TECHNICAL REPORT

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Design automation –

Part 1-1:
Harmonization of ATLAS test languages

Automatisation de la conception –

Partie 1-1:
Harmonisation de langages d'essais ATLAS

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DESIGN AUTOMATION –

Part 1-1: Harmonization of ATLAS test languages

FOREWORD

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Technical reports do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful by the maintenance team.

IEC 61926-1-1, which is a technical report, has been prepared by IEC technical committee 93: Design automation.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
93/93/CDV	93/102/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

This document which is purely informative is not to be regarded as an International Standard.

A bilingual version of the technical report may be issued at a later date.

OVERVIEW

A common standard test language has been of interest to the electronics testing community for many years. Such a common language offers a single communications "medium" for the description of Unit Under Test (UUT) test requirements to both humans and machines, as well as the hope for Test Program Set (TPS) cost savings through code re-use and code sharing (just as a single spoken language would benefit mankind in international communications, or a single computer programming language would allow "anyone" to read/develop/maintain computer software code). The Abbreviated Test Language for All Systems (ATLAS)™[1)] was developed, and is being maintained, to provide this communications " medium".

This technical report presents the efforts taking place, as well as recommendations/ suggestions to harmonize two differing ATLAS test language specification "dialects", to enable a common use across two user communities

The evolution of the ATLAS language leading to the interest in harmonization of the two dominant representations of this language today, i.e. C/ATLAS 716-95 and ATLAS 626-3, took place in a technological time and context which the reader may find helpful and interesting to know when considering ATLAS today. The following material provides a brief overview of the technical history of Automatic Testing, Automatic Test Equipment and the Testing Economics which existed during the time that ATLAS was evolving. At the conclusion of this background section, a brief history of ATLAS will be included to complete the technological picture and provide the reader with a context for assessing the ATLAS issues being faced today.

The need for an automated means to perform testing followed closely on the heels of the explosive growth in complexity and functionality of the units requiring test. This explosion was driven by miniaturization. More and more capability could be packaged into a single device in the same physical envelope using less and less power and operating at faster and faster speeds.

By the early 1950s, it became clear that a methodology was required which would allow faster testing. The throughput[2)] of units through a manufacturer's factory was being limited by a test bottleneck. This was due to the large number of tests required for newer units being designed and built and the limitations of the speeds at which a factory technician could perform these growing number of tests.

In addition to throughput problems, other testing problems were appearing when testing was done manually, including the consistency of test. The need to perform the same tests in the same way every time was too often found to be compromised by the mood, mental state, health and/or interest of the test technician. Additionally, there were qualitative and economic issues involved. The quality of work conditions under which a person is expected to quickly and consistently perform repetitive work with increasing rapidity was coming under question and scrutiny, as was the cost of the human test technician per unit tested.

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1) ATLAS is a trade mark of the Institute of Electrical and Electronics Engineers.

2) Throughput – the number of units per unit time that can be processed.

A final element to this growing problem was the increasing complexity of the tests which needed to be performed. The tests and testing process reflecting the increasing complexity of the units to be tested became more difficult to perform and interpret. This further exacerbated the time and cost issues noted above by imposing a training cost to enable the technician to perform as required, plus a need for higher skilled technicians who were more costly and more difficult to find. The problems described in respect to the factory environment were being repeated in the field repair environment. Many companies in order to reduce time and shipping costs established field repair and maintenance depots. However, it was not long before these field depots were confronting very similar problems. These problems were made more difficult by the fact that the units requiring test and repair covered a broad variety of types and configurations. This meant that the test technician had less opportunity to become familiar with the traits and characteristics of a single unit. In addition, the field technician was at a remote site, not a factory. Therefore, he needed additional support documentation to compensate for the lack of access to the design engineer available at a factory for advice and guidance. The field technician had to be supported by a large number of expensive spares so that he could effect the needed repair. The expense of the repair, time and spares was at the mercy of the knowledge and diagnostic skill of the repair technician.

Suppliers and users of Automatic Test Equipment (ATE)

The users

On the user side there was a clear dichotomy in the use and application of ATE. The NATO forces were driven by the cold war and the perceived need to extract from technology its benefits in order to support their defense strategy and posture. Production rates, production costs, field maintenance and repair of what was arguably the most sophisticated of electronics were issues that were required to be addressed. Additionally, the ability of NATO to train and retain qualified field test technicians was under strain as local economies improved and increasing numbers of trained technicians left military service.

Commercially the airlines faced increasingly difficult field test and maintenance problems. Driven by concerns over safety, a far-flung set of test and maintenance repair depots and a very difficult avionics requiring test and maintenance, they too began to seek alternative test maintenance and repair approaches.

Other commercial enterprises, particularly those with broad markets and widespread field depot operations were close behind the airlines in identifying the need for a new and improved way to test.

It is safe to say that by the late 1950s all three, i.e., NATO, airlines and large commercial electronics developers were well on their way to developing test solutions, based upon automatic testing.

The suppliers

The suppliers to the three major using communities of ATE were not the same. The suppliers of ATE to the NATO communities were commercial suppliers of standard bench-top instruments configured to be controlled automatically for factory testing, and the suppliers of weapon systems for support of these systems in the field.

The suppliers of ATE to the commercial airlines in the factories were the same as those for NATO, and the suppliers of ATE at the factory test depots were the suppliers of the avionics units used in the aircraft.

The suppliers of ATE to other large commercial suppliers tended to be the suppliers of factory ATE used by NATO and commercial airlines in the factory, and alternative commercial suppliers of ATE in depots or occasionally ATE fashioned by themselves.

Automatic Test Equipment (ATE)

An ATE system has the general configuration shown in figure 1. This configuration is generally applicable from the earliest configuration of ATE to current systems.

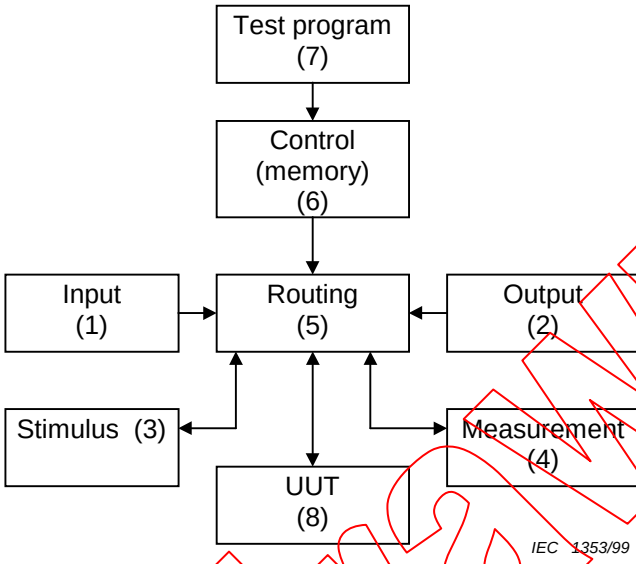

Figure 1 – General configuration of an ATE system

The eight elements of figure 1 perform as follows in any ATE system.

1 Input – the ATE input subsystem allows the ATE operator both to select the operating mode under which the system will perform (i.e. print all test results, stop after each test, print only failures) as well as provide the various media by which the operator can communicate with the system, i.e. tape, Compact Disk (CD), keyboard, floppy.

2 Output – the output subsystem provides the means by which the ATE system communicates with the ATE operator. This can include visual indicators (lights), cathode ray tubes, printers and even voice.

3 Stimulus – the stimulus subsystem consists of programmable[3)] devices which can provide either power or signals to a UUT.

4 Measurement – the measurement subsystem consists of programmable devices which can assess the parametric values of power or signals from a UUT.

5 Routing – the routing subsystem consists of switching devices which by program control are capable of interconnecting the output stimulus devices or the input of measurement devices to designated locations on a UUT. The routing subsystem can also route operator inputs to designated devices and/or output information to designated devices.

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3) "Programmable" denotes the ability of having the functional capability of devices controlled by input signals without human intervention.

6 Control – the control subsystem manages the operation of the ATE. It interprets signals from the input subsystem and controls the system operation in accordance with these inputs. The control system also interprets the test instructions contained within a test program and selects the appropriate stimulus device or devices; establishes the routing configuration required to connect the stimulus as required; sends instructions to the stimulus devices to output the signal required; instructs the measurement device required to set up to make the necessary measurement; interconnects the measurement device via the routing subsystem, analyzing the resulting measurement; and selects the next test to be performed predicated upon how the measurement result compares to predetermined limits.

7 Test program – the test program is a coded set of instructions which determines the tests to be performed and the consequence of passing or failing the test.

8 UUT – the UUT or Unit Under Test is the device that is assessed by the ATE in conjunction with the test program.

Evolution of ATE systems

First generation

The first generation of ATE appeared between 1955 and 1965. They were characterized by single function stimulus devices adapted to be programmable by the ATE manufacturers.

Control of these systems was accomplished by specially designed digital devices (not general purpose computers). These devices were typically driven by a perforated tape device.

The test system software consisted of a primitive executive program, normally supported by an off-line assembler designed to process a very low level test language unique to the test system.

The component technology used in these systems consisted of discrete components and vacuum tubes. The input/output devices on these systems consisted of Nixie tubes, other lights or small printers.

These systems were quite large, used a great deal of power and were typically designed for test of a single, specific UUT.

Second generation

The second generation of ATE was found between 1962 and 1972. These ATE systems were characterized by the use of general purpose bench top instruments for stimulus and measurement adapted to be programmable by the instrument manufacturers. These instruments tended to have all their normal manual controls on their front panels even though they were automatically controlled.

Control of the second generation of ATE was accomplished by a general purpose computer having many of the characteristics of today's desktop computers although much larger and more limited in performance, speed and memory size.

The system software was more sophisticated than that found in first generation systems. This sophistication was made possible by the general purpose computer. The software was supported by an off-line compilation system and utilized some type of higher level (human readable) language specially designed by the ATE developer and proprietary to his system.

The component technology used in second generation systems consisted of discrete components and some conductor elements. These systems were still quite large but occupied a much smaller space than equivalent first generation systems. The second generation systems also utilized less power. For certain field applications they could be readily transported, when housed in a small van.

The man-machine interface for second generation systems normally was an operator switch control panel and/or keyboard. Output devices included a printer, Cathode Ray Tube (CRT) and/or other message displays.

The applicability of second generation systems expanded to include classes or families of UUT of a given type and parametric range. Examples could include Power Supplies, AM or FM transceivers or testers of Analog, Digital or Hybrid Printed Circuit boards.

Third generation ATE [6]

Between 1970 and 1980 an ATE class was introduced which relied on the use of more capable computer systems and sophisticated software to replace many of the stimulus and measurement building blocks that had characterized second generation ATE.

The third generation ATE had unique attributes: they utilized digital to analog converters to create signals synthesizing; the signal characteristics were predicated upon the mathematical definition of that signal. Fundamentally, a signal could be synthesized and shaped to form any variety of Alternating Current (AC) signals. Conversely any complex signal could be broken down by a waveform analyzer and its characteristics parameters analyzed.

The advertised benefits of the third generation system were smaller size, since it required less building blocks, and broad flexibility, since any and all test requirements were relegated to a software problem.

The third generation system architecture ushered in the use of sophisticated solid state technology, as well as very sophisticated routing systems for the interconnection of signals.

Fourth generation ATE

The fourth generation of ATE began in the late 1980s and is still seen today. The significant changes introduced by fourth generation ATE was the increasing sophistication of the computer systems, the enormous increase in memory availability and the extensive use of distributed micro-processing, hybrid arrays, and other technological innovations.

Fourth generation systems utilized an array of smart instrumentation. These stimulus measurement and switching devices took a great deal of the burden away from the central computer and executive software. They were capable of scale selection, number conversion, loss analysis and asyn-chronous processing and analysis of test results, resulting in faster and more accurate testing.

Current ATE [7]

The ATE changes today are being driven by a significant expansion of processing capability and by recognition of instrument manufacturers that programmable instruments in ATE systems required their own design attention. The use of instruments on a card unencumbered by the bulk of the bench top instruments as well as use of the asynchronous processing capabilities of these instruments on a card is increasingly common. The range, repertoire and capabilities of instruments on a card are increasingly expanding. Software systems within ATE today are capable of far more than controlling the test process. They archive data, assess trends, provide sophisticated guidance and instruction to operators and assist in management and queuing of UUTs.

Evolution of ATE software

Executive software

The software which runs and manages an ATE operation is generally called the systems executive software. The systems executive software controls the manner in which tests are processed, the selection of tests, the selection of resources to perform the tests, the evaluation of test results and the disposition of the information obtained from performing a test. These tasks are introspective to the testing operation itself. In the early days of ATE, the test executive was only capable of executing a single instruction. Today, this software is capable of compilation, interpretation and selection of the optimum execution of test program software. Over time the role of the executive software has grown to keep pace with the power of the computers which process this software and the capacity of the memory that was available to store and manipulate data. Today's executive software is no longer introspective, but rather encompasses the environment in which the testing takes place, and is capable of multi-processing, i.e. running tasks simultaneously in foreground and background modes or, for that matter, under a hierarchy of priorities.

The executive software is also capable of monitoring the health and well-being of the test system and its resources; dynamically reallocating resources as necessary to perform testing, when and if a system resource fails; maintaining a diary of test processes and test results obtained over a unit time; automatically processing test reports; tracking histories of test results on similar UUTs; tracking spares inventories for repair; and a host of functions designed to integrate the test process into the total life cycle support process.

Application software

The software containing the instructions for testing a UUT connected to the ATE is denoted application software. Normally, outside of factory production lines, ATEs in use today will be required to support many UUTs of similar type and differing configuration or of similar class and differing type, i.e. analog, digital, video, radio frequency (RF), power supply, etc. For field ATEs, the variety of types and configurations can be very broad.

It is not unusual for the cost of application software to exceed the cost of the ATE itself.

Evolution of application software

The application software written for early ATE reflected the lack of the systems and controllers upon which they were run. The test languages used were digital codes, octal codes and a variety of very specific ordered codes often selected from a code menu.

It is worthwhile to mention one other unique aspect of the ATLAS language. It is a virtual language. This means that it is divorced from the test system it is to be run on. The rules of ATLAS require that no reference to the ultimate test system upon which the ATLAS test language is to be executed be included in the program or procedure itself. Thus, an ATLAS program may have a statement such as "APPLY, 50VDC, J-1, J-2 $". It will never have a statement such as "APPLY, BB*55_ _ _$" or "APPLY S*1_ _ _ " referring to a specific resource of a specific test system. This is not to imply that the test engineer who writes the test program or procedure is unaware of the target test system. On the contrary, the test methods and test strategy utilized by the test engineer are guided by the parametric envelope provided by the test system and the specific accuracy and capabilities of the resource suite. The concept of using virtual references is predicated upon the hope and expectation that virtual reference as opposed to explicit resource references will facilitate rehostability of test programs and procedures across differing test platforms.

ATLAS has enjoyed a variety of applications besides its use as a language for test procedures and test programs. It has been used as a basis for writing test specifications and test requirements. In addition, ATLAS has been the basis for test-related specifications such as the IEEE's "Test Equipment Description Language TEDL" (IEEE Std. 993).

Over time, the sophistication of application software improved with the sophistication of the processors used. For a time, a variety of general purpose programming languages were used to design the tests for UUTs. These included FORTRAN, BASIC and C.

The application software used for the ATEs tended each to be unique to the manufacturer of the ATE. Each manufacturer used a differing form, format and language for their own ATE. Often differing ATEs built by the same manufacturer used differing languages.

In the 1960s, both the airlines and defense communities who were major users of automatic test equipment recognized the drawback of diverse languages for each ATE they used. The language differences made them difficult for the user's personnel to learn and understand. This problem was exacerbated when a variety of systems and hence languages were in use. In addition, when the user of an automatic test system desired to add new UUTs to the systems work load, the time and cost to write the program was higher because of the burden of the language. Further, the change of personnel resulting when the designer of a test program using an esoteric language changed jobs, made it difficult for a new person to pick up and maintain the test program that had been written.

At another level, both the airlines and defense communities recognized that the development of a test program for an ATE began with a test procedure by an engineer familiar with the UUT which was then converted into the language of the ATE. They reasoned that it would be of great benefit if both test procedures as well as test programs were written in an unambiguous, human readable form, using explicit testing terminology which only a test engineer could readily understand. This musing formed the genesis for the development of the ATLAS language which will be discussed next.

It should be noted that commercial ATE system suppliers, in the factory, rejected the concept of a common or standardized test language and do so today. The thinking of these vendors was a combination of belief that their unique and proprietary test languages were superior to other test languages, and an understanding that a competitive advantage was possible if customers for their ATE systems could not easily switch to an alternative ATE to support existing UUTs with their attendant test programs once a significant back log had been built up.

Evolution of ATLAS

The quest for a standard testing language began in the 1960s. Aeronautical Radio Incorporated (ARINC) started the development of a standard testing language in response to the needs of commercial airlines. (The language itself was purported to be conceived by Tom Ellison of United Airlines). The commercial airlines had a need to test and repair similar or identical avionics systems on their aircraft. They desired a means by which they could exchange test procedures they had developed in a standardized and unambiguous way, thereby precluding the need for each airline to redevelop these procedures.

The name of the language developed under the auspices of ARINC was the Abbreviated Test Language for Avionics Systems or ATLAS. The development of ATLAS was undertaken through the cooperative and supporting efforts of a large number of commercial companies interested in avionics test and support. These companies provided skilled engineering personnel familiar with the maintenance and support of avionics systems who met together and worked over time to define and develop ATLAS. Over time, the recognition of the need and benefit of a standardized testing language grew beyond the bounds of the commercial airlines.

The United States Army, Navy, Air Force and NATO services became increasingly active in the ATLAS language development efforts. Commercial companies working with these agencies as part of the defense industry also recognized the potential benefit of ATLAS for support of avionics systems. During this period, participation at ATLAS meetings swelled and became an increasingly difficult administrative burden for ARINC.

In 1976, administrative control and responsibility for ATLAS was passed from ARINC to the IEEE. At this time, the name of the language was changed to reflect the broader field of application. ATLAS became the Abbreviated Test Language for All Systems.

Within the IEEE, control of ATLAS was vested in an ad hoc committee which became Standard Coordinating Committee 20 (SCC20). However, from its beginnings under ARINC to the current time the group has been known as the ATLAS committee. This continues despite the fact that the interests of SCC20 have broadened to include other test-related standards.

The first publication of the ATLAS language standard took place in 1968 and was entitled ARINC Specification 416-1. Subsequent versions were published by ARINC when sufficient changes, upgrades, or enhancements had been processed into the language to represent significant improvement to the previously published version.

By 1976, ARINC Specification 416-13A, which was the fourteenth published version of ATLAS had been released. In 1976, IEEE Std. 416-1976 was also published. This was the first ATLAS published under the auspices of the IEEE and represented the ARINC Specification 416-13A ATLAS in IEEE format. Subsequent publications of 416 ATLAS took place through 1988. These publications represented the evolution of ATLAS from version 13A to 33.

By the time version 33 of ATLAS was published the language had grown very large. This growth reflected the sensitivity of the developers to the need for upward compatibility between versions. However, there was increasing concern and pressure to reduce the maintenance burden represented by 416 ATLAS.

In May of 1985, the IEEE published IEEE Std. 716-1985 (C/ATLAS) which represented a common subset of the 416 ATLAS. During the same year ARINC published an ATLAS subset titled ARINC Specification 626-1985. Unfortunately the 716 standard and the 626 specification were not compatible nor were they true subsets of 416 ATLAS. The IEEE ceased to publish 416 ATLAS, and formally withdrew it in 1993. IEEE C/ATLAS has been published in an updated form every three or four years since the initial publication. This is in accordance with IEEE requirements for a revision/affirmation every five years. ARINC 626 ATLAS has followed a similar publication schedule.

In 1984 the IEEE also published standard 771. This standard is a guide to the use of the ATLAS language.

Recently contacts have been made between ARINC, the sponsor and maintainer of ATLAS Specification 626, and members of a technical team associated with maintenance of C/ATLAS Std. 716-95, via the IEEE SCC20 and the use of ATLAS within the NATO community. The purpose of these contacts was to discuss the possibility of coordination and harmonization between the two communities in a variety of potential areas of automatic testing among these areas of ATLAS. The following paper will discuss explicit steps to achieve and subsequently maintain harmonization between these two dialects of ATLAS which represent the largest utilization of the language.

INTRODUCTION

Commercial airline manufacturers and carriers, United States Department of Defense (DoD) and DoD contractors, United Kingdom Ministry of Defence (MoD) and MoD contractors, as well as other NATO member countries MoDs and contractors each use implementations of a test language standard called ATLAS. The ATLAS language standard specification used by the commercial airlines is maintained and published by ARINC. The Common ATLAS (C/ATLAS) standard specification used by the defense industries is maintained and published by the IEEE on behalf of the American National Standards Institute (ANSI).

The ATLAS language specification maintained by ARINC and the C/ATLAS language standard maintained by the IEEE, initially started from a common base line, which over time, has seen the two standards diverge (see figure 2) with respect to language syntax and semantics (e.g. similar to having two dialects of the English language). The International Electrotechnical Commission (IEC) plans to publish soon the IEEE Std. 716-1995 C/ATLAS as IEC standard 61926 – ATLAS. This technical paper is the response to the IEC request that an effort be undertaken to determine how the two diverged dialects of the ATLAS definition could best be brought back into harmonization. This harmonization would allow for a common use of the ATLAS language across both the commercial airline and defense communities. This technical report presents the result of the efforts performed by the authors to first compare and contrast the two ATLAS dialects and second their conclusions and recommendations in respect to achieving harmonization. It is additionally hoped that the efforts performed can be used to point the way towards achieving harmonization between ATLAS implementations, or other test languages and thus facilitate TPS code sharing and TPS code re-use in solving test problems.

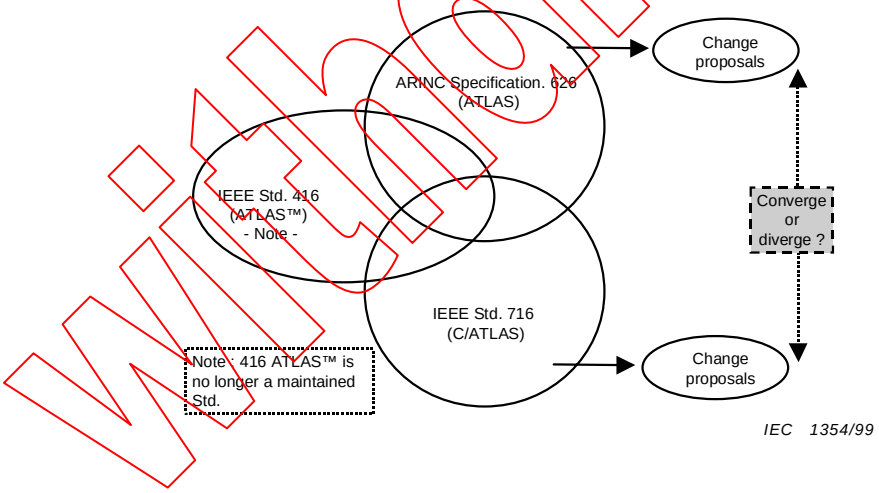

Figure 2 – ATLAS and C/ATLAS evolution

DESIGN AUTOMATION –

Part 1-1: Harmonization of ATLAS test languages

1 Scope

This technical report is applicable to the ATLAS language, the purpose of which is to define a high order language used for the writing of test programs for UUTs, so that these programs can operate on various makes and models of ATE / Automatic Test Systems (ATS).

There are at present two published language definitions of the ATLAS language; this technical report will address the differences between these and provide recommended harmonization and/or convergence of the two standard definitions.

The basis for this technical report are chapters/clauses 1 through 17 of the published IEEE Std. 716-1995 (C/ATLAS) and ARINC Specification 626-3 (ATLAS) publications. The IEEE published IEEE Std. 716-95 in March of 1995, while ARINC published ARINC Specification 626-3 in January of 1995.

2 Reference documents

ARINC Specification 626-3, *Standard ATLAS language for Modular Test* [4)]

ARINC Specification 627, *Programmers Guide for SMART® Systems using ARINC 626 ATLAS*

IEEE Standard 716-1995, *Common Abbreviated Test Language for All Systems (C/ATLAS)* [5)]

IEEE Standard 771-1990, *Guide for the use of ATLAS* [6)]

IEEE Standard 993-1997, *Test Equipment Description Language (TEDL)* [7)]

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4) Currently being revised – see current IEEE and ARINC Working Groups for further information.

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