IUT's actual functions and data.

3. X-Window.

The U.S. Government will provide third-party conformance testing services through NVLAP when test suites and testing policy for FIPS PUB 158 are available. Such availability is expected around 1995.

4. Integrated Services Digital Network (ISDN).

NIST is developing the abstract test suites for ISDN layers one through three, which will be included as part of the conformance testing program for "GOSIP 2" (FIPS 146-1). These ATSs will also cover the conformance requirements associated with the proposed FIPS for ISDN. The conformance testing service for the ISDN applications associated with layers one through three is anticipated by the end of 1992.

The European Community (EC), under the Conformance Testing Service II (CTS2) activities, is also developing a conformance testing service for the ISDN layers. NIST and the ISDN CTS2 EC participants are attempting to harmonize their abstract test suites through the Consultative Committee on International Telegraph and Telephone (CCITT). Currently, there is too much disagreement to harmonize the layer one ATS; therefore, the United States and Europe will each retain their own for ISDN layer one conformance testing activities. Further agreement has been reached for layers two and three: Europe has adopted the U.S. ATS for layer two, and the U.S. has adopted the European ATS for layer three. The CTS2 initiative is working on an ATS for layer four which the United States is considering for adoption [SU92].
VII. CONCLUSION.

Multiple disparate activities have been started and is continuing under the CALS umbrella of "testing." The CEIO continues to assess the overall testing investment and the continued requirements for the various levels of testing within the CALS community. Testing is a recognized and accepted process to be performed at various levels of standard and product development and enterprise user integration:

{standards} test and develop the standard
{component} test and develop the COTS implementation
{conformance} test and deploy the COTS implementation
{acceptance} test and accept the COTS implementation into the user enterprise

These levels of testing activity are dependent on one another. The ultimate goal is to ensure the government user's requirements at the system procurement level have been met. Without the cumulative support from strong standards testing, component testing, and conformance testing programs, the effort and cost associated with CALS acceptance testing would be redundant and inefficient.

Several issues which face the CALS initiative were highlighted in this report. The following are a summary of the issues and their associated recommendations. The CEIO should:

Issue. Whether the CEIO should recognize any acceptance testing performed by the systems integrator prior to government procurement.
Recommendation. The government user applies predefined requirements which the systems integrator applies in-house, and the government user accepts the results.

Issue. Whether it is cost-effective for the CEIO to fund a validation testing system for STEP, and if so, where should such a system be hosted.
Recommendation. Sustain a Validation Testing System for STEP at NIST.
**Issue.** Even if conformance testing services existed for all the CALS military specifications, how does the CEIO guarantee enterprise users will take advantage of such services?

**Recommendation.** Instill conformance testing into the infrastructure through changes to the Federal and Defense Acquisition Regulations; develop policy and guidelines which implement conformance testing into the purchasing infrastructure; provide funding to establish and ensure conformance testing services exist for each of the CALS specifications; and leverage existing commercial efforts and any commercial demands for conformance testing.

The world of information technology standards is not a finite, bounded environment where decisions can be made and proven with mathematical precision. The CEIO must depend on consensus building to acquire standards for the CALS community which reflect the functionality necessary to meet DoD requirements. Testing activities and supportive terminology and policies can also be selected from many correct alternatives. This report has highlighted some of the most commonly recognized terminology and processes, and supports the CEIO in choosing what best meets its environment. The CEIO must assess the technical, political, and economic ramifications of its decisions for any given weapon system acquisition or supporting life cycle program.
VIII. BIBLIOGRAPHY.


[1144K] NIST-1144K (Rev.11-91), National Voluntary Laboratory Accreditation Program Fee Schedule (Effective 10/1/91).


ANSI Z34.1-1987, Third-Party Certification Program.

ANSI Z34.2-1987, Self-Certification by Producer or Supplier.
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Appendix A: Terminology and Acronyms

A. Terminology.

abstract test method: The description of how an IUT is to be tested, given at an appropriate level of abstraction to make the description independent of any particular realization of the means of testing, but with enough detail to enable tests to be specified for this test method [9646-1].

abstract test suite: A complete set of abstract test cases, possibly combined into nested abstract test groups, that is necessary to perform conformance testing for a standard or group of standards [31-92].

acceptance test: (ISO 2382, Vocabulary - Information Processing) A test of a system or functional unit, usually performed by users on their premises after installation, with the participation of the vendor to ensure that contractual requirements are met [FIPS11-3].

{user} acceptance testing: Determines whether a software system satisfies its acceptance criteria and enables the user to determine whether to accept the system. This includes the planning and execution of several kinds of tests (e.g., functional, volume, performance tests) to demonstrate the implemented software satisfies the user requirements. NOTE - This does not form part of conformance testing [31-92].

(laboratory) accreditation: The formalized initial and continuing process of ensuring a testing laboratory is competent to carry out specific (types of) tests. NOTE - The term "laboratory accreditation" covers the recognition of both the technical competence and the impartiality of a testing laboratory. Accreditation is normally awarded following successful laboratory assessment and is followed by appropriate surveillance [31-92].

accreditation body: A body that conducts and administers a laboratory accreditation scheme and grants accreditation [31-92].
conformance assessment process: The complete process of accomplishing all conformance testing activities necessary to determine the conformance of an implementation [31-92].

conformance test report: A document written at the end of the conformance assessment process, which provides both summary and detailed information [31-92 generalized9].

conformance testing: Testing the extent to which an IUT is a conforming implementation [9646-1].

conformity, conformance: Fulfillment by a product, process, or service of specified requirements [ISO2].

enterprise user. An organization or person who builds, uses, maintains, or disposes of information generated from an implementation.

executable test suite: A complete set of executable test cases (an instantiation of an abstract test case with values) that is necessary to perform conformance testing for a standard or group of standards [31-92].

first party testing laboratory: See third party testing laboratory.

Implementation Under Test: That part of a product which is to be studied under testing, which should be an implementation of one or more characteristics of the standard(s) [31-92 generalized].

implementor: See supplier.

interoperability testing: Related to acceptance testing, but applied to the examination of the information exchange and sharing between two specific implementations under test (IUT) and the ability of each IUT to use such information. NOTE - This does not form part of conformance testing [31-92].

9 Those definitions referenced in this manner have been generalized since the definition contained text specific to STEP.
static conformance review: A review of the extent to which the static conformance requirements are met by the IUT, accomplished by comparing the PICS with the static conformance requirements expressed in the relevant international standard(s) or CCITT recommendation(s) [9646-1].

supplier, vendor, implementor: An organization or individual who develops commercial off-the-shelf implementations.

supplier's declaration: Procedure by which a supplier gives written assurance that a product, process or service conforms to specified requirements. Note - In order to avoid confusion, the expression "self-certification" should not be used [ISO2].

System Under Test: The computer hardware, software, and communication network required to support the IUT [31-92].

test campaign: The process of running the executable test suite for a particular IUT [9646-1].

test method: Specified technical procedure for performing a test [ISO2]. Specified technical procedure for performing a testing service, including the specification of the individual test cases which comprise a test suite; the test tools (both hardware and software) used to run those executable test cases and the way in which those test tools are used; and the procedures used to select and run the test cases and to analyze the observations and state the test results [EW15].

test tool: Hardware and/or software, excluding the test suite itself, which is run under the control of the testing laboratory, in order to carry out, or assist in carrying out, the testing required [EW15].

testing: Action of carrying out one or more tests (Technical operation that consists of the determination of one or more characteristics of a given product, process or service according to a specified procedure.) [ISO2].
CCITT: Consultative Committee on International Telegraph and Telephone
CD: Committee Draft
CE: Concurrent Engineering
CEC: Commission for European Community
CEIO: CALS Evaluation and Integration Office
CITIS: Contractor's Integrated Technical Information Service
CGM: Computer Graphics Metafile
CIM: Corporate Information Management
COTS: Commercial Off-The-Shelf
CTN: CALS Test Network
CTS: Conformance Testing Service
DLA: Defense Logistics Agency
DSREDS: Digital Storage and Retrieval Engineering Data System
EC: European Community
EDCARS: Engineering Data Computer Assisted Retrieval System
EDIF: Electronic Design Interchange Format
EDMICS: Engineering Data Management Information and Control System
GCA: Graphic Communications Association
GKS: Graphical Kernel System
GOSIP: Government Open Systems Interconnection Profile
JITC: Joint Interoperability Test Center
IEC: International Electrotechnical Commission
IGES: Initial Graphics Exchange Specification
IPC: Institute for Packaging of Electronic Components
IPO: IGES/PDES Organization
IRDS: Information Resource Dictionary System
ISG: Industry Steering Group
ISO: International Organization for Standardization
ITI: Industrial Technical Institute
IUT: Implementation Under Test
MOU: Memorandum of Understanding
NIST: National Institute of Standards and Technology
NPT: National PDES Testbed
NSIA: National Security Industrial Association
PDES: Product Data Exchange using STEP
PHIGS: Programmer's Hierarchical Interactive Graphics System
PICS: Protocol Implementation Conformance Statement
Appendix B: Existing Directives and Guidelines

Standards Testing.

- CTN 91-042, CALS Test Network Handbook.

This series of NIST publications are specific to validating various aspects of STEP:

- NISTIR 4417, Development Plan: Validation Testing System.

- NISTIR 4636, Validation Testing System Requirements.


- NISTIR 4735, Validating STEP Application Models at the National PDES Testbed.

- NISTIR 4742, Architecture for the Validation Testing System Software.

Component Testing.


- ISO/IEC Guide 27, Guidelines for Corrective Action to be Taken by a Certification Body in the Event of Either Misapplication of its Mark of Conformity to a Product, or Products which bear the Mark of the Certification Body being Found to Subject Persons or Property to Risk.


- ISO/IEC Guide 45, Guidelines for the Presentation of Test Results.

- European Norm, EN45000 series: These "European Norm" standards relate to criteria for accrediting testing laboratories, operating laboratory accreditation bodies and certification bodies, and performing supplier's declaration of conformity.

- IS 9646-1 through 5: This series of standards pertain to conformance testing requirements specific to GOSIP.

- ISO "CD" 10303-31 through 34: This series of working draft and committee draft standards pertain to conformance testing
- FIPS 75, Guideline on Constructing Benchmarks for ADP System Acquisitions, September 18, 1980.


- CTN Report 91-023, "Field Testing of Phase I Data Acceptance Procedures."


- CALS/CE ISG Report, "Delivery Verification and Acceptance Testing Guideline."


- IPO, "Interoperability Testing Methodology IGES Guidelines."
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Sharon J. Kemmerer

If the CALS initiative is to be successful, government and industry have to attain a high level of confidence that the CALS specifications and standards are adequate to satisfy the requirements for digital delivery of technical data supporting user applications. Equally as important, both government and industry must be satisfied industry implementations can deliver this technical data according to a set of specifications and standards. For this to happen, CALS has to influence testing in three areas: standards, conformance, and acceptance testing [JCMO91].

The content of this report covers those testing activities which have been or are funded by CALS, by DoD services, or by industry to support CALS. Although specific activity descriptions may be limited to the CALS community, the types of testing activities generically described in the following pages, the author believes, satisfy most enterprise users' application requirements.

acceptance testing; CALS; component testing; conformance; conformance testing; military specifications; standards; standards testing; Validated Products List.

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