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In analyzing air combat operations during the Vietnam War it was clear that aircrews needed some method of providing real-time training feedback in order to adequately prepare them for battle. It was in this post Vietnam era that the Tactical Aircrew Combat Training System (TACTS) was developed. The TACTS system was unique in that it provided the combat aircrew with weapons simulations and real-time kill removal. The aircrews could land, be debriefed on the mission and apply lessons learned that same day. The instrumentation designed for this effort was also unique for its time. It had to have communications, processing, position determination capabilities, and aircraft interface hardware fielded in a small durable package capable of surviving high dynamic, edge of the envelope maneuvers. Now, over 20 years later, TACTS is still being used but new instrumentation packages which are about the same size, but capable of doing much more, are in the acquisition pipeline. As aircraft and other weapons platforms evolve, so must our test and training instrumentation.

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Implementation of Common Modular Test and Training Instrumentation Standards A Government/Industry Partnership

Background.

In analyzing air combat operations during the Vietnam War it was clear that aircrews needed some method of providing real-time training feedback in order to adequately prepare them for battle. It was in this post Vietnam era that the Tactical Aircrew Combat Training System (TACTS) was developed. The TACTS system was unique in that it provided the combat aircrew with weapons simulations and real-time kill removal. The aircrews could land, be debriefed on the mission and apply lessons learned that same day. The instrumentation designed for this effort was also unique for its time. It had to have communications, processing, position determination capabilities, and aircraft interface hardware fielded in a small durable package capable of surviving high dynamic, edge of the envelope maneuvers. Now, over twenty years later, TACTS is still being used but new instrumentation packages which are about the same size, but capable of doing much more, are in the acquisition pipeline. As aircraft and other weapons platforms evolve so must our test and training instrumentation.

Shrinking budgets along with complex new weapons platforms require us to rethink how we will test and train in the future. Our instrumentation packages, which traditionally have been carried on external hard-points now, must be integrated into the aircraft, tanks and ships. In the past test and training instrumentation has provided state-of-the-art capabilities, but as avionics and technology evolve the basic capabilities of the aircraft may out perform our test and training systems.

While most knowledgeable persons agree that test and training requirements overlap, there is some debate as to the degree of commonality. Many in the industry feel that a requirement overlap of approximately 70-80% is conceivable depending on the test and training scenarios. Today, the three services specify and procure most of their own instrumentation. This results in a plethora of instrumentation and systems each with its own expensive support infrastructure. During East Coast joint exercises (JTFEX's) it is interesting to see many of these systems come together but do basically the same tasks. The Large Area Tracking Range is one of the first systems to merge TACTS and fleet range data and provide a near real-time data product to fleet commanders at sea. But, in order to get the most out of LATR and TACTS during one of these exercises one has to 'dual-pod' the aircraft, which is not a practical solution.

The recent trend of selling off frequency bandwidth has caused us, as developers and users, problems both operationally and programmatically. Some systems have lost their operating frequencies all together resulting in system redesigns or retirement, while others wage an ongoing battle to retain their spectrum allocation. We can expect this trend to continue and without a strong argument to keep our frequencies we can expect to loose them.

While the combat avionics systems developers are trying to lower costs and embrace Commercial Off The Shelf (COTS) hardware, the cost of developing, procuring and maintaining test and training hardware is still relatively high. Much of this has to do with the fact that most, if not all, instrumentation is custom designed for the environment and form factor. Ground systems are transitioning to a pure COTS product. Recently, the LATR upgraded all of its VME ground processors to new ones that have four times the processing power for less than $10,000 a range while updating/redesigning a module for one of our newer systems has been estimated at almost $1,000,000.00!

Our test and training systems have, traditionally, been complex state-of-the-art systems but they were designed for specific and limited applications. With the advent of large complex joint exercises involving hundreds, if the not thousands, of participants we need to look how we can field affordable interoperable instrumentation.

Mandates and Roadmaps

The idea of procuring standard test and training systems is not new, we have been discussing it for years. The three services and the Office of the Secretary of Defense (OSD) have recognized that test and training system development and integration needs to be executed through a long range plan or roadmap. To facilitate managing test and training assets OSD formed the Defense Test and Training Steering Group (DTTSG) whose mission is to "... oversee requirements development and integration of all test and training range instrumentation and to facilitate the development of a consolidated acquisition capabilities policy, including embedded test and training capabilities in weapons systems"[1]. The DTTSG fulfills its mission through standing subcommittees that have been formed to address specific aspects of the mission. These committees are the Test and Evaluation Resource Committee (TERC), Training Instrumentation Resource Investment Committee (TIRIC) and the CROSSBOW Committee. The DTTSG with inputs from the committees publishes the Joint Test and Training Range Roadmap. This roadmap is meant to "enable progress toward a vision of cost effective development and seamless employment of range instrumentation, while enhancing joint and mutual test and training capabilities"[2]. The latest version, which is available on TECWEB, is a great improvement over past versions and puts into place the foundation and processes needed to execute the DTTSG's mission.

In addition to following the roadmap, system developers also have to comply to mandates, many of which may or may not be in the best interest of the individual program but will allow the system to evolve to a common vision. High Level Architecture, Common Digital Architecture, Joint Technical Architecture, IT-21 and DIICOE are just a few of these initiatives that test and training system developers must address.

The ramifications, both good and bad, of recent acquisition reform initiatives still need to be sorted out. Ultimately evaluating the quality and cost of systems procured using reform initiatives will do this. The move to performance based specifications and the elimination of military specifications and standards has made our jobs both easier and harder. It is now much harder to write a specification in such a way that it will ensure the government gets what it wants. The use of commercial and industrial specifications and standards has helped but in many cases there are no commercial standards that cover the government's requirements. What we are seeing in performance based contracting is that different vendors come up with different solutions, some of which are more desirable than others but which all meet the basic requirements. Without some controlling measure this can result in a greater diversification of systems and support infrastructure than what we have today. Using a COTS processor does not gain you much if it is mounted on a unique, custom designed card which will cost $1 million to redesign due to parts obsolescence. We are seeing parts becoming obsolete during the development phase and requiring injections of time and money before full rate production can begin. Will we get smarter? Certainly, but we don't buy that many systems, the ones we do buy have long lives. Figure 1 shows how system modernization cycles have become shorter due to parts obsolescence. While this information applies to weapons systems we are seeing short modernization cycles showing up in test and training range systems.

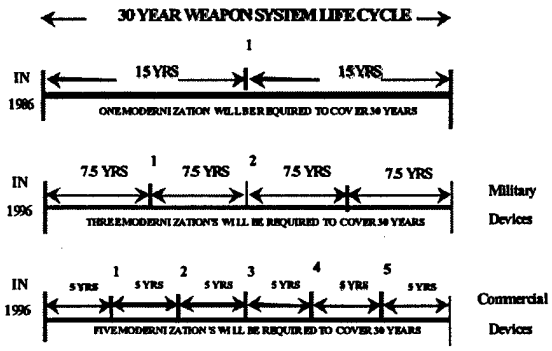

Figure 1 - Number of Modernization Efforts Required for a 30 Year Weapon System Life Cycle (Based on Active Device Content)[3]

As we continue to integrate COTS components into our systems we have to be aware of the commercial life span of those components and continually adapt our acquisition and life cycle management strategies. Figure 2 shows the average introduction rate for new generations of commercial integrated circuits.

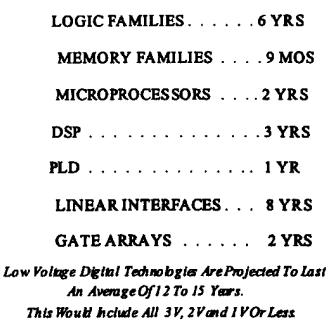

Figure 2 - Average Introduction Rate for New Generations of Commercial Integrated Circuits[4]

Total Ownership Cost has always been important and the maintenance of a system is a major portion of long-term system cost. We now have multiple contractors and activities dedicated to maintaining our test and training systems. Our legacy systems, many of which are based on discrete components, lend themselves nicely to being repaired by operations and maintenance contractors or local vendors. With Built in Test many of our new systems do not require large, expensive and complex test sets to repair systems in the field. Modules can be diagnosed and swapped rapidly. As we move to high density, surface mount technology subcomponent/module diagnosis and repair becomes more expensive and difficult without the proper training, hardware and test program sets. Some of the modules may be so inexpensive as to be throwaways while others may require special skills and test equipment. Since the maintenance of the new systems is different than what is in the field today we have to ensure that a system is put in place that cost effectively maintains the system while is sensitive to the operational concerns of the users.

Standards Based System

Over the years we have seen presentations for common, universal and plug-n-play systems. Often, these systems are pushed by companies or agencies trying to sell their product as a catch all solution rather than something that is really meets the requirements of the three services as a whole. A good example of a standards based system is the personal computer. For example, if I want to buy a new graphics card for my home computer I need to get one that is AGP 2X compliant. The form factor and interface are defined. I have a wide choice of cards, some very expensive and capable and others providing just basic graphics. I choose the capability I need and can afford. Many will argue that the standards are changing to quickly and that a graphics card purchased today is obsolete in two years. This is true, but by taking the lead in defining standards for ourselves we also control when to upgrade. While this is influenced by industry it is ultimately driven by our ability to manage COTS in our systems. Moving to a standards based system will reduce development costs, give services the flexibility to upgrade systems in a modular fashion and lower total ownership costs of the systems we field. We are seeing this today with our COTS based ground hardware.

How do we evolve our systems to a common standards based goal? I contend it is time to stand back and start with a clean sheet of paper. Instead of looking how we can evolve our current systems towards an undefined future, I would set a goal and then see if the current systems can make to our goal, and if so, how. How can we build, field and support standards based instrumentation across all three services? How can we take advantage of the economy of scale common systems would bring while at the same time satisfy the requirements of the individual users? How do we leverage the legacy systems investments made to date? I contend we do it by:

1) Laying out a long-range plan
2) Moving towards embedded capabilities
3) Adopting common standards.

A basic long-range plan is in place with the Joint Test and Training Range Roadmap (JTTRR). This document is a living document and will be updated as changes in philosophy and technology emerge but it has to be an accurate depiction of where DOD wants to go with its test and training systems.

The government is expending tens of millions of dollars on new instrumentation packages which, in many cases, are used just to determine participant position. By embedding training and test capabilities within the participant we can, in many cases, go with a COTS based solution and get relief from some of the more severe environmental requirements driving the high cost of our systems today. Embedding our requirements is often not any more expensive than building separate instrumentation. The F-22 was built with a built in ACM capability. JSF must embed a training

capability also but whether this should be done as a separate, stand-alone module or built into the basic capability of the aircraft avionics is open for debate. Our test and training systems today interface with many of the weapons platforms subsystems from avionics to weapons processors, radar's, defensive systems and displays. The need for a reduced radar cross section is driving the development of expensive low visibility antennas and/or integration with the aircraft's antenna and communications systems. Communication systems being developed are going to be high bandwidth, encrypted, jam resistant, frequency agile digital systems tied directly to the platforms combat systems. Antennas are moving to a 'smart skin' technology for aircraft and ships. Navigation systems are becoming more accurate and onboard processors more capable. The ability to embed test and training capabilities into a platform is becoming more realistic each year but will only happen if planned in conjunction with the tactical systems development. In order for us to ensure embedded training succeeds support is needed at the highest levels of DOD.

The next logical step is looking at adopting or developing commercial/industry standards to be used in test and training system acquisition. As we look more towards modular upgrades as a way of improving system performance it is important to maintain several vendors to ensure competition and the availability of the latest technology. Upgraded modules, if based on standards, could be used by any system adhering to the standard. For example, if the Army upgraded a processor module to a specific standard the Air Force may be able to use that processor in their system even though a different vendor manufactured it.

The government alone cannot define instrumentation standards and expect to get quality affordable products without industry assistance. I propose the formation of a government/industry consortium, sponsored by OSD, that would act as an advisory council and working group for the review of existing standards as they apply to test an training instrumentation and to develop new standards where needed. The consortium would report to the executive committee that would report to the DTTSG through its committees.

Some standards are evolving, such as High Level Architecture (HLA), but still have a long way to go before they will be able to be integrated into instrumentation effectively. The Common Digital Architecture (CDA) is attempting to define a common bus network architecture and the Family of Interoperable Range Systems Transceivers (FIRST) CTEIP project is looking at developing standard interfaces for range radios. These efforts, as well as others, are all needed but how do they all fit into our test and training instrumentation acquisition plan? The consortium will be able to propose a roadmap based on a logical assessment of where and when industry feels it can effectively integrate capabilities based on technology trends. In discussions I have had with range instrumentation companies they have indicated that they would be interested in focusing some of their internal R&D efforts towards the consortium goals and all felt it would be good for the industry. The consortium would be chartered to:

- Develop a list of standards to be used by the three services in procurement/modification of test and training systems. Standards would include but not be limited to those for form, interfaces, software development and portability and environment.
- Propose and maintain a technology insertion roadmap that dovetails with DOD's long term test and training instrumentation plans.
- Review and recommend commercial/ industrial standards appropriate for test and training instrumentation.
- Draft standards where none exist and, through existing processes, have them validated and approved.
- Review mandated products/standards for direct applicability to test and training instrumentation. Many of the information management mandates (JTA and DII COE for example) are applied against test and training systems yet they often do not fit the system requirements due to environmental design constraints and limited available bandwidth. Recommend modifications/ additions to the products/standards.
- Coordinate with RF spectrum managers to consolidate the test and training community into one or two frequency bands.
- Coordinate with other OSD sponsored programs in order to leverage off ongoing technology development efforts.
- Propose a series of products that could be accomplished by members of the consortium

or proposed as CTEIP, SBIR or Advanced Technology Demonstration efforts.

- Keep abreast of technology improvements and recommend modifications to the adopted standards based on industry trends.

Potential Products

Based on consortium recommendations potential products for Central Test and Evaluation Investment Program (CTEIP) or an Advanced Technology Insertion project may include:

1) Paper Studies such as:

   - RF optimized run time infrastructure for HLA (tailored services).
   - Environmental requirements options and alternatives.
   - Form factors for modules, pods, internal instrumentation and antennas.
   - Data link requirement definition and options. Common frequency study.
   - Encryption.
   - Common system/ subsystem interfaces.

2) Projects or demonstrations such as:

   - An experimental RF optimized RTI.
   - Digital data link transceiver.
   - COTS based instrumentation for functional validation of standard interfaces.
   - Instrumentation based on draft standards and form factors.

In order for these products to be meaningful they must adhere to a predefined plan that allows us to see how their completion moves us closer to a goal of common, modular, affordable instrumentation based on industry standards.

Conclusion

With shrinking budgets and the probable reality that test and training activities will be, to the greatest extent possible, merged it in our best interest to establish a plan for standardizing instrumentation. Large complex joint operations further justify the need for standards based interoperable test and training instrumentation. Hardware used for test and training instrumentation must sometimes be packaged in unique configurations and operate in physically and/or electrically hostile environments but there has not been many "commercial off the shelf" products available to fulfill our requirements. Recent positive efforts have been made using COTS components and best commercial practices in the design and manufacture of test and training instrumentation. Still, in most cases the hardware we are developing today is a custom design. With acquisition reform moving towards performance based procurements incorporating more COTS components the potential for instrumentation interoperability and divergence will increase without careful thought, planning and management.

Between acquisition reform and COTS we have been given the tools we need to effect changes in the way we acquire and maintain test and training instrumentation systems. The formation of a Government/Industry Consortium will allow us to chart our future with respect to system acquisition planning and life cycle support. By jointly adopting a set of common standards and showing a logical evolutionary process for systems acquisition and technology insertion we help maintain a healthy industry base as well as strengthen our political positions.

Standards based instrumentation and the Government/Industry Consortium will only work if all parties involved actively pursue the agreed to goals. This includes everyone from the lowly engineer, such as myself, to the highest levels of DOD.

References:

[1, 2] **"The Joint Test & Training Range Roadmap"**, Office of the Secretary of Defense, July 1998

[3] **"Obsolescence Overview"** briefing, Transition Analysis of Component Technology, Inc., 28 October 1998

[4] **"DMSMS Presentation '97"** briefing, Transition Analysis of Component Technology, Inc., 27 August 1997

International Test and Evaluation Association Workshop
Partnering for Success - Land, Sea and Air Instrumentation
April 1999

Implementation of Common Modular Test and Training Instrumentation Standards 'A Government/Industry Partnership'

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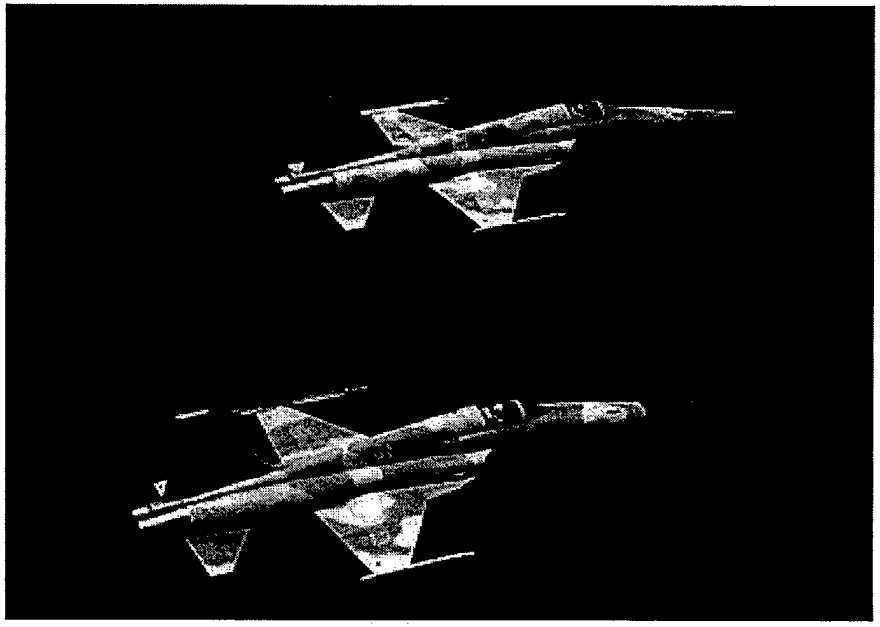
Background

- Uniqueness of test and training systems
- Shrinking budgets
- Requirements overlap
- Cost of systems development
- Redundant support infrastructures
- Recent efforts with Commercial-Off-The-Shelf products
- Severe operating environment
- Frequency Issues

System Diversity

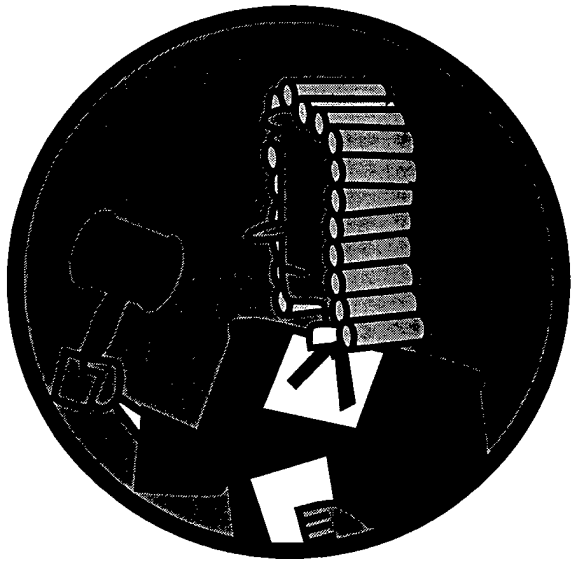
- TACTS/ACTS
- LATR
- NTC Air Warrior
- SMODIN
- DLS-1
- RAP

To name a few…..



Mandates and Roadmaps

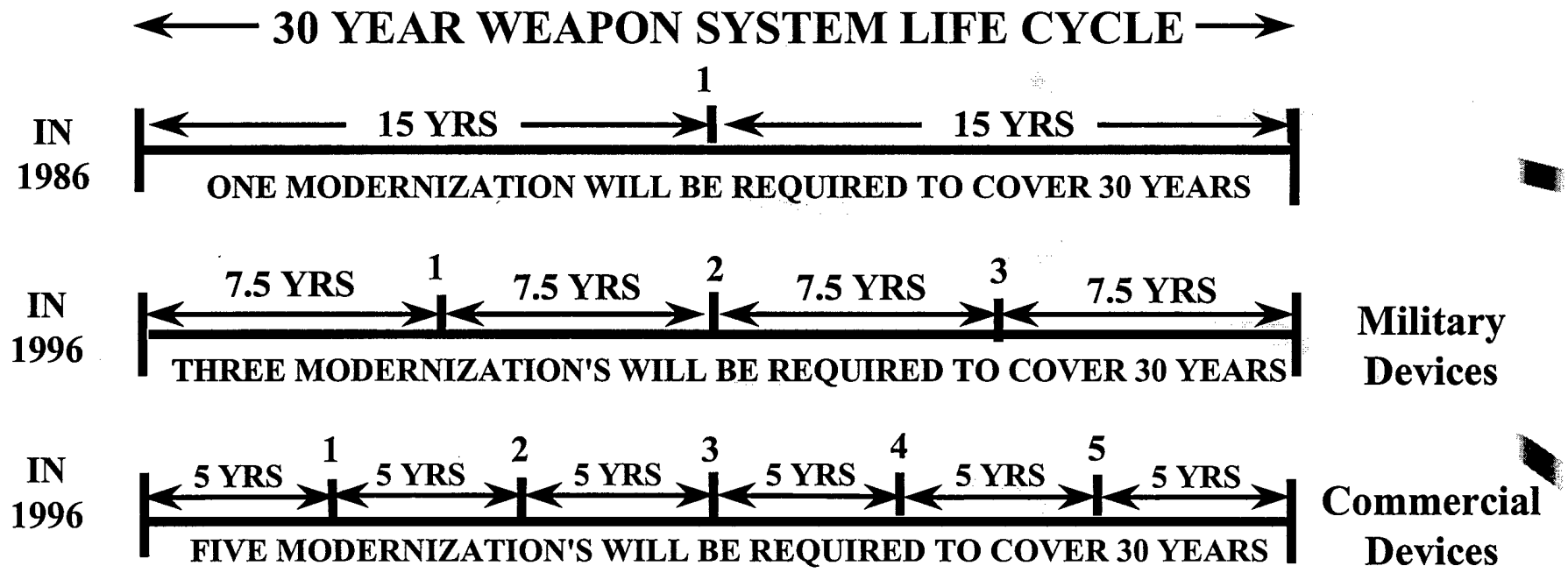
- Joint Test & Training Range Roadmap (JTTRR)
- Mandates
  - High Level Architecture (HLA)
  - Joint Technical Architecture (JTA)
  - IT-21 & DII-COE
- Commercial Off The Shelf (COTS)
- Acquisition Reform
- Total Ownership Cost (TOC)



COTS

- Good
  - Reduced development costs
    - Only if COTS integration is well planned
  - Reduced production costs
- Bad
  - Obsolescence
    - A current program is experiencing COTS obsolescence driven redesign of custom modules which is costing as much as $1,000,000.00 and this program is still in the development phase!
  - May not meet your requirements

Number of Modernization Efforts Required For A 30 Year Weapon System Life Cycle
(BASED ON ACTIVE DEVICE CONTENT)



SOURCE: ICE, "*Status 97*" & TACTech, Inc.

Average Introduction Rate For New Generations of Commercial Integrated Circuits

LOGIC FAMILIES . . . . . 6 YRS

MEMORY FAMILIES . . . . 9 MOS

MICROPROCESSORS . . . . 2 YRS

DSP . . . . . 3 YRS

PLD . . . . . 1 YR

LINEAR INTERFACES . . . 8 YRS

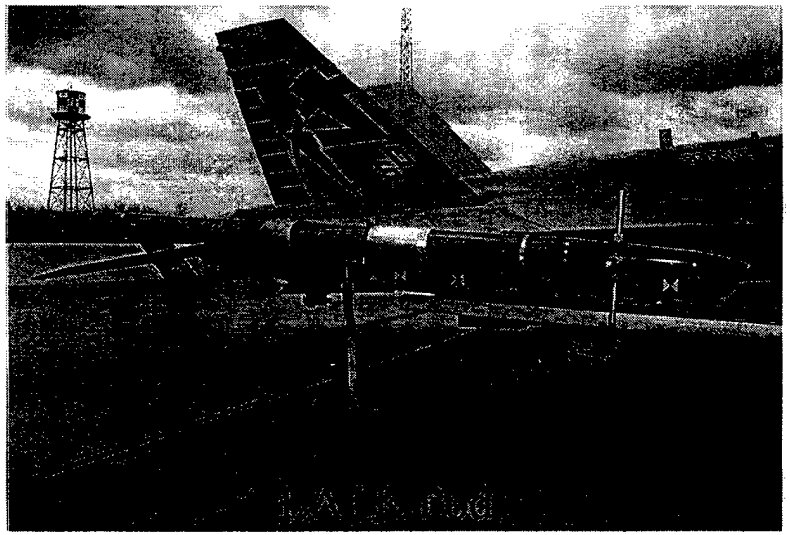
GATE ARRAYS . . . . . 2 YRS

Low Voltage Digital Technologies Are Projected To Last
An Average Of 12 To 15 Years.
This Would Include All 3V, 2V and 1V Or Less.

SOURCE: *TACTech, Inc.*

Standards Based System

- Why?
  - Reduced costs
    - Acquisition
      - Development
      - Production
    - Life Cycle
  - Flexibility
  - Facilitates joint training/testing



Standards Based System

- How?
  - Long Range Plan
    - Coordinated system acquisition
  - Active Involvement NOW for embedded capabilities
  - Adoption of Commercial/Industry Standards

Long Range Plan

- Defense Test and Training Steering Group
  - Joint Test and Training Range Roadmap
- Emphasis on training for all tactical training programs at the highest levels of DOD
  - Investment paid back with increased readiness

Embedded Capabilities

- New generations of weapons platforms demand it!
- New avionics will be more capable than our test and training systems are today.
- Must get on-board now in order to guarantee embedded capabilities in the future!

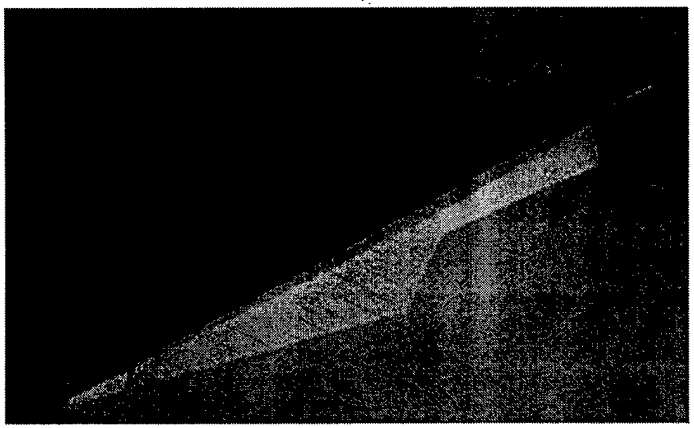
Standards

- Why adopt Commercial/Industry Standards?
  - $$$$$$$
    - Reduced acquisition costs
    - Reduced Life Cycle Costs
  - Defines performance
  - Larger vendor pool
    - Commercial response to a market requirement
- The government cannot define instrumentation standards and expect to get quality, affordable products without industry assistance!

Government/Industry Consortium

- Goals
  - Develop standards list to be used by the services for procurement and modification of new and legacy systems
  - Review and adopt commercial/industry standards
  - Draft industry standards where none exist and, through existing processes, have them validated and approved
  - Review/evaluate mandated products and standards for direct applicability to test and training instrumentation
  - Advise RF spectrum managers
  - Coordinate with other OSD sponsored programs
  - Track technology and recommend changes based on industry trends
  - Propose and maintain a technology insertion roadmap

Potential Products



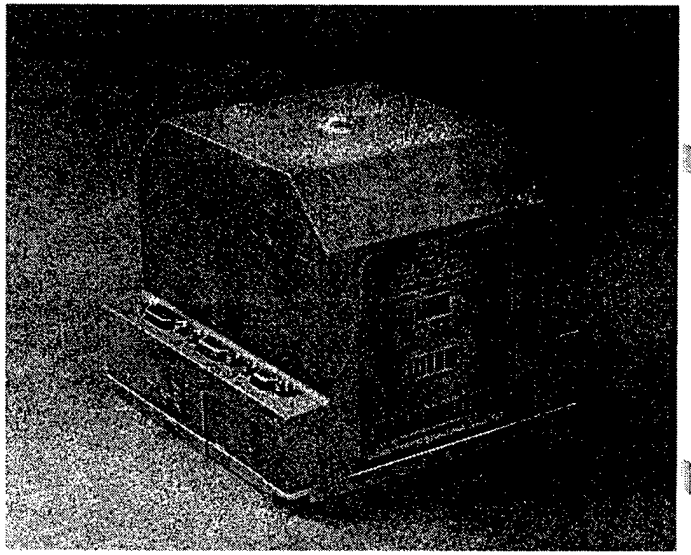
- Paper Studies
  - Data Protocols
    - RF Optimized HLA RTI (tailored services)
  - Environmental Requirements
    - Options & alternatives
  - Form Factors
    - Pods, Internal Units, Antennas
  - Data Link Requirements
    - Definition and options
    - Common frequency study
  - Standards Based System/Subsystem interfaces and modules

Potential Projects/Demonstrations

- Experimental RF Optimized RTI
- Digital Data Link Transceiver/technology comparison
- COTS based instrumentation for functional validation of standard interfaces
- Instrumentation based on draft standards and form factors

Encryption

- Encryption is no longer an option!
  - Few available encryption devices limit options but standardize interfaces.
- Advanced Message Oriented Data Security Module (AMODSM), KGV-23
  - NSA Certified and in production
- Range Encryption Module (REM) in development



Conclusion

- Future
  - Budgets continue to shrink.
  - Test and Training activities, to the greatest extent possible, will merge voluntarily or involuntarily. (It's our choice!)
- Acquisition Reform and COTS affords us the tools to change the way we do business.
- Government/Industry Consortium allows us to define our system acquisition and life cycle future.