

EVALUATION AND VALIDATION OF ADA PROGRAMMING SUPPORT ENVIRONMENTS : 5 YEARS AFTER

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ABSTRACT

This paper provides information on the Evaluation and Validation Task sponsored by the Ada Joint Program Office. Included is a rationale for the program, a description of objectives and a summary of active projects. With the recent proliferation of APSE tools, compilers in particular, it is important to have the capability to select the proper tools for the intended application. To address this complex problem the E&V Task uses several mechanisms including the E&V Team composed of government representatives and distinguished reviewers from industry and several E&V-technology development contracts. These elements actively interact to insure that all E&V products address the needs of the Ada E&V community.

INTRODUCTION

The Ada Joint Program Office (AJPO) was formed in December 1980. It is the principal DoD agent for development, support and distribution of tools, common libraries, and coordination of Ada activities within the DoD. The AJPO coordinates all Ada efforts within DoD to ensure their compatibility with the requirements of the Services and DoD agencies, to avoid duplicative efforts and to maximize sharing of resources.

In June 1983 the AJPO proposed the formation of the E&V Task and a tri-service APSE E&V Team, with the Air Force designated as lead service. In October 1983 the Air Force officially accepted responsibility as lead service on the E&V Task with the Air Force Wright Aeronautical Laboratory as the lead organization. Since June 1985, the E&V Task has been led by Mr Raymond Szymanski of the Avionics Laboratory.

THE NEED FOR EVALUATION AND VALIDATION TECHNOLOGY

The Ada community, including government, industry, and academic personnel, needs the capability to assess APSEs (Ada Programming Support Environments) and their components and to determine their conformance to applicable standards (e.g., DOD-STD-1838, the CAIS standard).

The technology required to fully satisfy this need is extensive and largely unavailable; it cannot be acquired by a single government sponsored, professional society sponsored, or private effort. The purpose of the Evaluation and Validation (E&V) Task is to provide a focal point for addressing the need by (1) identifying and defining specific technology requirements, (2) developing selected elements of the required technology, (3) encouraging others to develop other elements, and (4) collecting information describing existing elements. This information will be made available to DoD components, other government agencies, industry, and academia.

Technology for the assessment of APSEs and APSE components (tools) is needed because of the importance of the decisions to be supported by these assessments and because of the difficulty of making them. The importance of the decision to select an APSE (or the approach to incremental development of an APSE) is evident when one considers the large, critical, Ada-based systems to be developed in the coming years. The effectiveness, reliability, and cost of these systems will be strongly influenced by the environments used to develop and maintain them. From the point of view of a software developing organization, the decision to select an APSE can be an important investment decision with long lasting influence on a

number of projects and the organization's methods of operation, training, and competitiveness.

The difficulty of assessing APSEs and tools is evident for several reasons. First, an APSE represents complex technology with many elements which can be assessed individually or in combination. Second, there is a confusing diversity of choice with respect to individual tools, tool sets, or "whole APSEs"; and there are a number of ways of viewing APSEs. The state of the art of APSE architecture and of some categories of tools is undergoing rapid change (Eg. graphic design tools). Finally, there is a lack of historical data relevant to APSEs, partly because of the general pace of technological change and partly because we are dealing with Ada, a relatively new implementation language.

In addition to the need for assessment technology, there is a need for information about this technology. Potential buyers and users of APSEs and tools need a framework for understanding APSEs and their assessment, as well as information about specific assessment techniques. Similarly, vendors of tools and APSEs need to be aware of the deficiencies of current products, as well as the criteria to be used in the assessment of future products. Such awareness by both producers and consumers of APSE products, expressed in a common terminology, will accelerate the development of better software environments.

OBJECTIVES AND ACTIVITIES

In order to accomplish the purpose of the E&V task, several specific objectives have been identified. These are discussed next with descriptions of activities that will enable the E&V task to meet these objectives.

1. Develop Requirements for E&V

As a prerequisite to the development of APSE E&V technology, E&V requirements must be specified. The development of E&V requirements will be based upon examination of APSE related

issues such as life-cycle methodologies, human engineering aspects, software engineering practices, etc. The E&V requirements which are developed will be used to guide the E&V technical effort.

The currently defined set of E&V requirements are contained in The E&V Requirements Document, Version 2.0. This document is part of the E&V Team Public Report, Volume III, which is available through the Defense Technical Information Center as AD Number A196 164.

2. Develop APSE Evaluation Capability

An evaluation capability will be developed for some APSE components for which there exist no formal standards (i.e., MIL-STD, ANSI, etc.). The evaluation capability for some components will be provided through established metrics, whereas the evaluation capability for other components may be limited to a detailed questionnaire.

As a first step toward achieving this objective, an Ada Compiler Evaluation Capability is being developed which will enable the user to compare the performance of different Ada compilers. Details of this effort will be presented later.

3. Develop APSE Validation Capability

A validation capability will be developed for the Common APSE Interface SET (CAIS), DoD-STD-1838, which has been developed under AJPO sponsorship. As other APSE related standards are established (i.e., 1838A), appropriate validation capabilities will be considered for development. Examination of the current validation procedures and the Ada Compiler Validation Capability (ACVC) test suite utilized by the Ada Validation Organization (AVO), as well as procedures implemented by ANSI and ISO, will be used as a foundation. The CAIS Operational Definition (CAIS OD) work at Arizona State University will provide a baseline from which a validation capability may be evaluated.

At present, a validation suite for DoD-STD-1838 is under development. Plans are also being

established for a validation suite for proposed DOD-STD-1838A. The 1838 validation suite effort will be detailed later in the paper.

4. Develop Evaluation & Validation Tools and Aids

As the requirements for E&V are determined, various software tools/aids will be identified as essential to the E&V effort. Such tools/aids include test sets, test scenarios, data reduction capability, and other designated means of automated support. As these tools/aids become more clearly defined, an assessment will be made to include such capability. Existing tools/aids which are applicable to the E&V Task will be considered for use.

A document titled "E&V Tools and Aids" details the E&V Team's deliberations and recommendations on this subject and is available in the E&V Team Public Report, Volume III.

5. Provide Initiative and Focal Point For APSE E&V

There currently exists a need to provide a focal point for APSE developers and users with regard to information about E&V of APSEs. APSE E&V questions arise frequently within professional societies and user groups. A forum is needed in which APSE E&V questions can be addressed and discussed, and in which APSE E&V information can be disseminated throughout the Ada community.

The E&V Team, through its quarterly meetings, will provide a focal point for APSE E&V for the Ada community. Public reports on the results of this activity will be made available to professional organizations such as SIGAda and AdaJUG. This is in keeping with the AJPO philosophy of public dissemination of information. The E&V task is the lead DoD effort with regard to APSE E&V. In this respect, the E&V Team will participate in, and assist where possible, other programs technically related with APSE E&V. Such programs include the Ada Validation Organization and international development efforts. To insure that its activities are relevant to the entire Ada community the E&V task

will continue to allow distinguished reviewers from industry to attend the quarterly E&V team meetings.

6. Promote Community Use and Acceptance of the E&V Effort

Use of the E&V technology developed through this task will provide for an orderly progression of technology insertion into user environments. The E&V technology thus developed will be extendable to other software development efforts, thereby maximizing the economic benefits of the E&V task products and minimizing the cost within DoD and industry of doing E&V related work.

In addition to the E&V Team products mentioned above, the E&V Task is responsible for three major contractual efforts. These include the Ada Compiler Evaluation Capability (ACEC), the E&V Reference System, and the CAIS Implementation Validation Capability (CIVC). As part of each development effort the E&V contractors provide quarterly briefings to E&V Team meeting participants. This information is generally used during the E&V team's working group sessions, during which the presentation issues are discussed in detail as a form of feedback from the E&V community.

The following sections provide brief technical descriptions of the ACEC, the E&V Reference System, and the CIVC.

E&V TECHNOLOGY DEVELOPMENTS

APSE E&V REFERENCE SYSTEM

The E&V Reference System is a coordinated set of documents comprised of the E&V Reference Manual, Version 1.1 and the E&V Guidebook, Version 1.1. They provide information about APSEs (Ada Programming Support Environments) and their assessment.

The E&V Reference Manual establishes common terminology and a framework for understanding APSEs. It includes a Life-Cycle Activities Index, a

Tool Category Index, a Function Index, and an Attribute Index. Each index entry contains a definition, cross references to entries in the same or other indices, and pointers to relevant sections in the E&V Guidebook. As a stand-alone document it is intended to help users find information about index elements and relationships among them. In conjunction with the Guidebook, it is intended to help users find criteria, metrics, and methods for assessment of APSEs and their components.

The E&V Guidebook provides descriptions of specific instances of assessment technology. These include evaluation (assessment of performance and quality) or validation (assessment of conformance to a standard) techniques. For each category of item to be assessed (e.g. compilation system, test system, whole APSE, etc.) there are descriptions of various techniques such as test suites, questionnaires, checklists, and structured experiments. The Guidebook also contains synopses of documents of general historical importance to the field of Ada environments and their assessment.

ADA COMPILER EVALUATION CAPABILITY (ACEC)

The Ada Compiler Evaluation Capability (ACEC) is a product which enables users to determine the performance characteristics of Ada compilation systems. The ACEC includes the ACEC Software Product and three supporting documents: the ACEC Users Guide, the ACEC Version Description Document (VDD), and the ACEC Readers Guide.

The ACEC Software Product consists of both operational software and support software. The operational software is a suite of performance test programs which makes it possible to:

- compare the performance of several Ada compiler implementations;
- isolate the strong and weak points of a specific system relative to other systems which have been tested;

- determine what significant changes were made between releases of a compilation system; and
- predict performance of alternate coding styles.

The ACEC tests provide assistance in measuring execution time efficiency, code size efficiency, and compile time efficiency. The test suite does not explicitly cover tests for usability, capacity, or existence of language features. However, in the course of exercising the test suite, these items may be covered.

The support software consists of a set of tools and procedures which assist in preparing the test suite for compilation, in extracting data from the results of executing the test suite, and in analyzing the performance measurements obtained. The support software consists of the following tools:

- **INCLUDE** -- assists in adapting programs to particular targets by performing source test inclusion;
- **FORMAT** -- extracts timing and code expansion data; and
- **MEDIAN** -- compares results of performance tests of various systems.

The ACEC Software Product was developed for uniprocessor, uniprogramming target systems and is distributed on one 9-track, 1600 bpi, VAX/VMS backup tape.

The ACEC Users Guide provides ACEC users with the information necessary to adapt and execute the ACEC Software Product. This guide explains how to use the support tools and how to deal with problems which may occur in the process of executing the ACEC Software Product. The ACEC Readers Guide describes how users can interpret the results of executing the benchmark test suite, the statistical significance of the numbers produced, the organization of the test suite, and how to submit error reports and change requests. The ACEC Version Description Document (VDD) describes the ACEC Software Product as contained on the distribution tape. This product includes the compilation units, programs, test problems, specific language features and optimizations, and sample data.

CAIS IMPLEMENTATION VALIDATION CAPABILITY (CIVC)

The goal of the CAIS is to promote interoperability and transportability of Ada software across APSEs used by the DoD. Those Ada programs that are used in support of software development and lifecycle maintenance are defined as "tools". The CAIS, more formally known as DoD-STD-1838, is a document produced under AJPO sponsorship that defines the Ada package specifications for interfaces to those services, traditionally provided by operating systems, that significantly impact tool transportability. A second evolutionary step towards a full, state-of-the-art interface definition is currently under Government review. This proposed standard, DoD-STD-1838A, is an upgraded and more complex set of interfaces with compatibility to DoD-STD-1838.

The objective of the "CAIS Implementation Validation Capability" (CIVC) is to develop usable and reliable validation test suites for CAIS and CAIS-A implementations. The purpose of this validation capability is to test conformance of an implementation of the CAIS to the standard. The rationale for such a capability is to increase the reliability, usability, and acceptability of such a standardized interface set.

The CIVC contract provides for the development and delivery of a CIVC test suite and associated support products. The contractor will develop a taxonomy suitable for evolutionary development of the validation capability and deliver an integrated hypertext-based requirements traceability product to facilitate assessment of the completeness of the validation capability.

The CIVC Test Administrator will provide a convenient and reliable user-interface to the validation capability. This feature will facilitate application of the CIVC by both CAIS developers and CAIS users. The hypertext product provides an interactive vehicle for analyzing the connection between:

- requirements (paragraphs in DoD-Std-1838);
- test objectives (developed from requirements);
- test scenarios (test design definitions); and,
- actual test cases (Ada code).

The CIVC contract has recently completed CDR and has moved into the development phase where test cases, the Test Administrator code, and associated traceability documentation will be produced. The initial operational capability is scheduled for delivery in the fourth quarter of this year (4th Q, 1989).

E&V TASK OUTLOOK

To date, considerable progress has been made in the the areas of E&V problem definition and creating solutions to those problems in the form of E&V technology developments. This author believes that many challenges in this area still exist and will exist for some time to come. The E&V task is scheduled to continue through 30 September 1991 when the last contractual effort terminates. Hopefully, a far-sighted organization within the Air Force will understand the importance of the E&V effort and will continue where the current effort leaves off.

OBTAINING E&V INFORMATION

The ACEC documentation described above is available in hardcopy form or as a package distributed in Latex format on one 9-track, 1600 bpi, VAX/VMS backup tape.

Please note that all ACEC products are subject to the DoD Directive 5230.25, Withholding of Unclassified Technical Data from Public Disclosure, which limits the distribution of unclassified export-controlled technical data to organizations certified as qualified contractors by the Defense Logistics Services Center (DLSC). It is not necessary for Government activities to be DLSC certified.

To order the ACEC software and documentation,
please contact the DACS at the following address.

Data & Analysis Center for Software
RADC/COED
Griffiss AFB, NY 13441-5700

ATTN: Document/Dataset Ordering
(315) 336-0937

To obtain information concerning the availability
of E&V products such as the E&V Reference
System, the CIVC, or E&V Team documents send
your name and address electronically (preferred)
to: szymansk@ajpo.sei.cmu.edu, or by regular
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About the author, Raymond Szymanski:

Mr Szymanski is currently the Program Manager
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Task sponsored by the Ada Joint Program Office.
In addition to administering technical contracts for
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AdaJUG, Ada Europe (Edinburgh), and the Ada
Board (former member).