

IEEE Trial-Use Standard for Artificial Intelligence and Expert System Tie to Automatic Test Equipment (AI-ESTATE): Overview and Architecture

Sponsor

**IEEE Standards Coordinating Committee 20,
Abbreviated Test Language for All Systems (ATLAS)**

Approved September 21, 1995

IEEE Standards Board

Abstract: This document is the base standard for the AI-ESTATE set of standards. The overall concept of AI-ESTATE, which is a set of specifications for data interchange and for standard services for the test and diagnostic environment, is defined; mandatory requirements for implementing AI-ESTATE are specified; the elements of AI-ESTATE and their interrelationships are described; guidelines and requirements to govern the documents in the AI-ESTATE set of standards are established; and the terminology used throughout the set is defined. The purpose of the AI-ESTATE set of standards is to standardize interfaces between functional elements of an intelligent test environment and representations of knowledge and data for the functional elements of the intelligent test environment.

Keywords: AI-ESTATE, artificial intelligence, diagnosis, system test, unit under test (UUT)

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ISBN 1-55937-565-5

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Introduction

[This introduction is not part of IEEE Std 1232-1995, IEEE Trial-Use Standard for Artificial Intelligence and Expert System Tie to Automatic Test Equipment (AI-ESTATE): Overview and Architecture.]

The domain of equipment test and diagnosis is one in which numerous reasoner systems have been successfully developed and deployed. The benefits of using standards in test-related applications have long been recognized. The scope for standardization extends from low-level standards associated with instrument control to high-level standards associated with specifying tests in an implementation-independent manner.

In the 1960s, Aeronautical Radio Incorporated (ARINC) started the development of the Abbreviated Test Language for Avionics Systems (ATLAS). In 1976, management of the ATLAS standard was passed to the IEEE, and the meaning of the ATLAS acronym was changed to Abbreviated Test Language for All Systems to reflect its broader field of application.

Within the IEEE, development of ATLAS-related standards was vested in Standards Coordinating Committee 20 (SCC20). This was also known as the ATLAS Committee. In the mid-1980s, SCC20 broadened the scope of its activities to include other potential standards related to testing including Automatic Test Program Generation (ATPG) and Test Equipment Description Language (TEDL).

Current and proposed test standards, including IEEE Std 716-1995 (C/ATLAS), IEEE 993-1990 (TEDL) and IEEE 1029.1-1991 (WAVES), provide no guidance regarding the use of artificial intelligence techniques and test applications. Proposed artificial intelligence standards, such as IEEE P1252 (Draft Standard for a Frame-based Knowledge Representation), and other artificial intelligence initiatives, such as Knowledge Query Management Language (KQML) and Knowledge Interchange Format (KIF), do not specifically address the requirements of test and diagnosis applications. In this context, artificial intelligence techniques most often take the form of reasoners that control test sequences and perform diagnosis. The use of such systems can simplify the programming of decision logic and improve the efficiency associated with executing sequences of stimulus and measurement tests (i.e., test procedures). However, in the absence of defined standard interfaces and supporting standards, the development of reasoners in test and diagnosis applications will be arbitrary and system-dependent.

A task group of the IEEE SCC20 meeting in Edinburgh on May 24, 1989, considered the role of artificial intelligence and expert system technology in testing. This was a continuation of previous SCC20 discussions on the subject.

The task group determined there were many advantages in using reasoning systems to control test equipment and perform diagnosis. This view does not eliminate nor conflict with the use of conventional test program languages. Rather, it establishes the need to standardize the various human and test machine interfaces to reasoning systems that use artificial intelligence.

As a working title, the acronym AI-ESTATE was coined. AI-ESTATE stands for Artificial Intelligence and Expert System Tie to Automatic Test Equipment (ATE). The AI-ESTATE standards were to define the interfaces between a reasoner and the users of the reasoning system as well as test equipment, test information knowledge bases, and more conventional databases. In addition to interface standards, the AI-ESTATE standards were to include a set of formal data specifications to facilitate the exchange of unit under test (UUT) related data.

At the 90-1 SCC20 meeting (the first meeting of 1990), the AI-ESTATE requirements document and an associated rationale document for the various requirements were written and approved by the AI-ESTATE Subcommittee. In addition, a Project Authorization Request (PAR) was developed at this time and subsequently approved.

Following this, a third document was written to describe the AI-ESTATE architecture, that is, the elements of the AI-ESTATE environment and the relationships between the elements.

It was soon realized that, due to the breadth of the AI-ESTATE concept, multiple standards would be required to define the various AI-ESTATE functions and interfaces. In such cases, the IEEE recommends creation of a base document—in this case, numbered 1232—and a set of component standards, numbered 1232.1, 1232.2, and so forth. A revised set of PARs was submitted for approval at the 92-2 SCC20 meeting.

The current document, IEEE Std 1232-1995, is the base standard for the AI-ESTATE set of standards. It combines and expands information from the requirements, rationale, and architecture documents.

Anticipated users of the AI-ESTATE set of standards include the following:

- ATE system developers
- ATE system maintainers
- Test program set (TPS) developers
- Test instrument developers
- Developers of AI-ESTATE-based tools and systems
- Developers of prime mission equipment that have embedded diagnostic reasoning systems
- System integrators who are concerned with any of the above

At the time this draft standard was completed, the SCC20 AI-ESTATE Subcommittee had the following membership:

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IEEE Trial-Use Standard for Artificial Intelligence and Expert System Tie to Automatic Test Equipment (AI-ESTATE): Overview and Architecture

1. Overview

The Artificial Intelligence and Expert System Tie to Automatic Test Equipment (AI-ESTATE) set of standards and guides was developed by the AI-ESTATE Subcommittee of the IEEE Standards Coordinating Committee 20 (SCC20) to serve as standards for the application of artificial intelligence to system test and diagnosis. The AI-ESTATE set of standards defines interfaces among reasoners and reasoning system users, test equipment, test information knowledge bases, and more conventional databases. In addition to interface standards, the AI-ESTATE standards will include a set of formal data specifications to facilitate the exchange of unit under test (UUT) related data. The AI-ESTATE standards consist of this base standard and a series of component standards. An introductory guide is associated with the AI-ESTATE standards.

1.1 Scope

The AI-ESTATE set of standards defines the software interface of artificial intelligence to system test and diagnosis.

1.2 Purpose

The purpose of the AI-ESTATE set of standards is to standardize interfaces between functional elements of an intelligent test environment and representations of knowledge and data for the functional elements of the intelligent test environment.

This standard describes the elements of AI-ESTATE and their interrelationships; it establishes guidelines and requirements that govern the documents in the AI-ESTATE set of standards; and it defines common terminology that is to be used throughout the set. The purpose of the guidelines and requirements in this base standard is to ensure that the elements in the AI-ESTATE set of standards fit together into a cohesive whole.

1.3 Document set

The AI-ESTATE set of standards consists of the current base standard and a series of proposed component standards (to be designated as IEEE Std 1232.1, IEEE Std 1232.2, etc.). The component standards will provide an interchange format for diagnostic information and a specification of services for the use of artificial

intelligence systems in test and diagnosis. The AI-ESTATE set of standards will also include a set of formal data specifications that define the form of the data and knowledge necessary to support AI-ESTATE. Specifications will be developed as appropriate to support various types of reasoners.

At the present time, the document set for the AI-ESTATE standard is as follows:

- a) IEEE Std 1232-1995, IEEE Trial-Use Standard for Artificial Intelligence and Expert System Tie to Automatic Test Equipment Overview and Architecture.
- b) IEEE P1232.1, Draft Trial-Use Standard for Data and Knowledge Specifications for AI-ESTATE.
- c) IEEE P1232.2, Draft Trial-Use Standard for Service Specifications for AI-ESTATE.
- d) IEEE P1347, Draft Guide for the Understanding of the Artificial Intelligence and Expert System Tie to ATE.

1.4 Application

This document presents the architectural concept for AI-ESTATE and defines the requirements for the AI-ESTATE set of standards. The set of AI-ESTATE component standards can be used in developing AI-ESTATE conformant reasoners, AI-ESTATE conformant knowledge bases, AI-ESTATE conformant systems for system test and diagnosis, and AI-ESTATE-based automated tools.

The requirements outlined in clause 5 of this document and the component standard requirements in clauses 6 and 7 provide the guidance necessary to develop component standards for the AI-ESTATE architecture. Each requirement identified in the above-mentioned clauses must be complied with by each component standard and guide for AI-ESTATE, when the requirement applies. The individual requirements have been identified with paragraph numbers to facilitate the traceability of requirements.

This standard provides

- a) An overview of the AI-ESTATE set of standards;
- b) Requirements for developing component standards and guides;
- c) Requirements for conformance with the AI-ESTATE set of standards.

2. References

This standard shall be used in conjunction with the following publications. Components of the standard shall reference publications from the following list only:

IEEE Std 100-1992, The New IEEE Standard Dictionary of Electrical and Electronics Terms (ANSI).¹

IEEE Std 716-1995, IEEE Standard Test Language for All Systems—Common/Abbreviated Test Language for All Systems (C/ATLAS).

IEEE Std 993-1990, IEEE Trial-Use Standard for Test Equipment Description Language (TEDL).

IEEE Std 1029.1-1991, IEEE Standard for Waveform and Vector Exchange (WAVES) (ANSI).

IEEE Std 1226-1993, IEEE ABBET™ Trial-Use Standard for Test Equipment Description Language (ABBET), Overview and Architecture.

¹IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

3. Definitions

This clause defines terms used in the AI-ESTATE set of standards. For electrical and electronic terms not found in this clause, consult IEEE Std 100-1992.² A clear understanding of the following terms with respect to AI-ESTATE is particularly important in order to understand this standard.

3.1 Abbreviated Test Language for All Systems (ATLAS): A standard abbreviated English language used in the preparation and documentation of test procedures or test programs that can be implemented either manually or with automatic or semiautomatic test equipment.

NOTE—This language is specified in IEEE Std 716-1995.

3.2 ambiguity: In fault isolation, an ambiguity that exists when the failure(s) in a system have not been localized to a single diagnostic unit for a repair level.

3.3 ambiguity group: The collection of all diagnostic units that are in ambiguity.

3.4 anomaly: Irregularity; deviation from usual behavior.

3.5 architecture (of AI-ESTATE): The elements of AI-ESTATE and their interrelationships.

3.6 artificial intelligence: 1) The study of designing computer systems exhibiting the characteristics associated with intelligence in human behavior including understanding language, learning, reasoning from incomplete or uncertain information, and solving problems. 2) The discipline for developing computer systems capable of passing the *Turing Test* in which behavior of the computer system is indistinguishable from human behavior. 3) The study of problem solving using computational models.

3.7 Artificial Intelligence and Expert System Tie to Automatic Test Equipment (AI-ESTATE): A set of specifications that defines the software interface of artificial intelligence and expert systems to system test and diagnosis.

NOTE: The AI-ESTATE set of standards currently includes IEEE Std 1232-1995, IEEE P1232.1, IEEE P1232.2, and IEEE P1347.

3.8 automatic test equipment (ATE): A system providing a test capability for the automatic testing of one or more units under test (UUTs). The ATE system consists of a controller, test resource devices, and peripherals. The controller directs the testing process and interprets the results. The test resource devices provide stimuli, measurements, and physical interconnections. The peripherals, such as displays, keyboards, printers, mass storage, etc., supply the necessary capability for information management.

3.9 built-in-test (BIT): A test approach using built-in-test equipment (BITE) or self-test hardware or software to test all or part of the unit under test (UUT).

3.10 built-in-test equipment (BITE): Any device that is part of an equipment or system and is used for the express purpose of testing the equipment or system. BITE is an identifiable unit of the equipment or system.

3.11 component standard: One standard, within a set of standards, that is developed in accordance with the architecture, terminology, guidelines, and requirements set forth in the base document of the same set of standards, and that provides a detailed definition of a component part of the architecture.

3.12 dependency: A logical relationship between two tests or between a test and an element of the unit under test (UUT) (either an actual part or a failure mode of a part). A diagnostic test is said to be dependent

²Information on references can be found in clause 2.

on a particular diagnostic element or test if the failed outcome of the test implies the failed condition of the diagnostic element or test on which the dependent test relies.

3.13 dependency model: A diagram, list, or topological graph indicating which events depend on related elements and other events.

3.14 diagnosis: The conclusion(s) resulting from tasks, tests, observations, or other information.

3.15 diagnostic procedure: A structured combination of tasks, tests, observations, and other information used to localize a fault or faults.

3.16 diagnostic unit (recursive): A collection of one or more diagnostic conclusions and diagnostic units. It represents a conclusion that might be drawn through the process of diagnosis and is related to repair by physical mapping and repair actions.

3.17 Electronic Design Interchange Format (EDIF): An industry standard for transfer of schematic and structured connectivity information for electronic design automation.

3.18 encapsulation: In the context of AI-ESTATE, the act of specifying a test or collection of tests together with associated preconditions and post conditions.

3.19 expert system: A computer system designed to solve a specific problem or class of problems by processing information specific to the problem domain. (Typically, information processed by an expert system corresponds to rules or procedures applied by human experts to solve similar problems.)

3.20 EXPRESS: A standard information modeling language being developed by ISO 10303-11 : 1994.

3.21 failure: The loss of ability of a diagnostic unit, equipment, or system to perform a required function. The manifestation of a fault. Within the context of AI-ESTATE models, a manifestation is given by the outcome of a test unit.

3.22 false alarm: An indicated fault where no fault exists.

3.23 fault: A physical condition that causes a device or a diagnostic unit to fail to perform nominally.

3.24 fault isolation: Fault localization to a degree sufficient to undertake repair.

3.25 fault localization: The reduction of ambiguity by the application of tests, observations, or other information.

3.26 fault tree: An ordered arrangement of tests that are intended to lead to the localization of faults.

3.27 functional element: A component of the AI-ESTATE architectural concept that is expected to perform specific duties. These include reasoning system, human presentation system, unit under test (UUT), knowledge/data base management system, test system, maintenance data/knowledge collection system, and other system.

3.28 human presentation system: One system within the AI-ESTATE architectural concept. This system supports all users by providing a user interface for data entry and display to an AI-ESTATE implementation and knowledge acquisition support.

3.29 interface test adapter (ITA): A device or series of devices designed to provide a compatible connection between the unit under test (UUT) and the test equipment. May include proper stimuli or loads not contained in the test equipment.