# HLA Compliance Certification: Lessons learned from the US past activity and current developments within NATO and PfP nations

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**ABSTRACT:** *The US DoD adopted the HLA standard as its preferred interoperability standard for M&S in 1995. NATO adopted this architecture in 1998. HLA became an IEEE standard in 2000 (IEEE 1516) and recently a NATO Standard (STANAG 4603). The HLA has now considerably matured. It is widely accepted and used by the international community. The open international IEEE 1516 HLA standard is progressively replacing the US DoD 1.3 HLA standard according to the recommendations of the NATO M&S Group (NMSG) in April 2003 and the SISO in December 2003.*

*In 2001, the NMSG created a first working group in charge of examining how a HLA compliance certification capability could be established within NATO, the NATO member nations and the Partner for Peace (PfP) nations. This NATO technical activity was directed to extend the current US certification capability to NATO and PfP nations. This first NATO technical team was composed of members from 5 nations (France, Germany, Poland, UK and US). Its final report was published by mid-2002. A SISO paper presenting recommendations and findings of this task group was then published and introduced during the Euro SIW 2003, in Stockholm (Sweden). This new paper will complement and update the former 2003 SISO paper.*

*Since the achievement of the first NATO working group three new nations have joined the NATO technical activity: Canada, Spain and Sweden to form a new working group. The 8 nations are now working together for implementing a NATO HLA compliance certification capability distributed within NATO and PfP nations. This should be achieved in three voluntary nations as early as 2004.*

*This paper will first provide a short update of the current compliance certification process (as it is not well known in Europe). Secondly, it will report on lessons learned based on the US testing since the first compliance test in 1997 and introduce never-published statistics on certified federates providing important information on the way the HLA is used in the international community. Third, the current and planned activities of the recently created NATO MSG-025 group will be described.*

## 1. The HLA and the NATO Modeling and Simulation (M&S) Organization

In June 2003, the NATO "HLA Compliance Certification" team authored a first paper which was introduced in the Euro-SIW in Sweden (reference [1]). This paper was giving details about the history of the NATO activity and its background. The present paper does not plan to repeat former writing but provide a minimal level of information to keep the current paper self-explaining. A few repetitions should provide the reader with a better understanding of the purpose and the background of this second paper and the related current NATO activity

The 03E-SIW-050 paper introduced how the HLA emerged in the US in 1996, and its further recognition by the highest NATO authority (the North-Atlantic Council or NAC) as the key interoperability standard for M&S in 1998. Since the introduction of the 03E-SIW-050 paper during the Sweden Euro SIW some important events -related to the HLA- need to be mentioned since they clearly impact the NATO M&S community and the establishment of a NATO Compliance certification activity:

- The recognition and increasing use of the IEEE 1516 version of the HLA (references [7] to [10]),
- The publication of the new HLA FEDEP version (reference [10]) mentioning explicitly the HLA Compliance Certification process,
- The acceptance of the NATO HLA Standard agreement (STANAG 4603) in December 2003 recommending that HLA Compliance Certification be applied to federates participating in NATO HLA federations.

It is assumed that readers of this paper are already familiar with the main concepts and features of the HLA. People looking for more specific information on HLA can refer to references [4] to [10].

### 1.1 The NATO M&S Organization

This organization was described in details in the former paper. It is only useful to remind readers that, in NATO, M&S is the first responsibility of the Research and Technology (R&T) Organization (RTO) and particularly of its subordinate NATO M&S Group (well-known as the NMSG). Responsibilities of the NMSG were extended in 2003 to include the establishment of M&S interoperability standards. In August 2003 the NMSG was officially recognized by its NATO parent organization (the Conference of National Director of Armament or CNAD) as a delegated "Tasking Authority" for NATO.

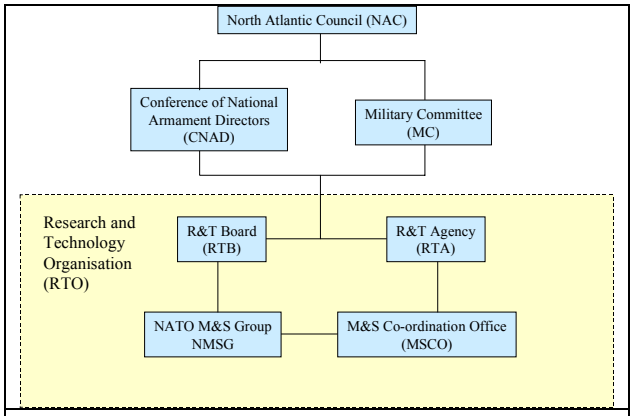


**Figure 1: The NATO M&S Organization**

### 1.2 The HLA compliance certification technical activity within NATO

The origin of this NATO activity comes directly from Objective 1 of the NATO M&S Master Plan ("Establish a common M&S architecture") and, more specifically, from Sub-Objective 1.1, which recommends the adoption of the HLA as the interoperability standard for NATO.

At the beginning of the NMSG activity (1999), the US proposed to support NATO with federate compliance testing as a voluntary national contribution, while waiting for NATO and/or some non-US member nations to establish their own capability. In response to this, the NMSG started to investigate how best to implement a similar capability within NATO and the member nations.

### 1.3 The first technical activity on HLA compliance certification within NATO (2001-2002)

Nations directly supporting this first technical activity were ***France, Germany, Poland, UK and US***. They issued a final report in 2002 [reference 12]. The main objective assigned to this task group was to "Do a investment/appraisal benefit analysis for establishing a NATO capability in assuming that the US capability

becomes unavailable". The Task Group globally addressed this objective, and its final recommendations were briefed to SISO and reported in the 03E-SIW-050 paper. Final conclusions are stated below:

*"HLA compliance testing provides a first level of assurance to the federation manager that a federate conducts it as it says. Even if HLA certification does not provide a full guarantee of interoperability, it provides the first and necessary step in establishing the future NATO interoperability infrastructure."*

No mandatory directive was ever issued by NATO requesting that HLA federates which form part of a NATO federation should be "HLA compliant" certified. Nevertheless, the 2001-2002 task group had the strong opinion that the establishment of a NATO HLA compliance certification capability was to be provided as a general and useful technical service to participating organizations in establishing HLA federations.

Nations agreed that the best solution was *to share the NATO HLA certification capability between NATO member nations and PfP nations*. The solution is described in some detail in reference [12]. Every nation supporting the establishment of the NATO HLA certification capability would be granted access to this service in the context of meeting national requirements. NATO agreed to delegate the HLA certification of national federates to those respective nations responsible for federate development.

Nations participating in the task group recognized the leadership of the US on this activity and agreed on the *requirement of using a unique process and a common testing suite based on the current US process and software*.

The task group also addressed the specific constraints, conditions and requirements for the evolution of the HLA certification process and supporting software. From 1997 to 2003 the US was the only nation dealing with the HLA certification process. When non-US nations join the process, it is agreed that future evolutions of the test suite should be decided on a consensus basis to ensure that a common process and testing suite are maintained by participating nations. The task group proposed that a users/testers club (or working group) be established.

The nations further recommended that this supporting organization should be established within the NMSG as a new technical activity.

In 2002, these final conclusions of the first Task Group were presented to the NMSG. They were all accepted and new nations expressed an interest in participating in the follow on NATO activity.

### 1.4 The current technical activity on HLA compliance certification within NATO (2003-2006)

This new technical activity was approved in March 2003 and started immediately after the approval. It is officially named *"Implementation of HLA Compliance Certification within NATO and NATO/PfP Nations"* and designated as the NMSG technical activity MSG-025.

With three new member nations, 8 nations are currently supporting this activity: ***Canada, France, Germany, Poland, Spain, Sweden, UK and US.*** First achievements and future projects of the new MSG-025 task group are introduced in section 4.

## 2. The current US HLA compliance certification process

Compliance with the High Level Architecture (HLA) was mandated for U.S. Department of Defense (DoD) simulations in 1996. The US Defense Modeling and Simulation Office (DMSO) established a federate compliance test process to evaluate simulations and certify them as HLA compliant to HLA Rules, Interface Specification and the Object Model Template (OMT). Testing began in October 1997 and as of February 2004 over 257 federates have undergone HLA compliance testing

The current certification process is described below. It is quite simple: to be certified as HLA compliant, a federate must demonstrate its adherence to the three specification documents defining the HLA: the Rules, the Interface Specification (IF), and the Object Model Template Specification (references [4] to [6]). The current process has four steps outlined below.

The compliance test suite is operated over the public Internet except when security reasons prevent the use of a public network.

### 2.1 Step 1: Completing a test application

This is achieved via the DMSO test web page. Information needed to complete the application includes:

- Point of Contact Information,
- Sponsorship Information,
- Federate Name, Version, and Brief Description,
- HLA Specification Version,

- RTI Version (verified using the DMSO RTI verification process),
- Expected Interface Test Date.

### 2.2 Step 2: Submission of a Conformance notebook

The federate developer submits a conformance notebook via the web site for the Federate Under Test (FUT). The conformance notebook consists of the following, i.e. a Simulation Object Model (SOM), a Conformance Statement (CS), and optionally, a Scenario File. The Certification Agent conducts three tests on the SOM and CS. These are the CS Dependency Check, the SOM Parseability Test, and the SOM/CS Cross-Check. The Certification Agent will notify the FUT having either passed the three tests or showing problems.

Once the Federate Under Test successfully passes Step 2, it is notified to proceed to Step 3.

### 2.3 Step 3: Submission of interface (IF) environmental data.

In preparation for the IF test the following information is requested, i.e.

- FOM (.fed file),
- RTI Configuration File (RTI.rid file, specific to the 1.3 HLA version and RTI NG),
- API, Hardware, and Operating System used,
- RTI Execution hostname and Internet (IP) address,
- Federation Execution hostname and IP address,
- Whether or not a firewall is in place,
- Additional Comment Section.

### 2.4 Step 4: Interface Specification Testing & Reporting.

The interface (IF) Test requires the Federate Under Test to demonstrate every service and SOM capability in the predetermined test sequence, which is designed to represent a subset of the complete capability of the FUT.

The IF Test has two parts:

- The Nominal Test, which ensures that the FUT can invoke and respond to all services for which it is capable, according to its CS and
- The Representative SOM (RepSOM) test, which ensures that the FUT is capable of invoking and responding to services using a range of data contained in its SOM.

The Federate Certification Agent will log service data from the test, analyze the data, generate results, and return a Certification Summary Report (CSR) to the federate developer. The CSR is the official record of HLA compliance for the specific version of the federate code tested.

The final part of Step 4 is the After Action Review (AAR) and paperwork to document the federate's certification of compliance with the HLA. The submission of the SOM to the HLA Object Model Resource Center (OMRC) is also required before receipt of the Certificate of HLA Compliance.

*Results derived from After Action Reviews of federates are a valuable source of information for the overall HLA community and particularly for people involved in the evolution of the HLA standard. Section 3 of this paper provides statistics and main results based on the US certification activity during its previous period (from 1997 to 2003). They are presented in the section 3 of the current paper.*

### 2.5 Current and recent improvements of the HLA Compliance Certification software

Since its early beginning the current software was based on the US DoD version of the HLA standard (currently the 1.3 version). It is under going testing for an upgraded to support the IEEE 1516 version of the standard. It will nevertheless support both 1.3 and 1516 versions of HLA. This version is expected to be released by the summer of 2004.
Due to the former generalized use of DMSO-provided RTIs the certification process was mainly based on the DMSO RTI NG successive versions. The new certification software will support the use of different RTI versions (either commercial or governmentally developed) allowing federates to run under their usual environment during the testing.

### 2.6 Rationale for establishing a certification capability within NATO

In reference [12] reasons for establishing a NATO/PfP HLA Compliance Certification Capability are extensively developed. Readers can review the former SISO paper for additional details (reference [1]).
The following paragraphs summarize the main arguments as they were developed and agreed by the NATO working group members.

#### 2.6.1 Interoperability aspects

*Technical* interoperability is the capability of federates to physically connect and exchange data in accordance with the HLA standard. The achievement of technical interoperability is a clear prerequisite for *substantive,*

*or meaningful* interoperability. *HLA federate compliance testing deals only with technical interoperability.* For assessing the capability of a federate in a specific federation, federate "certification" is recognized as one of the best, unbiased methods of inspection.
This process does not totally satisfy all the interoperability concerns of a federation manager, but do provide a level of assurance that:

- The federate produces and consumes what it claims it can,
- The federate manages itself in a manner consistent with what it claims,
- The federate can call and receive call-backs from a verified RTI as it states it can.

The current NATO MSG-025 task group plans to address the *substantive interoperability* issue in the future, but recognizes that maintaining rather then improving the current capability of verifying the technical interoperability is its first priority.

### 2.6.2 The HLA Compliance Certification activity as a technical help

The HLA Compliance Certification is mandatory in the US (see references [2] and [3]). In NATO and NATO/PfP nations depending upon various national policies, awareness and availability of the HLA compliance testing process is considered as a technical help to facilitate the integration of federates in a federation, *saving time and money*, in addition to encouraging reuse of federated applications.

### 2.6.3 HLA Compliance certification in support of federate reuse

With the interoperability of simulations the second main objectives of the NATO MSMP is their reuse. In this context the HLA testing process forces the development of SOMs in the HLA paradigm and provides the best way to record SOMs in a repository, which subsequently facilitates the reuse of federates. The availability of SOMs and other Certification artifacts (such as verified Conformance Statements) provides some guarantee on the claimed capability of federate applications, even if it is not a full insurance of their interoperability. This is particularly important for a large organization such as NATO where federates can provide from different countries with very different cultures, different level of commitments to HLA and possibly diverse interpretations of the standard.

### 2.6.4 General assessment of HLA Compliance Certification by NATO

First it was considered as very important to have a formal method to verify that developers of modeling and simulation applications (e.g. HLA federate developers), understand the HLA concept and associated standard.

Secondly, according to the different processes of main standardization organizations, every standard should provide the means to verify compliance to the standard. *In this context the HLA compliance testing process should be considered as an integral part of the High Level Architecture. This opinion is expressed in the text of the HLA STANAG and the compliance certification is recommended for national federates.*

Nevertheless the common feeling is that certification should not be considered as a mandatory requirement for every developed simulation application. Rather the HLA certification process is generally considered by NATO/PfP nations as a generic service offered to HLA federate developers to facilitate their integration in future federations and an help to improve skills in the HLA domain. This flexibility should not prevent any future NATO program manager to require the HLA certification process to be applied prior to federates being integrated within a NATO federation.

## 3. Lessons learned from the past US activity

The following information is extracted from the AAR results of the federates certified by the US since 1997. Those results were presented and commented within the NATO MSG-025 task group but not yet introduced in the SISO community. In June 2003 the unique statistics on the time required by federates to be "HLA compliant" certified was first introduced. Following results are related to the use or the support of RTI Services by HLA-certified federates.

### 3.1 Federation management

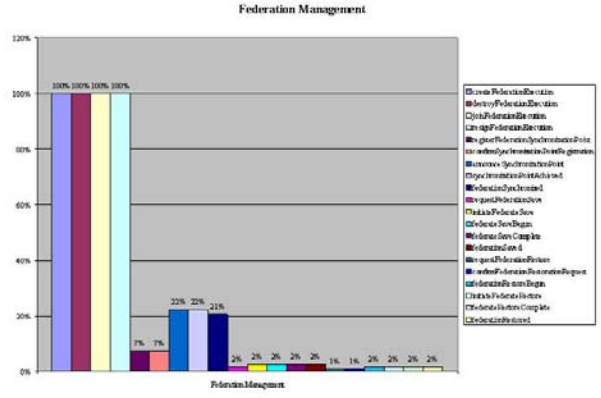


Table 1 **Federation management services statistics**

The table shows that 100% of the certified federates are using or calling the 4 first services, which it is not surprising since any federate shall be able to create, destroy, join, and resign a federation. About 20% are able to use or support Synchronization Points services. The other services are in direct support of Save and Restore activities: less that 3% of the federates use them!

### 3.2 Declaration management

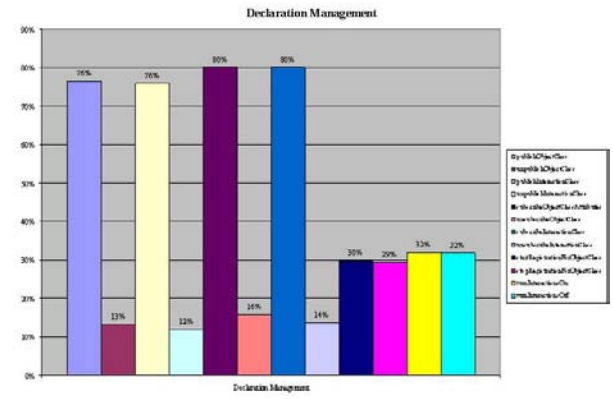


Table 2 **Declaration management services statistics**

Around 80% of federates are concerned with Publication and Subscription activities (for both Object and Interaction classes). The main question is "what level of capabilities the remaining 20% offer?"
More dynamical activities (runtime) such as Unsubscribe or Unpublish are supported by less than 15% of federates. Other dynamic services like Turn On/Off Interaction or Registration for Object Start/Stop are supported by around 30% of federates. These observations are less surprising.

### 3.3 Object management

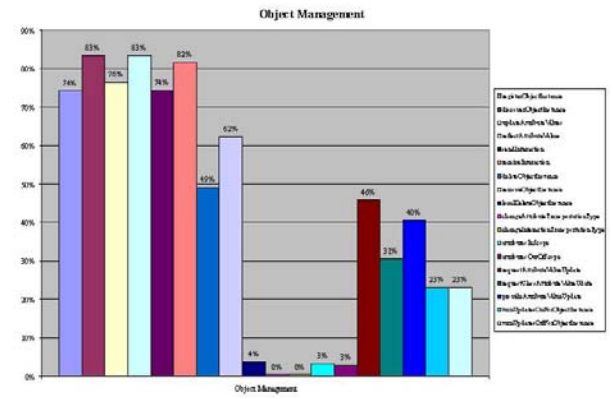


Table 3 **Object management services statistics**

Services related to the update/reflect attribute values, discover/register object instances or receive/send interactions are used/served by about 80% of federates. This observation is consistent with former remarks on services commented in the beginning of section 3.2.
More specific services, but still related to attribute updates, are used/served by about 40% of federates (or slightly less): these rates are considered as normal. 5 even more sophisticated services are used by less than 4%. Those results do not raise any special issue.

### 3.4 Ownership management

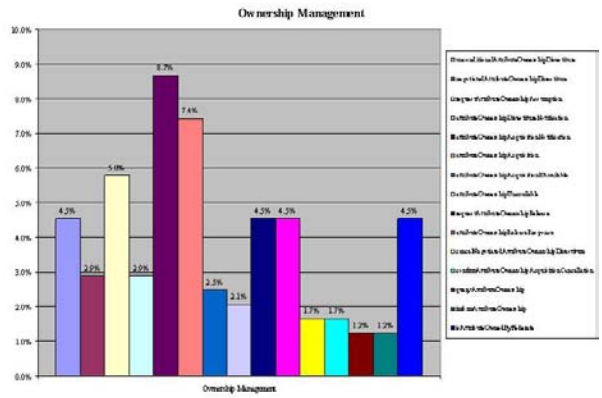


Table 4 **Ownership management services statistics**

Less than 8% of federates are using these services. This low number shows that few federations take profit from this mechanism that is clearly one of the great benefits of the HLA standard. It could be hoped that more developers realize the interest of this method to implement e.g. some multi-level modeling capability in a federation.

### 3.5 Time management

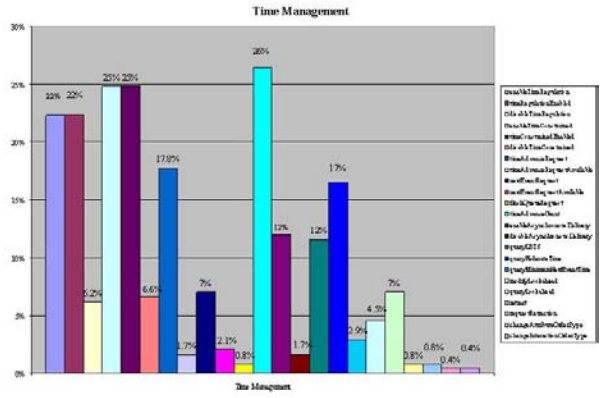


Table 5 **Time management services statistics**

About 25% from certified federates are using these services. One of the great advantages of HLA compared to the previous DIS standard is the possibility of mixing different types of Time Management. It does not seem that federation developers/managers were able to take advantage of that. Another interpretation could be that many federations are "real-time" and cannot (or don't want) to use non real-time, time-constrained federates. This hypothesis is reinforced by the large use of the RPR-FOM (Real Platform Reference FOM) used as the basic reference in many training federations.
Nevertheless after the observation of the weak level of use of Ownership Management services these results reinforce the feelings of surprise and disappointment realizing the real capability of the M&S community to exploit the best technology.

### 3.6 Data Distribution management

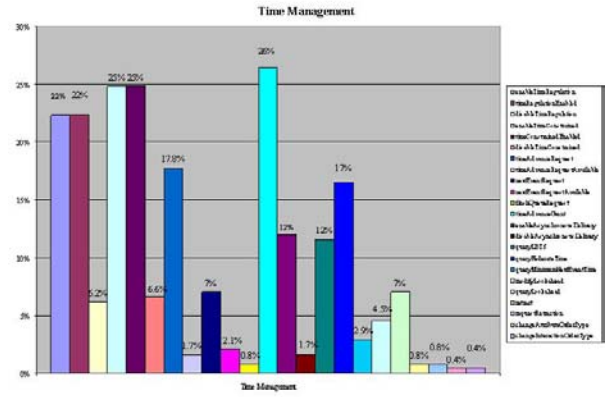


Table 6 **Data Distribution Management services statistics**

The more frequently use services are used by federates in about 5% of cases. This is not surprising: few federations are really requiring this capability. In addition DDM in the 1.3 version of the specification is difficult to implement, and it is not obvious that it was really cost-beneficial to implement it in specific cases.
DDM implementation in the IEEE 1516 version of the specification was greatly simplified. It will be interesting to see if more federate developers adopt this servise in the international version of the specification.

### 3.7 Support Services

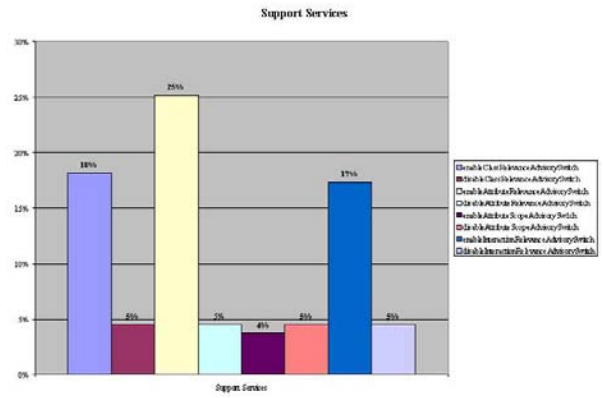


Table 7 **Support services statistics**

These services are rather specific. The observed rates of about 20% for the "Enable" confirms they are useful. Other services are used by less than 5% of the federates. Taking into account the specificity of this type of services the above statistics do not raise any issue.

### 3.8 Intermediate Conclusion

The observed results demonstrate that there is a gap between the possibilities provided by the HLA and their real use. It shall be underlined that these statistics are relative to more than 5 years of use: they show that technology improvements are not so quick to implement in real applications!

## 4. The new HLA Compliance Certification technical activity within NATO

The new NATO Task Group (MSG-025) has met three times in 2003. First it established its 3-year program of work that was approved by the NMSG in October 2003. In addition to the current US capability three other nations are about to implement a national HLA compliance certification capability in 2004: ***Canada, France and Sweden***.

The first delivery of the new task group is an "Implementation Plan" available since the first quarter of 2004. This document should be of a great support for the establishment of the 3 projected new capabilities. It will be updated as required according to the lessons learned from the first developments of the non-US capabilities and the increasing experience of the current US capability. A tutorial on the use of the certification process and corresponding software will soon be organized thanks to the US support in one of the participating nations to facilitate the other new implementations.

As it was proposed in 2002 by the former NATO Task Group, MSG-025 Task Group will serve as a "user club" to share certification experiences, to discuss possible improvements of the existing process and its supporting software. This "HLA Certification Advisory Group" will meet first in September 2004 in Canada.

## 5. Conclusions

The HLA is a living standard. Past Euro-SIWs proved that it has been largely accepted outside the US and outside the defense domain. The public IEEE 1516 version is being more widely adopted every day. Its application is now officially recommended by some European MoDs like France and Sweden, and at the upper level by the NATO M&S Group. The US DoD is developing its transition strategy to the public standard. The SISO is working on the revision of the IEEE 1516. All these recent events prove the vitality of HLA, 8 years after its first announcement.

Nevertheless the examination of the statistical results derived from the past US activity of HLA compliance certification from 1997 to 2003 suggests that the M&S community has not exploited the full potential of the standard yet.

For example:

- The "Save and Restore" capability does not seem largely implemented,
- The potential of Ownership management and Time management is rarely exploited (which is surprising enough)!

These observations should not be commented without expressing some caveat:

- Current statistics are mainly established on the capability of legacy simulations which have inherently some functional limitations,
- Maybe some of the certified federates were not really interested in an extensive HLA functionality, but it was rather felt that they had to implement some HLA capability to comply with a mandatory policy. In this case developers would be tempted to use only a minimal set of services to be declared conformant to the standard,
- Another interpretation could be that in the absence of formal requirements to be included in a specific federation, only a very limited number of services were supported,
- The extension of HLA Compliance Certification to new nations will produce a better understanding of the possibilities the standard offers. The increasing use of HLA and the transition to the IEEE 1516 will certainly modify the general trend which was previously observed.

Nevertheless it is recommended that developers/revisers of the *new version of IEEE 1516 Standard* carefully examine services which are not commonly used to examine if they are either "of little utility", poorly designed, misunderstood, not adapted to common requirements or more simply too costly or too difficult to implement.

No mandatory directive was ever issued by NATO requesting that HLA federates which form part of a NATO federation should be "HLA compliant" certified. However, HLA compliance was clearly mentioned as an important prerequisite to interoperability in the NATO M&S Master Plan and the NMSG has directed the MSG-025 to establish it. On the hand, HLA is the only standard fully complying with processes followed by main standardization organizations specifying that ***every standard should provide the way to certify compliance***.

The wishes of NATO and of NATO/PfP nations are

- that the HLA Compliance Certification capability evolve in consistency with the standard, which is continuously improving,
- that certification be considered as a useful and normal process in the development of HLA supported applications.

Nations participating in the NATO MSG-025 task group recognize the leadership of the US on this activity and agreed on the requirement of establishing a unique testing suite based on the current US software. They also plan to contribute to the improvement of this capability in accordance with the evolution of the standard. By end-2004 three new nations (Canada, France and Sweden) will have joined the US in proposing a compliance certification service to their own benefits and to the benefits of their partners from NATO and PfP nations.


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