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CREWSTATION TECHNOLOGY TRANSITION EVALUATION TOOLS

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ABSTRACT
This paper discusses the development of a core set of technology demonstration tools to enhance and shorten the process of transitioning technology to products. The process is explained, along with associated issues and current capability, focusing on the shortfalls of the transition process. It then describes the core set of tools, a demonstration architecture, that span all of the stages of technology insertion with emphasis on the advanced stages of the technology transition process: fixed simulation sites, mobile demonstration and flight demonstration.

Central to the paper is the description of the tool set of demonstration architecture to be hosted in a mobile demonstration (MDS), manned flight simulators, and a combat system test bed (CSTB) aircraft. A baseline hardware set intended for "quick-on/quick-off" aircraft demonstration consists of a high-throughput processor interface unit, a "state-of-the-art" color flat panel display compatible with current aircraft cockpits, and a 1553 "cockpit bus" connecting the processor, display and technology in demonstration as appropriate. The case is made for the ability of this quick-on/quick-off core set of tools to minimize the need for dedicated technology demonstration aircraft in the RDT&E inventory.

INTRODUCTION

THE ISSUES

Technology development in the Department of Defense (DoD) is funded in blocks with Research and Development (R&D) program elements in federal appropriations. The technologies that are developed under this type of R&D funding often never become products for several reasons. The lack of product line sponsorship and development risk aversion are the two most common characteristics inhibiting the transitions. For the most part the DoD field site activity infrastructure focuses on either technology development in laboratories or end product development in test activities. The process to get technology transitioned from its development funding to platform funding needs a set of development evaluation tools in place to allow evaluation at all stages of technology in labs, system integration facilities, MDS and/or CSTB, and at the same time, not impact the end product test activities and production. Throughout DoD, the availability of dedicated aircraft to support technology demonstrations is dwindling rapidly, resulting in the need to find an alternative to try out developing technologies in the combat aircraft flight envelope.

The problem is exacerbated by no clear method of necking down on the technologies that are usable by the warfighters. Generally, the performance of each technology block development manager is measured by the amount of funding that he/she is able to direct to technology projects as opposed to being measured by the number of those projects that are transitioned to end user platforms. In addition, the comparison of various technologies is difficult because of the lack of or inconsistent baselines against which the new technologies are evaluated.

Currently the cockpit-related technologies are at a critical juncture. The C4I explosion, the advances in computational and display resources, and the affordability of on-board sensors are about to invade the market with no real focused method of ferreting out the best to meet the joint commander's needs. In addition, cockpits are becoming the center of all sensor information from onboard and offboard systems. As such, the plethora of data and information that is flowing into the cockpit is taxing the ability of the pilot to manage and thereby becoming the limitation to the combat capability of the combat aircraft.

Another issue is the point design of demonstration and evaluation facilities focused at a particular technology. Particular focused technology requires dedicated assets for long periods of time as they grow more and more sophisticated and require more and more integration with other surrounding systems. As a result, large and complex integration facilities, MDS's and CSTB's are not cost efficient for the day to day efforts that are part and parcel to technology development. A portable set of tools that can host the developing technology for quick-on/quick-off insertion in the integration facilities, MDS's and CSTB's needs to be developed and the subject of this paper.

CURRENT DOD FACILITIES AND AIRCRAFT

Over the last several years of DoD Major Range and Test Facility Base (MRTFB) funding, the Services' ranges have developed tremendous capability to support ground and flight test. In parallel, although not as glamorous, has been the development of test facilities that support full system development evaluation in a laboratory environment. Some of these integrated evaluation facilities are sufficiently developed to provide near combat conditions through simulation and stimulation in a secure environment for the test of the concepts, rapid prototypes, integrated systems and fully integrated combat aircraft, satellites and ground vehicles. Through distributed interactive simulation the same facilities can insert the developing technology into the virtual battlefield wargame scenarios to verify value added to the warfighter. The integration facilities have capability to use the CSTB integrated system plugged into fixed and motion based dome by an umbilical to perform mission functions and to process data from all of its onboard and offboard sensors.

Also inherent in integration facilities are capabilities to accommodate developmental hardware-in-the-loop (HITL). In some the robust HUD, HDD, and HMD emulation for concept exploration and prototyping is installed and operating. Technology development products can be transported to/from the associated Silicon Graphics work stations in several of these facilities.

Fixed and motion based flight simulators provide high-fidelity digitized scenes, flight dynamics, and avionics system interfaces for developmental cockpit representations — quick-on/quick-off cockpit mockups with nominal interface standards. This capability is inherently supportive of technology demonstrations in many of the demonstration phases.

Although the total number of aircraft in the services is decreasing, the large number of aircraft types that are representative of service aircraft remains. Future Navy airborne flight test and development will require chase aircraft, normally current fleet-configured aircraft diverted to the test activities, which could be used for technology demonstrations with minimal impact to the chase mission. Current risk aversion to the use of support aircraft for technology demonstrators has resulted in the inability of the technology demonstrations to get at those resources for the reasons stated earlier — most significantly the risk associated with meeting schedules so as not to interfere with test programs.

TECHNOLOGY DEVELOPMENT DEMONSTRATION PROCESS

ROUNDTABLES

It is imperative that the technology development process have facilities and vehicles available to the technology development managers at appropriate stages with appropriate amounts of sophistication to allow evaluation of the technology in as close to combat environment as possible. Technology ideas and concepts from the technology managers are first compared to service needs through joint assessment by overarching roundtable panels. These roundtables compare service needs with available technologies from government, industry, and academia. The roundtable evaluation process helps evaluate complimentary programs at conceptual, simulation, and systems integration levels. The roundtable review process looks for opportunities to combine elements of different programs with a disciplined system engineering approach.

Below the roundtable oversight on technology development is the need for aircrew-centered pilot-vehicle interface design, better known as crew centered design (CCD), based on a standardized rapid prototyping development architecture (DA) with well defined open hardware interfaces and physical environment, leveraging the use of reusable software. This core DA will allow the more advanced technologies to be moved from fixed based labs, to MDS and CSTB environments with minimum interference and retooling. It will also provide a baseline for developing technology performance.

Key to supporting the roundtable oversight is the use of government facilities by technology development programs that have not or cannot facilitize organic resources. In addition, government facilities provide a relatively neutral site to evaluate multi-subsystem integration. The use of the large government research, development, test and evaluation (RDT&E) infrastructure has the following significant advantages:

- Removes contracting delays,
- Reduces or eliminates facilitization of high end demonstration facilities
- Leverages large existing infrastructure,
- Provides direct access to customers,
- Provides relatively neutral and level playing field, and
- Easily protects proprietary information.

Additional elements of the development evaluation tools suite enable the technology managers to get the technology close to the warfighters in the warfighting environment. These tools are the MSS and the CSTB as described earlier and are defined in more detail below. A pictorial showing the insertion points for demonstration of technology in development is shown in figure 1.

INDUSTRY

Current aerospace industry is necking down by acquisition and divestiture. Currently there are four major military airplane manufacturers, two of which are in the military helicopter business. There are two other helicopter manufacturers, making a total of six remaining manufactures of military aircraft in the US (not including Raytheon, the winner of the JPATS contract). As the number of prime contractors and the number of types of operational aircraft decrease, the opportunities for technology insertions will also decrease. Fortunately, current changes to the law concerning the use of the military services' facilities has opened up their infrastructure to use by the private sector.

MILITARY SERVICES

The Army, Navy/Marine Corps, and Air Force all have significant investments in the MRTFB. This investment has been provided because the cost of testing facilitization was and still is predicted to be prohibitive if done in an uncontrolled and independent manner by each of the contractors who need such facilities to complete the necessary test and evaluation for verification of system performance. As a result of over a decade of investment there is now an infrastructure in the DoD that is available and able to accommodate the private sector's needs for technology demonstrations. These government owned RDT&E facilities provide the capabilities necessary to evaluate virtual, breadboard, development and operational systems in combat environments with warfighters-in-the-loop during the evaluation.

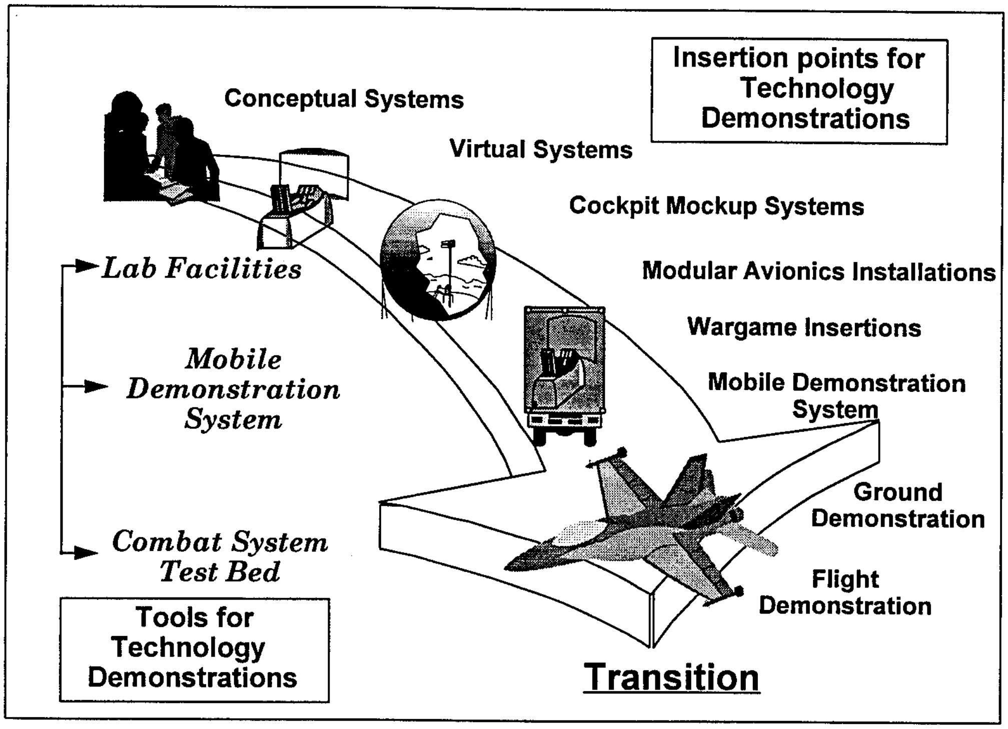

FIGURE 1
TECHNOLOGY DEMONSTRATION INSERTION OPPORTUNITIES

JOINT REVIEWS
The threads of commonality among the warfighters are the weapons that are hung on the airplanes and the cockpits used to fly the airplanes. Lethality of the weapon is required by all services to the same extent at the point of delivery. This common thread is being pursued in the acquisition arena by two common weapon products, the Joint Standoff Weapon (JSOW) and the Joint Direct Attack Munitions (JDAM). Following a similar thread is the need for the combat cockpits to be similar for the integration of sensor information and weapon designation.

To the maximum extent practicable, common cockpits are a focus of Joint Advanced Strike Technology (JAST) and Joint Affordable Cockpit Integration Program (JACIP). JAST is looking to future combat aircraft and JACIP is looking at those in the inventory. Current cockpits require a significant element of training to become usable by the pilot. As a result there is a significant learning curve required in the refresher training program every time a pilot returns to the fleet from non-flying tours. Providing common instrument locations, common symbology, and common locations for switches are just a few of the cockpit characteristics that would shorten the training and provide more time to mission planning and success for the aircrew. More significantly are the potential data fusion technologies that will enable information to be processed intelligently prior to display to the aircrew for their use, reducing the number of variables required to be interpreted and integrated by the pilot for mission accomplishment.

The Joint Cockpit Office (JCO) has been formed and is located at Wright-Patterson AFB to meet the need for commonality in cockpits. This office will be the focal point for the review of technologies that are promising to streamline and evolve the concepts of CCD.

WARFIGHTERS

Along with the JCO is the need for each service and the joint staffs to have a cadre of aircrew that are available to review the technologies that are emerging to enhance cockpit design and usability. This cadre of warfighters will then not only be combat oriented but also will be familiar with the inputs from industry and for cockpit improvements. Allies are also an important consideration as more and more of them buy our platforms and should be included in the cadre of technology conversant warfighters.

COMMONALITY

At the core of all the effort is the recognized need for common displays, common means of portraying data, and common methods of analyzing data and information to get maximum performance from the aircrew, the aircraft platform and the weapons carried. With the JCO, an agreed-to approach to needs for achieving the best CCD, an overarching integrated joint product team working through the JCO, and the current Service field activities providing a series of capabilities to evaluate technology insertions, the cross platform commonality needs for cockpit integration improvements should achieve success in a shorter time than in the past.

IMPLEMENTATION

TECHNOLOGY DEVELOPMENT EVALUATION TOOLS AND FACILITIES

The architecture for achieving success in demonstration requires a continuous stream of capabilities in the Service field activities to take concepts and ideas and evaluate them in real world scenarios. Within the Navy and Air Force are labs and test activities that, provide a spectrum of capabilities that can be used to evaluate concepts, virtual systems, breadboard systems, development systems, and operational systems. In each case there is a different mix of the tools, but the capabilities are there to assist the technology managers and platform program managers neckdown the systems that are viable and add value to the warfighters capability. Technologies in development may enter this transition from concept to operational system at any of the points shown in figure 1, depending on the complexity and the technology risk assessment. Once evaluated and found viable, there is no requirement that the technology march through every one of the insertion points before being considered for transition to a platform. Instead, the technology development continues, focused at the next appropriate demonstration point in the process. The following paragraphs describe the technology demonstration process as it is being implemented today.

TECHNOLOGY CONVERSANT WARFIGHTERS

What is most important about this sequence is the continuous participation by the warfighters from the fleet. These users are a major player in the reviews because of their participation in the evaluation of technologies at various stages. The user evaluation is paramount to the success of a system and therefore frequent user participation is required in the acquisition process, particularly in evaluation of cockpit improvements.

There are multiple advantages of this several-step transition of technology from concept to procurement and deployment:

- Warfighters can be involved throughout the process,
- The tools can provide a virtual environment for any aircraft type,
- Rapid prototyping software can be hosted directly,
- Hardware integration is facilitated by robust interface standards,
- The ability to move to fixed vendor sites such as those for the Mission Reconfigurable Cockpit (MRC),
- There is reduced risk and program cost by minimizing the disconnect between development lab and flight evaluation,
- Aircraft interface relieves need for dedicated avionics benches and eases transition to flight test when appropriate, and
- Laboratory installation remains available to support flight test and evaluation.

CONCEPTUAL SYSTEMS

By definition, conceptual systems are the ideas of the brilliant minds in our business. They are manifested by paper and drawings, or often only a software program running on a generic system which shows the capabilities of the system in general terms. The set of demonstration tools picks this concept up in evaluation in the fixed site laboratory element, shown in figure 1. The services and the joint roundtables use extensive teaming to understand the technology and how it addresses the cockpit information management issue. Supporting the roundtable are generic cockpits that are reconfigurable as the various cockpits that are available today. The intent of this step is to look at compatibility with current configuration, to understand the technology's potential added value, to establish a figure of merit and/or measure of effectiveness for the system, and to help provide a development path to success.

Because of the generic nature of a conceptual system, there are several field activities in the DoD that are capable of evaluating them in the first step of the technology evaluation process.

VIRTUAL SYSTEMS

Virtual systems are another stage in the development process of technology transitioning to products. At this stage the technology is represented by a refined but somewhat generic box with functional capability manifested through software and hardware. It requires some tailoring to meet the interfaces with evaluation systems. Once fitted to evaluation systems, there is the ability of aircrew and engineers to evaluate system performance against canned scenarios to gain better understanding of the measure of effectiveness of the system. Although this step in the process is not necessarily performed by the aircrew, they take on a moderating influence on technology application to guide the technology on a path to successful transition into a platform for improving warfighting capability.

The increased sophistication of the technology in development will limit the number of facilities that can support the hardware and software demonstration and evaluation. The Service laboratories and field activities are required to determine which of the remaining locations for evaluation support are best suited for the particular system under evaluation.

COCKPIT MOCKUPS

To be demonstrated in a cockpit mockup implies that technology in transition has functionality, some well defined interface capability for a particular cockpit, and will add to or replace some system in the baseline cockpit. In this step (also the entry point for established technology looking for an extension of application) the roundtable evaluation is supported by substantial data that can be gleaned from the performance of the system when used by the warfighters, supported by simulation and stimulation. In addition, the added value can be measured directly against the current baseline in integration facilities in the many-on-many battlefield if desired.

Integration facilities are ideal for development at this stage of technology insertion because of their modularity and support for quick-on/quick-off cockpit configurations. A cockpit mockup can be configured off-line and moved quickly into the integration facilities, be evaluated for effectiveness and then moved out and deconfigured, freeing the facility for other activities, the next technology demonstration in the pipeline. Exposure of the technology at this stage provides extremely wide dissemination when it is uplinked into the battlefield and wargame scenarios. Value added to the warfighters can be measured as improvements to the warfighters capability by comparing to the baseline existing system. Because of the significant effort that goes into the wargame scenarios, the scheduling of this stage of technology demonstration becomes much more important that in the previous stages.

MODULAR AVIONICS INSTALLATIONS

While the system that is providing the technology insertion at this stage may be still generic, there is sufficient complexity in compatibility with the targeted aircraft platforms that installation in the platform is required to accomplish the task. Technology insertion at this stage requires the hardware and software to meet interface requirements with the target platform. Its fit must be in the avionics bays that are available and its software must show compatibility with the aircraft bus standards.

To avoid the issues associated with aircraft bus integration and operational flight program (OFP) development, the DA associated with the JACIP program (described below) includes a separate cockpit 1553 bus to allow modular avionics installations including cockpit displays for demonstrations. As a consequence aircraft bus integration is not required.

In this stage the ability of the technology to undergo evaluation by the warfighters, both planners and executors, is extensive. Evaluation in DoD integration facilities and other associated labs, along with the portability of system performance into wargame activities, allows the system to be thoroughly demonstrated. The fixed based and motion based flight simulators and their output to the wargame make this stage ideal to completely understand the added value of the technology in development. Most important, the effect of the system on aircrew performance can be measured directly and in real time.

WARGAME INSERTIONS

This is not necessarily a stage but an emerging capability in some of the DoD test facilities. With their connection into the global battlefield, the technology in demonstration can be flown by aircrew in its designated cockpit through simulation, with a visual system representative of combat environment, using all the sensors that would be available to the aircrew in flight, and receiving off board data and information for processing. The platform performance can then be ported into wargames to determine effectiveness of system in the simulate battlefield environment. A significant feature of this capability is simulation of the almost limitless emissions that can be received and transmitted by the platform sensors. In addition, the aircrew can be put in harm's way without endangering their lives and the systems can be stressed to failure without dire consequences to the platform and aircrew. What cannot be demonstrated is the effects of atmospherics and flight regime stress on the platform being used in the evaluation. This limitation is one of the reasons that flight evaluation is ultimately required.

MOBILE DEMONSTRATIONS

A key element of the development evaluation tool set is the ability to get many users to touch and use the new technologies in their intended environment. The use of aircraft is expensive, time consuming, and reaches a limited number of aircrews. DoD integration facilities are available 24 hours a day but still require the aircrews to be moved to the facility to evaluate the system in development. Mobile demonstrations are a key element of the process because they can take the demonstration to the customers. This provides an opportunity for many aircrew to evaluate a technology relatively quickly and inexpensively. The MDS to be built will be based on an existing AH-1W trainer. It is treated in greater detail below.

GROUND AND FLIGHT DEMONSTRATIONS

For technologies in development that continue in the process towards ultimate acceptance by the warfighter, ground and flight demonstrations in an end user platform are important to ferret out their limitations in the stress of the flight environment. From the evaluation in integration facilities, those areas of system test and evaluation that are not suited to the simulation and stimulation approach to evaluation can be identified and flight evaluation pursued. In addition, there remains the need for flight check of the results of evaluation from simulation to ensure their validity.

Unfortunately, the current ability to install a system into a flight demonstration aircraft is not simple nor of short duration. The mounting, the wiring, the integration with the other systems on the aircraft, and the analysis of the resulting system often takes a considerable amount of time and takes a flight ready aircraft out of its intended mission for an extended period of time. On the other hand, the rapid developing technologies in computer processing power now allow all the processing needed for near and medium horizon cockpit technologies to be done in a single box fitted in the avionics racks and a flat panel display inserted in place of one of the displays in the cockpit.

DEMONSTRATION ARCHITECTURE

JACIP as conceived at this time and discussed in more detail below, will provide a quick-on/quick-off technology demonstration host generic system, consisting of two boxes, a Processor Interface Unit (PIU) and a Display Unit (DU), coupled together with their own 1553 bus. The PIU will be standard size to fit on current racks and the DU is designed to fit in most consoles that have displays for aircrew use and operation. Its software will be compatible with standard laboratory system protocols. This host set of tools is called the Demonstration Architecture (DA). As a result, the only modification that is required for the designated aircraft is a wiring harness to connect the PIU and the DU with the aircraft electrical system and the technology in demonstration. It is intended to designate an aircraft, install the wiring harness, check it out with the PIU and DU, and then return the aircraft to a flying status. This aircraft becomes the CSTB, the designated platform for CCD systems that make it to the flight stage of demonstration. It is important to note that the DA also provides a quick-on/quick-off capability for the labs, vendors, manned flight simulators and the MDS.

Those technologies that make it to the flight demonstration stage should be well on their way to production and integration into designated combat aircraft platforms. Key to the success of JACIP is the ability of the test and evaluation teams to upload a technology into the DA, demonstrate the ability to quickly install it into the designated platform, gain data for evaluation on a not-to-interfere with the other missions of the aircraft, and uninstall it in minimum time, doing the evaluation after data has been collected. The technology demonstration insertion point into an integration facility coupled with the PIU and DU before inserting it in the aircraft is important for the following reasons:

- Maximize the use of laboratory environment to save costs and determine optimal use of flight test,
- Prior integration of the quick-on/quick-off installation in flight simulator cockpits facilitates flight clearances and installations,
- Modular approach minimizes aircraft down-time,
- Synergistic lab support of flight test for anomaly investigation, flight envelope preflight/expansion, and
- Portability of system performance to other ranges and facilities as required, through satellite uplink or in the CSTB.

The impact of flight evaluation is minimal but needs to be demonstrated to the owners of the designated platforms to prove it.

CONCEPT UTILITY

CUSTOMERS

The military aircrew are in the acquisition corps to bring fleet experience to the development and acquisition process. It is important for the acquisition corps to bring their aviators into technology development on regular basis, including staff and students at the test pilot schools to develop an operator advocacy base. In addition the operational test and evaluation forces' aircrew are selected to evaluate technologies periodically and should be involved in technology demonstrations. With the technology hosted and/or processed by the PIU and DU, their compatibility with integration facilities, the MDS and the designated CSTB provides significant opportunity to get a large number of aircrew exposed to the technology to assist in its evaluation.

The MDS will provide the capability to take the technology to aircrew sites and limit the impact to aircrew in operational squadrons. This ability to take the technology to the fleet customer provides a tremendous asset in gaining consensus on technology that can (or cannot) add value to the aircrew in sorting and utilizing the vast amount of data and information that is coming into current cockpits.

War planners will also be able to gain insight into new technologies by their insertions into wargaming simulations. The MDS will also be able to be positioned at the HQ sites for demonstration of the technology to the commanders and their staffs. The ability of the DoD labs to port to the wargame simulations also facilitates this evaluation and customer exposure to the technology.

CREW CENTERED DESIGN

All the information presented so far is focused at shortening the time it takes for technologies to reach the warfighters. A series of stages has been presented which can be entered at any point, depending on the maturity of the technology, to allow the technology to get exposure and be evaluated in the scenario for which it is intended.

What is equally important is the ability of this process to look at the integration of information for better presentation to the aircrew for their use in the quick decision-making process that is inherent in the combat environment. The PIU and DU will be able to take technologies that are intended to show integration of information that is now available for better display and use to the aircrew. This aspect of the capability gets at the current issue that is driving the length of training, the amount of information that is required to be sorted to conduct a combat mission, and, more importantly, allow the aircrew to adjust the mission once airborne because of changed conditions on the battlefield after takeoff. The JACIP concept will allow the crew centered design technologies to be evaluated throughout their development cycles and gain consensus from various customers.

JACIP AND JAST INTERFACE

Conceptually, the JAST program is looking to the future for systems to meet and enhance the JAST requirements. The platform for the JAST systems and technologies is yet to be defined. On the other hand, the JACIP program is looking for future capabilities to put into current operating platforms on a production or retrofit basis. The search for technologies is essentially the same. The difference is the integration requirements — in the JACIP it is in real airplanes in the fleet, whereas in the JAST program it is building a set of systems around which to wrap a suitable airframe and engine.

While all systems developed from the technology streams are not necessarily going to be applicable to JAST and JACIP platforms, most will be suitable for consideration through most of the stages of technology insertion if they are found to add value to the warfighting capability of the platform. In addition, the JACIP program allows well-developed but interim improvements in capability to be inserted in the fleet. It also allows aircrews from more than one platform to evaluate the technology for their respective missions.

CANDIDATE PROGRAMS

NEAR-TERM

There are several systems and technologies under development that are in need of demonstration. Among those that are closest to insertion and in the later stages of technology development are:

- Helmet vision systems (Agile Eye, Crusader),
- Crew Laser Protection,
- Integrated Advanced Tactical Displays,
- Terrain Referenced Navigation and Ground Proximity Warning,
- Advanced Technology Crew Station (ATCS) Subsystem Transition, and
- Airborne Tactical Information Management System (ATIMS) Flight Demonstrations.

LONGER-TERM

Longer term are technology developments that will require technology insertions at the advanced stage:

- Crew-centered technology integration with open architecture core,
- Helmet Program with PMA-202,
- Warbreaker Technologies, and
- JAST technologies.

JACIP

INITIAL SYSTEM

There are several reasons for the development of the JACIP effort, not the least of which is the loss of development aircraft dedicated to technology development. There are two papers, "Advanced Avionics Architecture; the NAVAIR Study" and "Crew Centered System Design," that focus on the rapidly emerging need for a new way to insert developing technologies into the combat environment sooner to determine their value added to the warfighter. From these two papers has developed the concept of modular generic units to process and display information in the cockpit. Two separate generic DA units are currently on contract, each consisting of a PIU, the DU, and connecting wiring harness that includes a 1553 bus. Figure 2 shows the schematic of the system as used to evaluate a helmet system. Unique to this system is the non-interference to the platform bus by the DA 1553 bus, the DA bus only listening and passively extracting the information necessary for effective use of the PIU, DU, and the technology in demonstration.

PURPOSE OF JACIP DEMONSTRATIONS

The vehicles for the JACIP DA are the integration facilities, the MDS and the CSTB. The purpose of the MDS is to get as many operators close to the technology under development as possible at a stage in the technology's development that is mature enough for the operator to realize value added if the technology were added to current operational platforms. The CSTB is inherently more expensive and less available because it is a flying platform. However, the real mettle of any new technology is not its promotional view graphs or in its evaluation achieved by the MDS and simulators, but

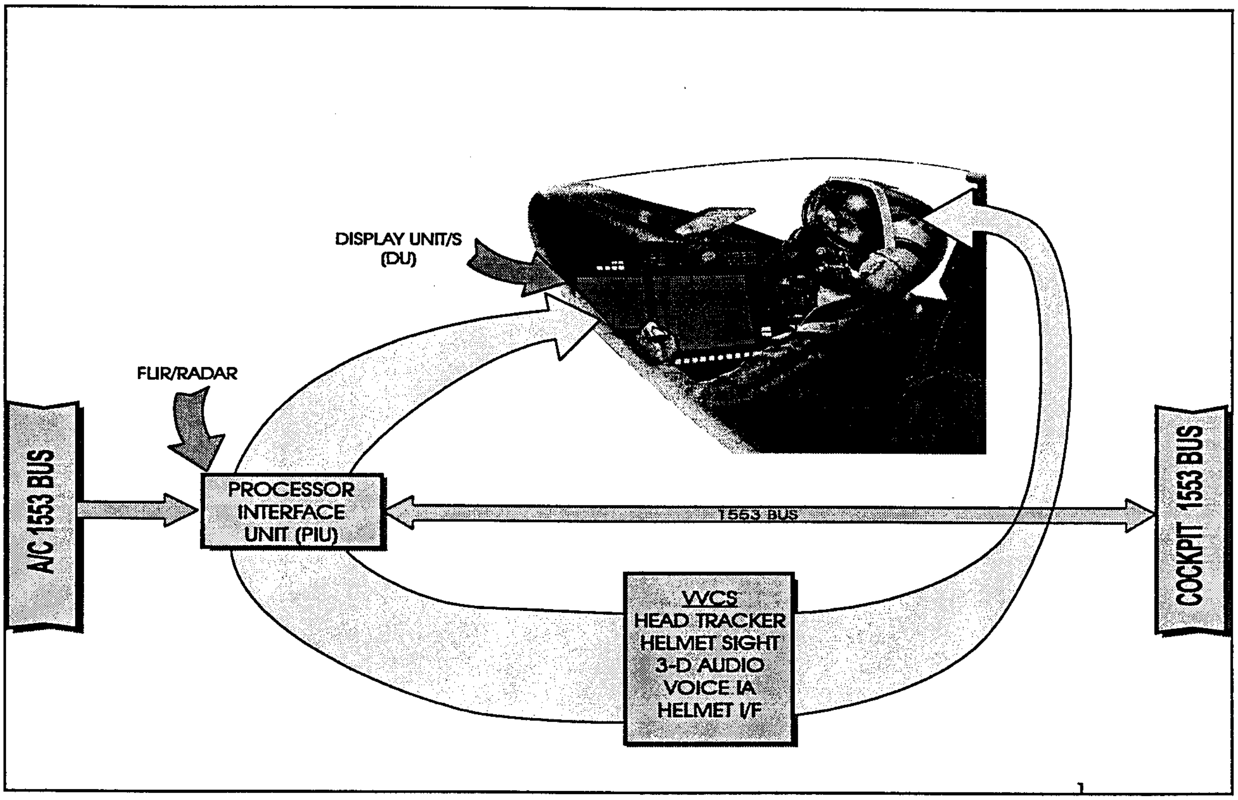

FIGURE 2
GRAPHIC DESCRIPTION OF THE JACIP BASELINE DEMONSTRATION

in its wringing out in the cockpit by the warfighters. To do that requires airborne evaluation by trained aircrews to determine that the results from integration facilities, MDS, and other forms of ground evaluation are substantiated in the air under the stress of the flight regime. Graphically, figure 3 shows the relationship of the demonstration activities, the DA and the technologies in development.

Once the MDS and CSTB are established as viable entities to use in the final stages of new technology development, they then become test bed vehicles for the host of maturing technologies that are focused on the integration of cockpit information into the aircrew decision making, as follows:

CSTB

- Allows technology products to be flown and validated at earlier stages in the development process,
- Provides a baseline to introduce and demonstrate technology products in a combat platform,
- Becomes a technology testbed for common-systems program managers, as well as being available for JAST or platform program managers.

MDS

- Provides user feedback on real and proposed features earlier in the technology development process,
- Demonstrates technologies to a wide variety of customers,
- Supports CSTB integration and flight test programs.

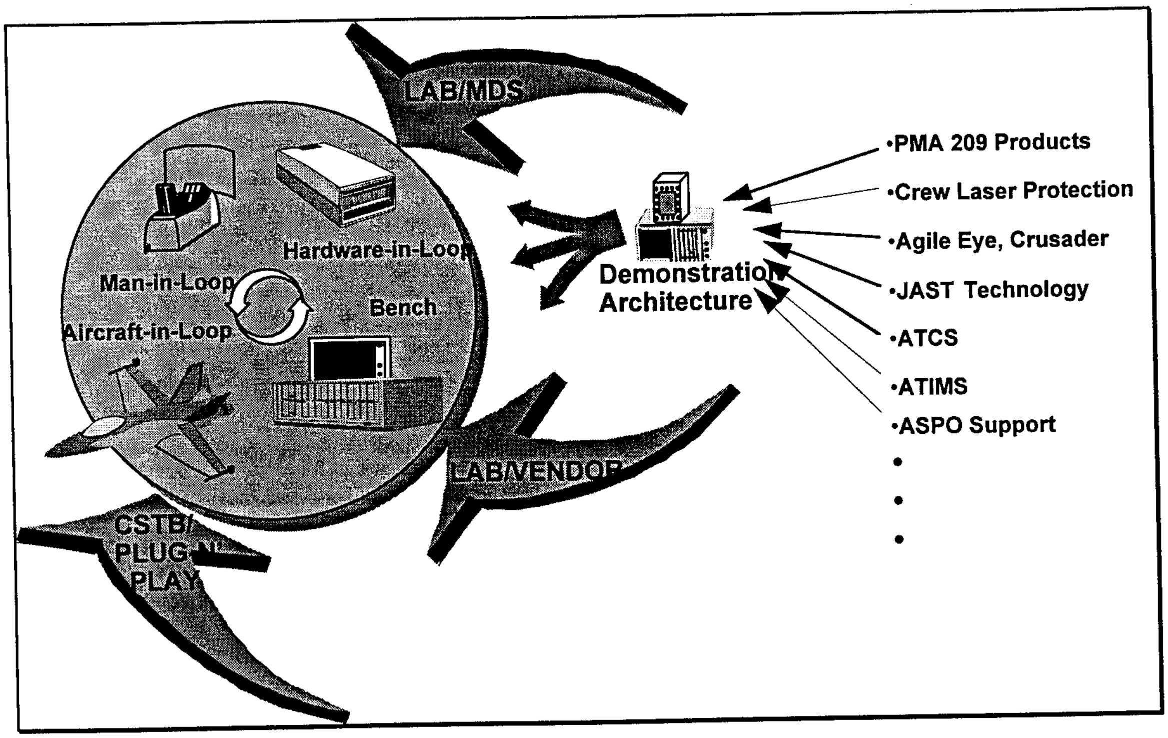

FIGURE 3
RELATIONSHIP OF TECHNOLOGY, DA, AND DEMONSTRATION ACTIVITIES

INITIAL DA COMPONENTS FOR BASELINE DEMONSTRATION

The PIU has been designed with as many useful data interfaces as possible. It will be able to take both analog and discrete signals; video from FLIR, RADAR, and TV sensors, and the TAMPS Mission Planning inputs. The PIU system bus interface will have the following capabilities/architecture:

- RISC 3000
- Digital Map

- Growth Capacity for Helmet
- I/O
    - 1553 (2)
    - RS422
    - ARINC 429
    - 64 Disc/Analog
    - SCSI 2
- Video Multiplexor
- Controller for Multiple Displays.
- Helmet Video Control
- DU Video and Control (4 Channels),
- Miscellaneous analog, discrete and other interface signals.

The DU will have the following characteristics:

- Smart AMLCD Flat Panel Display (Self contained graphics generator)
- NVIS and high ambient light compatible
- 6.25"x6.25" or 6"x8" or 6.71"x6.71" sizes
- High Performance Graphics Generator
- Raster Color Digitization
- Graphics Video Mixer
- VTR Output.

The production of two PIU/DU sets (different technologies in each set) has been contracted by the staff at NAWCAD Warminster. Figure 4 shows a schematic, identifying some of the key features in the system. The cockpit bus connects the PIU, the DU and the technology under evaluations. It is incorporated separately into the aircraft wiring harness, allowing remote sensors under evaluation such as a helmet mounted sight to pass information to and from the DU without the requirement to be integrated into the aircraft system bus.

In the MDS the PIU and the DU will be set up in simulation with a core capability provided by a Silicon Graphics Computer system Additionally, the MDS will have the initial helmet system along with 3D audio and projection screens to provide some realism to the evaluation aircrew using the system.

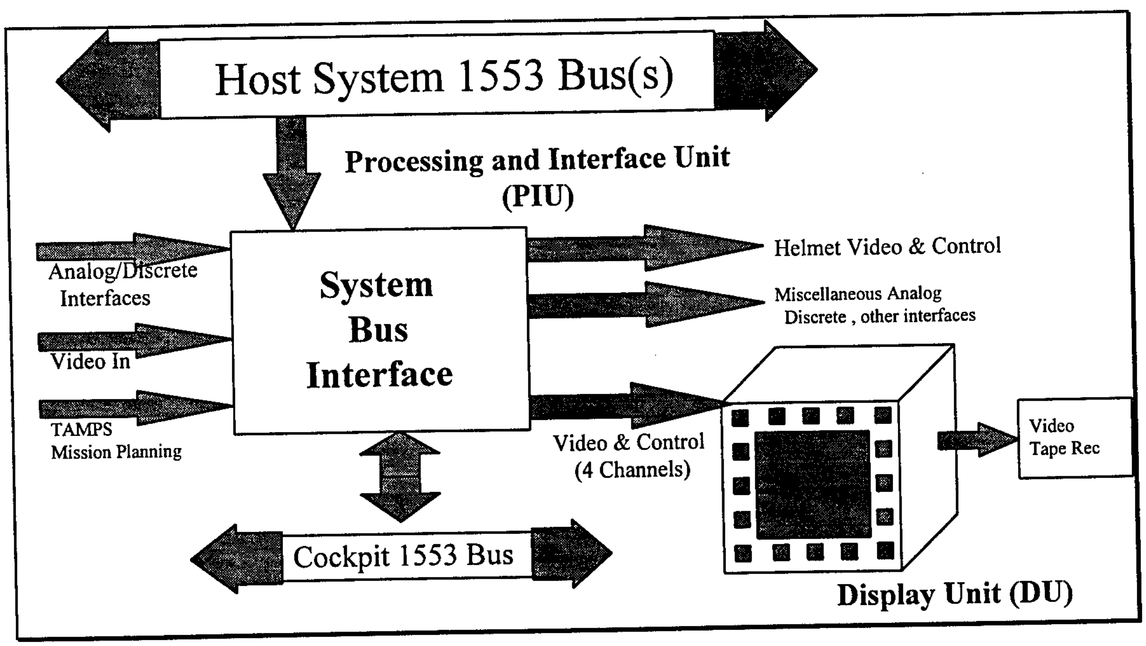

FIGURE 4
SCHEMATIC OF THE JACIP BASELINE

JACIP INITIAL DEMONSTRATION SYSTEM

In order for the quick-on/quick-off concept to work, it must be demonstrated to the owners and operators of the target test beds. Several helmets are in development, some of which are available now for integration into the cockpit. The JACIP project proposes to install the DA that is now being built into an available chase aircraft and designate this aircraft as a CSTB.

RISK ELEMENTS

Initial risk to the chase supported development programs is in downtime on the chosen aircraft for the wiring installation, DA installation and checkout, and DA removal (except for the wiring harness). Subsequent to this initial downtime there is additional risk associated with the time required to install and remove the quick-on/quick-off equipment on a not-to-interfere basis. It is proposed that the time required for this operation be part of the initial demonstration of the system with the helmet technology. Another risk element is the number of technologies that will require the aircraft for evaluation and the time required to achieve adequate evaluation of those systems. The incorporation of the processing into the DA quick-on/quick-off core technology rather than into existing operational flight programs and the fit of the DU where the current displays are now located in the F/A-18 cockpits reduces to a minimum the risk for time lost when reconfiguring the aircraft to receive new technologies for ground and flight demonstration.

SCHEDULE

The DA units were put on contract in September 1994. The units are scheduled to be delivered in the 1995 and 1996 time frame. Software development has started with initial demonstration in the lab in the Fall of 1995. Flight evaluation and demonstration of the quick-on/quick-off capability are scheduled for the first quarter of 1996.

TEST RESOURCES/FACILITIES

COMBAT SYSTEM TEST BED

The reduction of aircraft from the RDT&E aircraft inventory has left a gap in the assets needed to evaluate emerging technologies. JACIP requires some form of CSTB to allow evaluation of emerging technologies in the airborne environment as does JAST. The demonstration of the quick-on/quick-off capability in a multi-use chase aircraft is essential to technology demonstrations because there are not enough dedicated assets available. There is confidence that the JACIP program will mitigate the need for a dedicated asset for the following reasons:

- Supports the NAWC RDT&E role and DoD technology thrusts more efficiently,
- Makes efficient use of existing laboratory and flight test infrastructure,
- Provides a vendor-neutral environment for implementation of crew-centered open architecture and standards,
- The PIU and DU are being built to minimize cockpit and aircraft integration disruption,
- Allows more extensive and rapid modifications because the changes are in the DU and PIU, not the base CSTB aircraft,
- Integration into the aircraft operational flight program is not required because the cockpit bus handles all traffic associated with the demonstration systems, and
- Does not compete directly with other development and operational test aircraft priorities.

Ideally there would be a family of CSTB's to evaluate technologies in their advanced development model (ADM) stages where a larger platform would be suitable for some of the bulkier configurations that have not undergone the size and weight refinement for combat aircraft application. In addition, a larger platform would allow scientists and engineers, both contractor and government, to fly with the system in its airborne evaluation.

MOBILE SIMULATION SYSTEM

JACIP resources would be complemented by a MDS, where the DA is hosted in a trailer similar to the deployable AH-1W Trainer built at the NAWC and would be sponsored by common-system PMA's.

A depiction of the MDS is shown in figure 5. The advantages of a MDS include:

- Flexibility of deployment as a stand alone operation on trailer, moved by trailer and installed in a host laboratory, or remain in trailer next to the host laboratory with an umbilical into the host laboratory,
- Self-contained visual system,
- Silicon Graphics-based platform environment simulation and stimulation available to all vendors and labs,
- Interface Control Document's available to all vendors and labs,
- Distributed Interactive Simulation (DIS) gateway for networking,
- Reconfigurable Manned Flight Simulator-compatible interfaces
  - Organic virtual aircraft/environment
  - Organic virtual environment linked to bench or aircraft (e.g., at WSSA)
  - Linked to environment/linked to virtual aircraft (e.g., trainer dome at operating base),
- Multi-level security depending on classification of technology,
- Precedent established with the Deployable AH-1W Trainer,
- Ability to take technology to the customers
  - Strike U/MAWTS/Training sites
  - CINC and other HQ sites,
- Provide support for multiple programs
  - ATIMS
  - Common Avionics
  - ATACK
  - ATCS.
  - JACIP
  - JAST
  - MRC

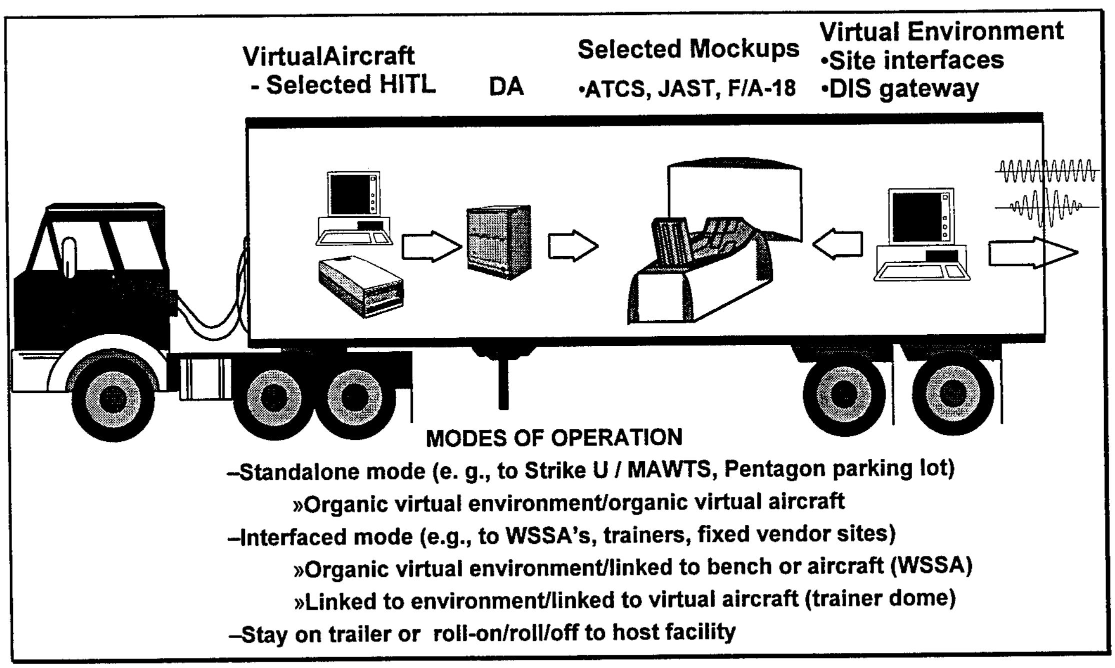

FIGURE 5
DEPICTION OF THE MOBILE DEMONSTRATION SYSTEM

SUMMARY OF BENEFITS

The crux of the issue is the availability of aircraft assets to the laboratory environment for ground and airborne evaluation at early stages in the technology development process. In one camp aircraft are looked upon as warfighting machines and therefore underutilized if they are not available for the flight schedule. On the other hand, even with the use of modeling, simulation and stimulation techniques and capabilities, there is a need to get the scientists and engineers in the technology development environment a status of the applicability of their technology as early in development as possible. There are several thrusts now being funded such as Foreign Comparative Tests, Advanced Technology Demonstrators, etc., that require aircraft to be look at as part of the laboratory structure and not as warfighting machines.

This paper has presented background, technologies, and needs for a set of demonstration evaluation tools to complement the DoD lab facilities. One of those tools is the MDS to extend the ability to get a larger base of users involved in the new cockpit technologies earlier. The other is a CSTB to put a well developed technology through the stress of the flight regime. These three demonstration evaluation tools have a common core DA which hosts the emerging technologies.

To recap, the benefits of this DA-based approach are:

- Enhances acquisition program risk reduction and requirements validation by providing a parallel vendor-neutral definition/demonstration forum,
- Facilitates transition of systems-level cockpit-intensive technology programs (ATCS, ATIMS, etc.) from private and public labs to customer,
- Supports integration, validation and verification of new hardware and software functions,
- Provides a direct path to integration facilities for subsystem-level vendors,
- Takes advantage of the co-location of engineers, aircrew, prototyping facilities, flight simulation, and aircraft in the government development laboratories,
- Leverages existing DoD/industry laboratory infrastructure, and
- Potentially the most cost-effective combination of services for DoD, industry and foreign technologies in demonstration.

BIOGRAPHICAL INFORMATION ON AUTHORS

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Currently Branch Head, Systems Technology, Naval Air Warfare Center Aircraft Division Warminster PA (215) 441-3186.

Over 15 years experience as a Branch Head involved in the hands-on-design and development of computer based Avionics and Laboratory Systems. Over 30 years experience in both government and industry in the specification, design, development, and integration of electronic systems, including wide band communications systems, Modeling and Simulation Systems, and Advanced Prototypes. Education includes a BS in Electronic Physics from LaSalle College and a MS in Engineering Science from Pennsylvania State University.

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In current assignment Mr. Kahle is responsible for coordinating technology programs and facilities. He has over 30 years of experience in aircraft mission systems testing and the development of test facilities. Education includes: BSEE, University of MD; MS in Computer, Information and Control Engineering, University of Michigan; MS in Engineering Management, George Washington University; Program Management Course, Defense Systems Management College.

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Currently working in project management support for the Federal Government. Retired from the Navy after nearly thirty years of service. That 30 years included significant aviation experience as a helicopter pilot, engineering test pilot, squadron command, ship operations officer, H-2/H-3/executive helicopter program manager in NAVAIR, test facility and resources management at NAWC Patuxent River as Vice Commander, and a final tour as a Branch Director in OPNAV logistics. Has Bachelor of Arts Degree in Biology from Dartmouth College and Masters of Business Administration from George Washington University. Also graduate of the USN Test Pilot School and the Program Management Course at Defense Systems Management College.

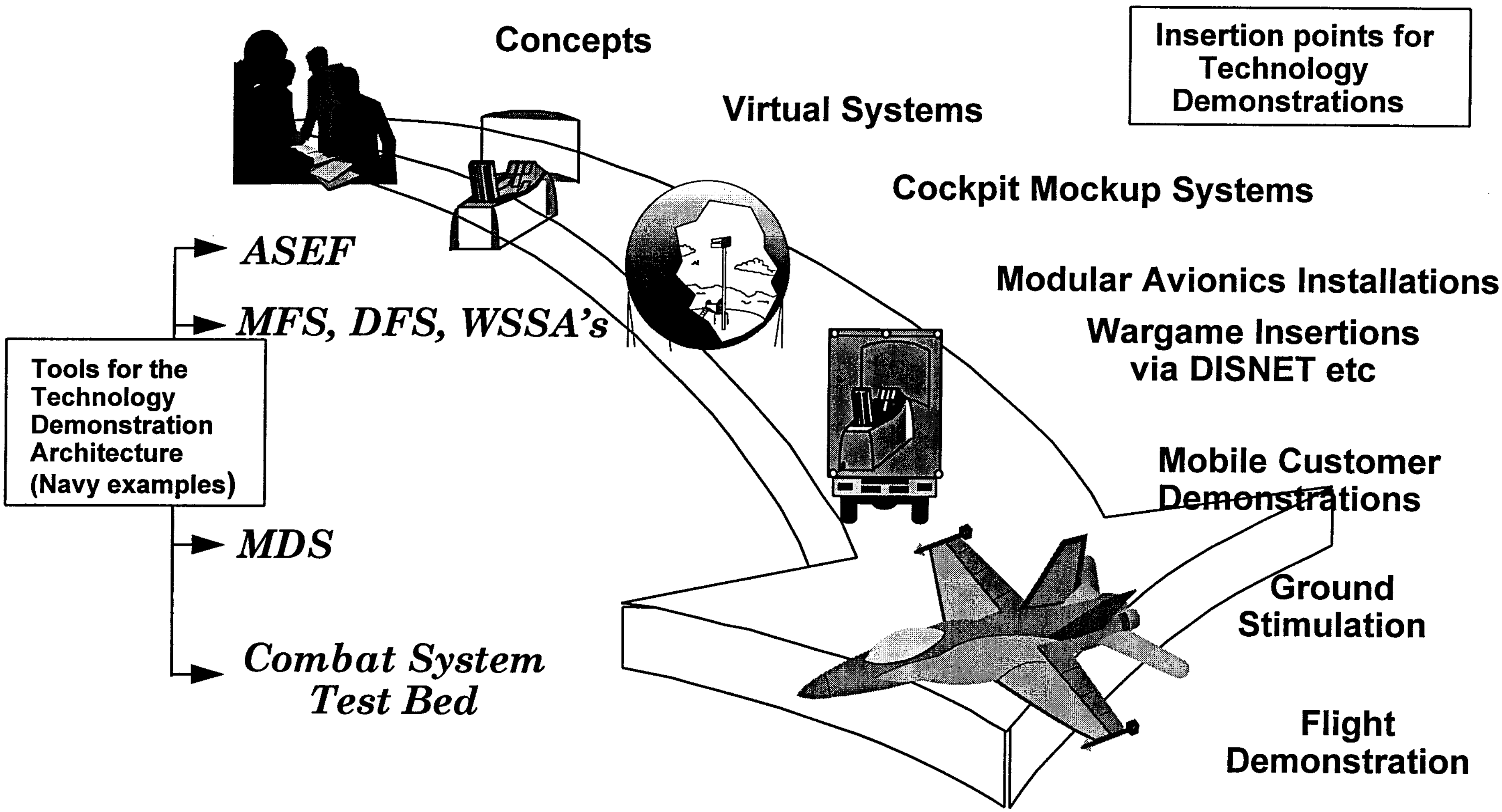
Technology Demonstration Tools for the Strike System Design Team

Objectives

- **Long-term vision:**
  - An integrated set of technology demonstration tools for the Strike System Design Team which provides a seamless transition for maturing technologies using a Crew-Centered Design (CCD) process across the the spectrum from initial concepts through flight demonstration
- **FY96 Plan:**
  - Establish a CCD Demo Architecture (DA) to support near-term "plug-and-play" demonstrations of currently-available technologies in ground and flight environments
  - Integrate the DA in a Quick-On/Quick-Off (QO^2) configuration in an F/A-18 aircraft and demonstrate in flight
  - Plan and design a portable Mobile Demonstration System (MDS) to take technology demonstrations to customers
- **Underlying philosophy--Affordability:**
  - Provide environment to maximize leverage of existing programs across DoD and industry in era of declining resources
  - Leverage existing laboratory and aircraft resources
    - » No new labs
    - » No dedicated aircraft
  - Utilize COTS & Air Force & Navy Labs & Industry Networked

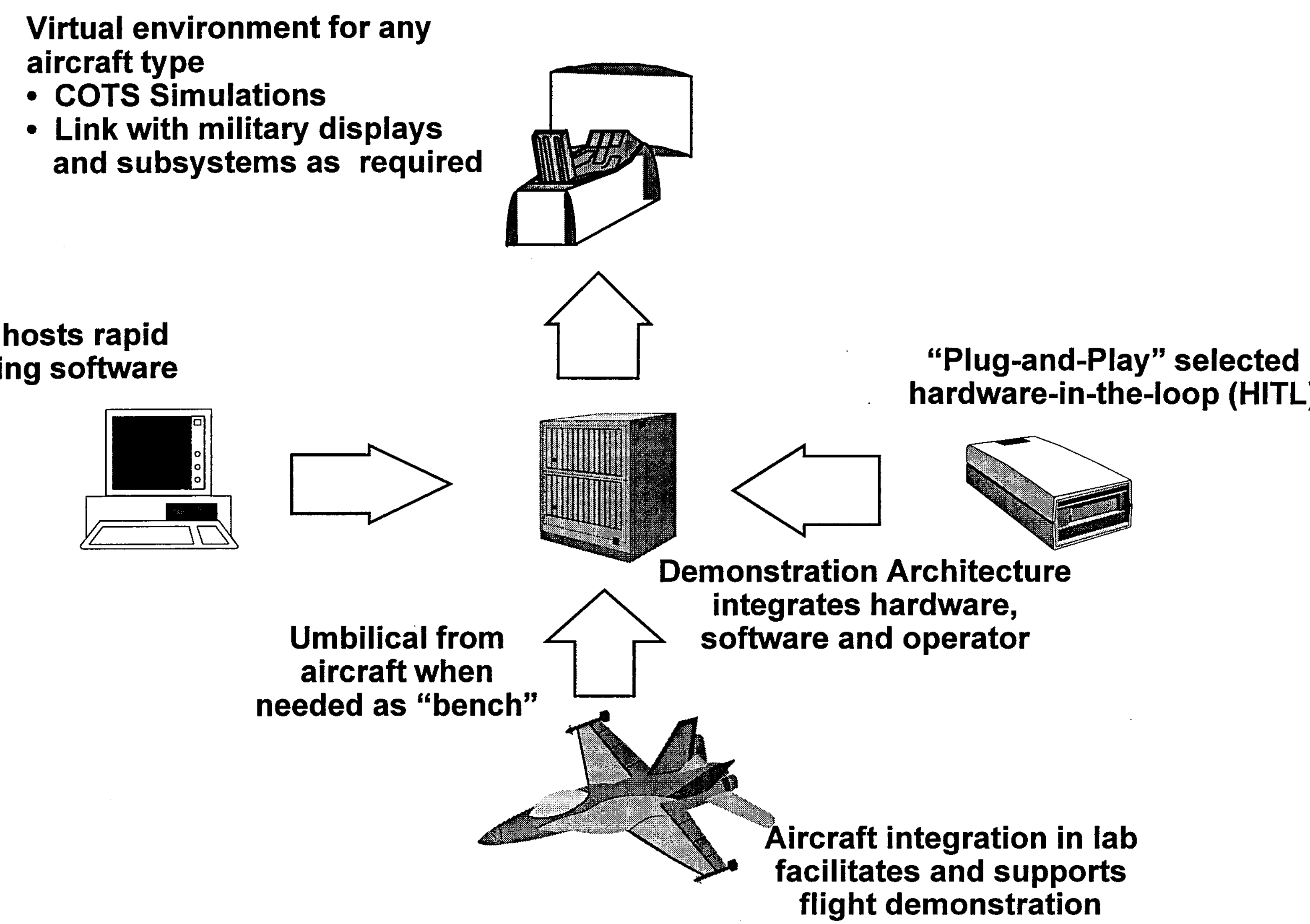
Technology Demonstration Process

Requirements driven...

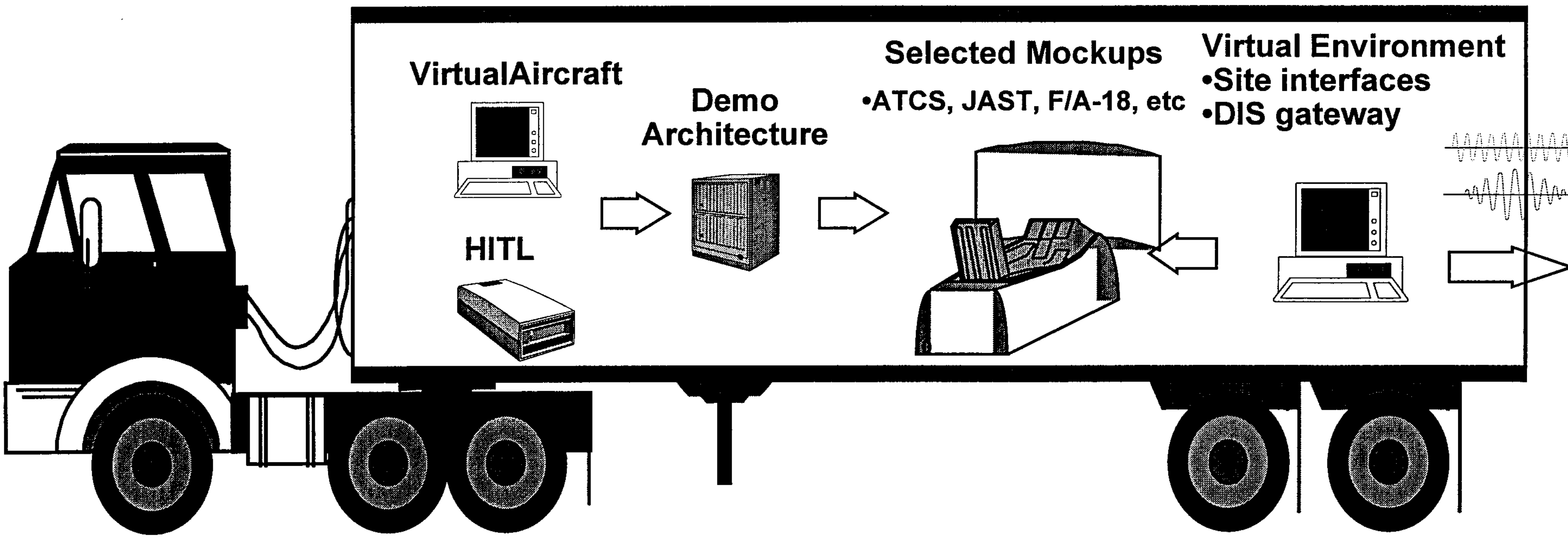


Improved transition of products for multiple platforms

Laboratory-based Demonstration Environment

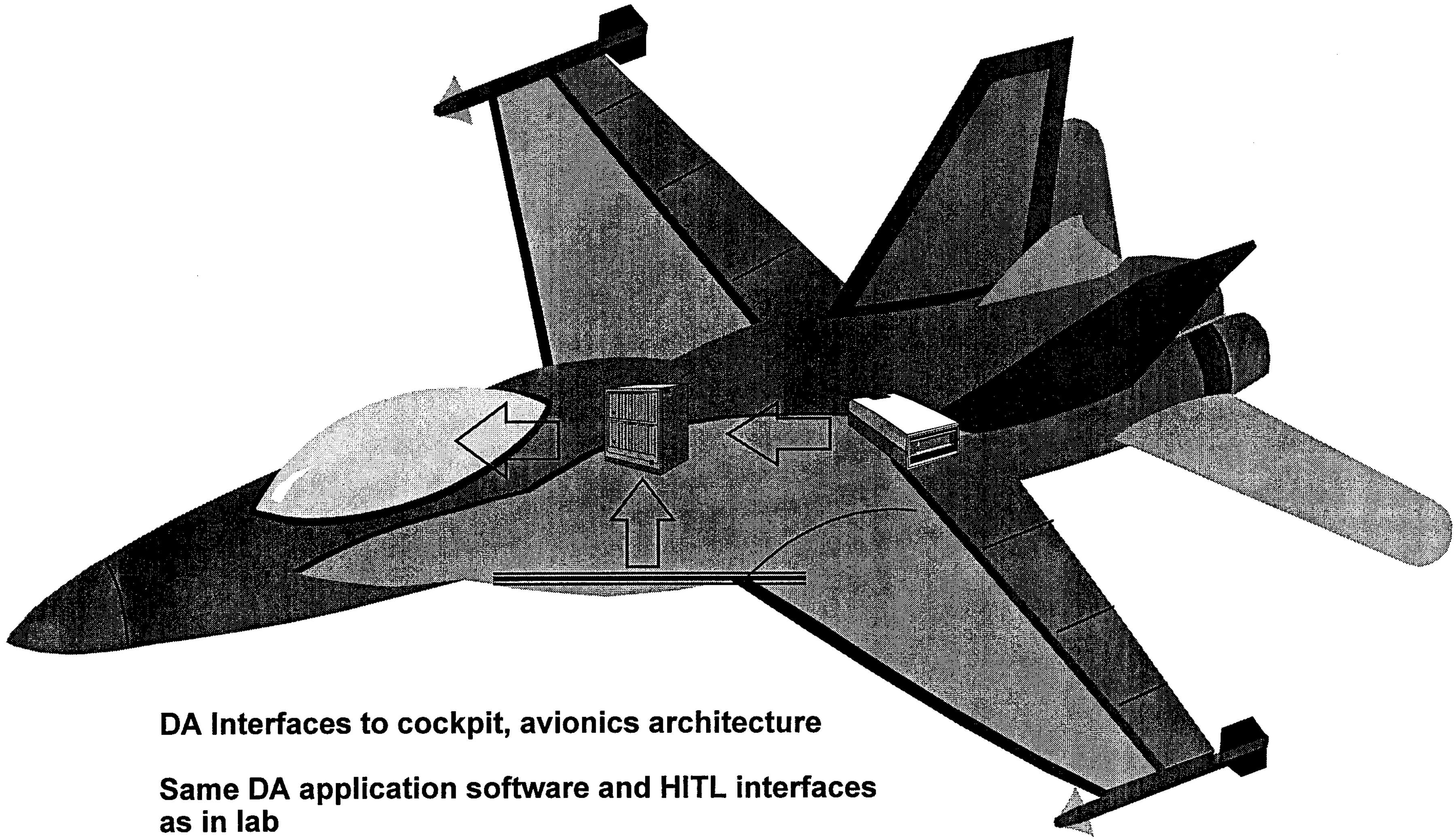


Mobile Demonstration System



- –Standalone mode (e. g., to Strike U / MAWTS, Pentagon parking lot)
  - »Organic virtual environment/organic virtual aircraft
- –Interfaced mode (e.g., to WSSA's, trainers, fixed vendor sites)
  - »Organic virtual environment/linked to bench or aircraft (WSSA)
  - »Linked to environment/linked to virtual aircraft (trainer dome)
- –Stay on trailer or roll-on/roll/off to host facility

Flight Demonstration Combat System Test Bed



DA Interfaces to cockpit, avionics architecture

Same DA application software and HITL interfaces as in lab

Design for Quick-On/Quick-Off installation

Potential Applications

- Helmet Vision Systems (Agile Eye, Crusader)
- Crew Laser Protection
- Integrated Advanced Tactical Displays
- Terrain Referenced Navigation and Ground Proximity Warning
- Advanced Technology Crew Station (ATCS) Subsystem Transition
- Airborne Tactical Information Management System (ATIMS)
- Provide support to ASAPs, MITL COEA trades, etc.
- Promote up-front fleet involvement by inviting fleet aircrew to participate in demonstrations
- Involve integrated advanced technology systems as participants in wargaming simulations

NAVAL AVIATION SYSTEMS TEAM

Potential Applications, Continued

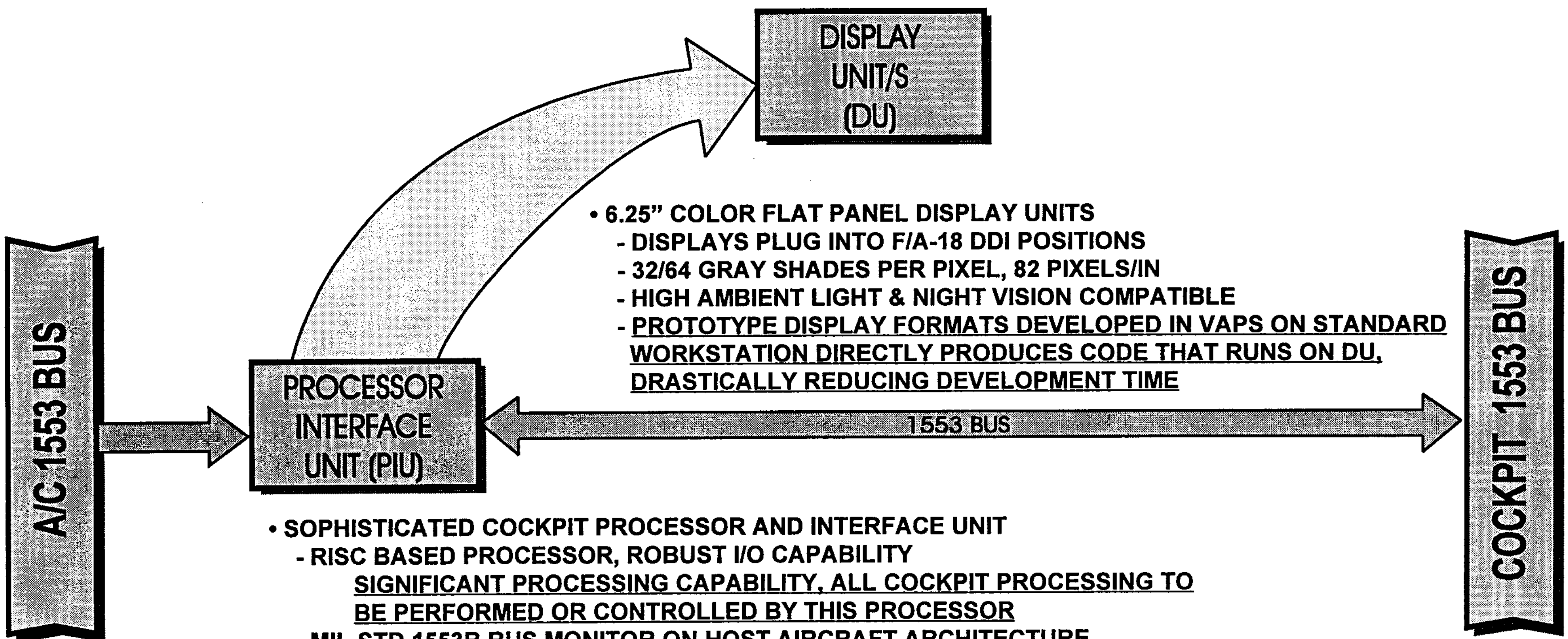
NAWC NAVAL AIR WARFARE CENTER

- COTS Product Insertion/Validation for ONR/JAST/PMAs
- ONR Product Testbed
  - 3D Stereo Graphics, 3D Audio
  - Air Vehicle Diagnostics Systems (AVDS)
  - Virtual Reality (VR)
  - Open DataBase Connectivity (OBDC) -- open real-time database driven system
- Technology Testbed
  - PMA 201, 202, 205, 209, 233
  - JAST
  - F/A-18

CCD Demonstration Architecture (DA)

- **Baseline architecture to integrate demonstration of hardware and software**
  - Consists of Processing and Interface Unit (PIU) and Color Flat Panel Display Unit (DU) with adjunct systems
  - Components already procured, in pipeline for delivery
- **Modular packaging to facilitate technology transition from integration laboratory to flight simulation to trailer or test bed aircraft**
  - Robust hardware and software interfaces
  - Growth to accommodate emerging open architecture standards
- **Minimal physical or schedule impact on cockpit mockups or test bed aircraft**
  - Non-intrusive one-time interface cabling installation in host platforms
  - No modifications to host operational flight programs
  - Quick installation/removal of DA components and units under test

CORE DEMONSTRATION ARCHITECTURE



- 6.25" COLOR FLAT PANEL DISPLAY UNITS
  - DISPLAYS PLUG INTO F/A-18 DDI POSITIONS
  - 32/64 GRAY SHADES PER PIXEL, 82 PIXELS/IN
  - HIGH AMBIENT LIGHT & NIGHT VISION COMPATIBLE
  - PROTOTYPE DISPLAY FORMATS DEVELOPED IN VAPS ON STANDARD WORKSTATION DIRECTLY PRODUCES CODE THAT RUNS ON DU, DRASTICALLY REDUCING DEVELOPMENT TIME

- SOPHISTICATED COCKPIT PROCESSOR AND INTERFACE UNIT
  - RISC BASED PROCESSOR, ROBUST I/O CAPABILITY
    SIGNIFICANT PROCESSING CAPABILITY, ALL COCKPIT PROCESSING TO BE PERFORMED OR CONTROLLED BY THIS PROCESSOR
  - MIL STD 1553B BUS MONITOR ON HOST AIRCRAFT ARCHITECTURE
    NO MODIFICATIONS TO OFP REQUIRED, NO REVALIDATION OF MISSION SOFTWARE, ALL PROCESSING IN COCKPIT
  - RASTER & STROKE GENERATIONS FOR HELMETS
  - SINGLE CARD DIGITAL MAP
    DIGITAL CHARTS, CONTOUR MAPS, THREAT & TARGET SITE PICTURES
  - MULTI CHANNEL VIDEO SWITCH
  - MULTISCAN RATE VIDEO INPUT - FLIR, RADAR, VISUAL VIDEO

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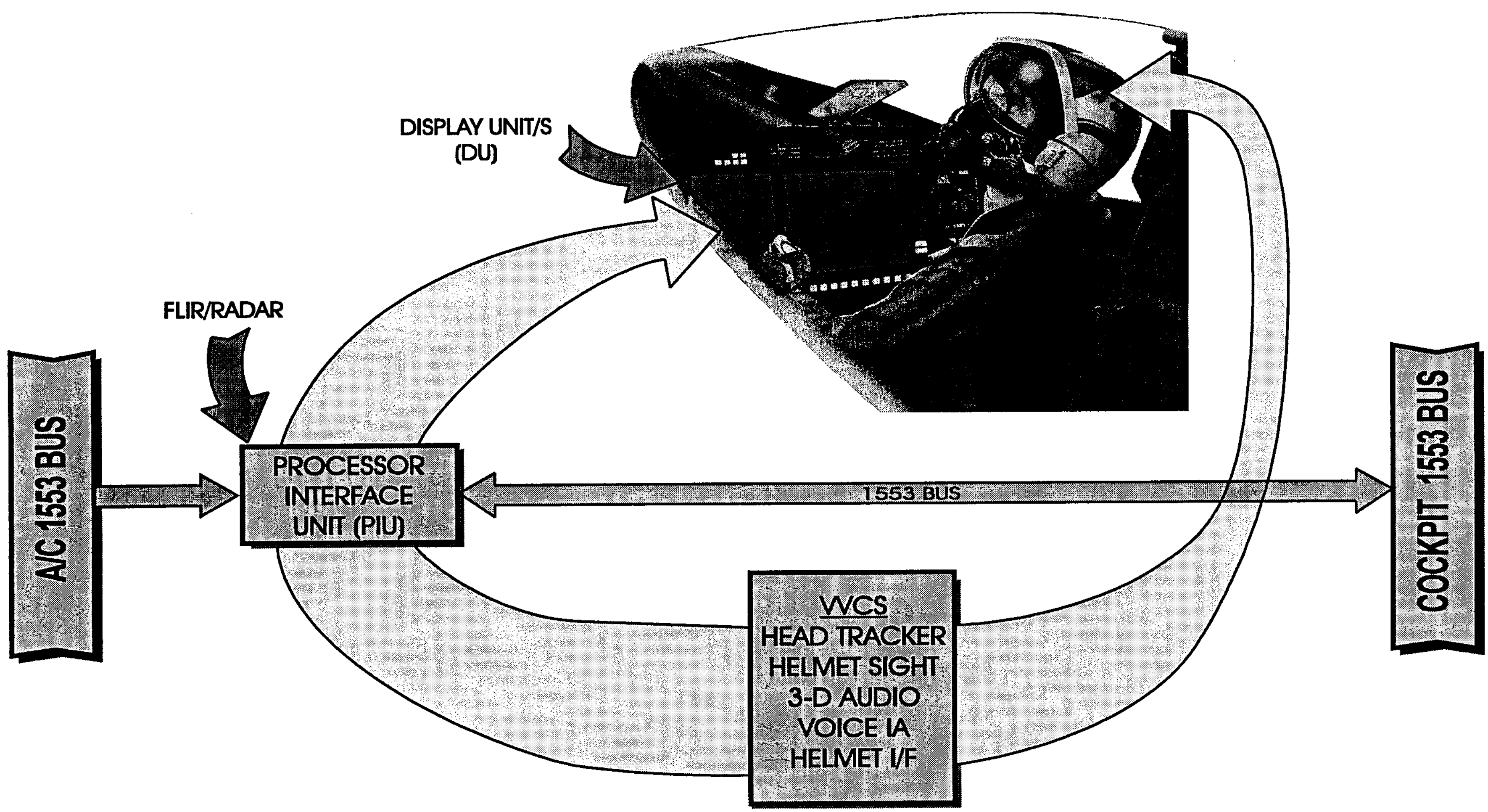
BASELINE SYSTEM COMPONENTS



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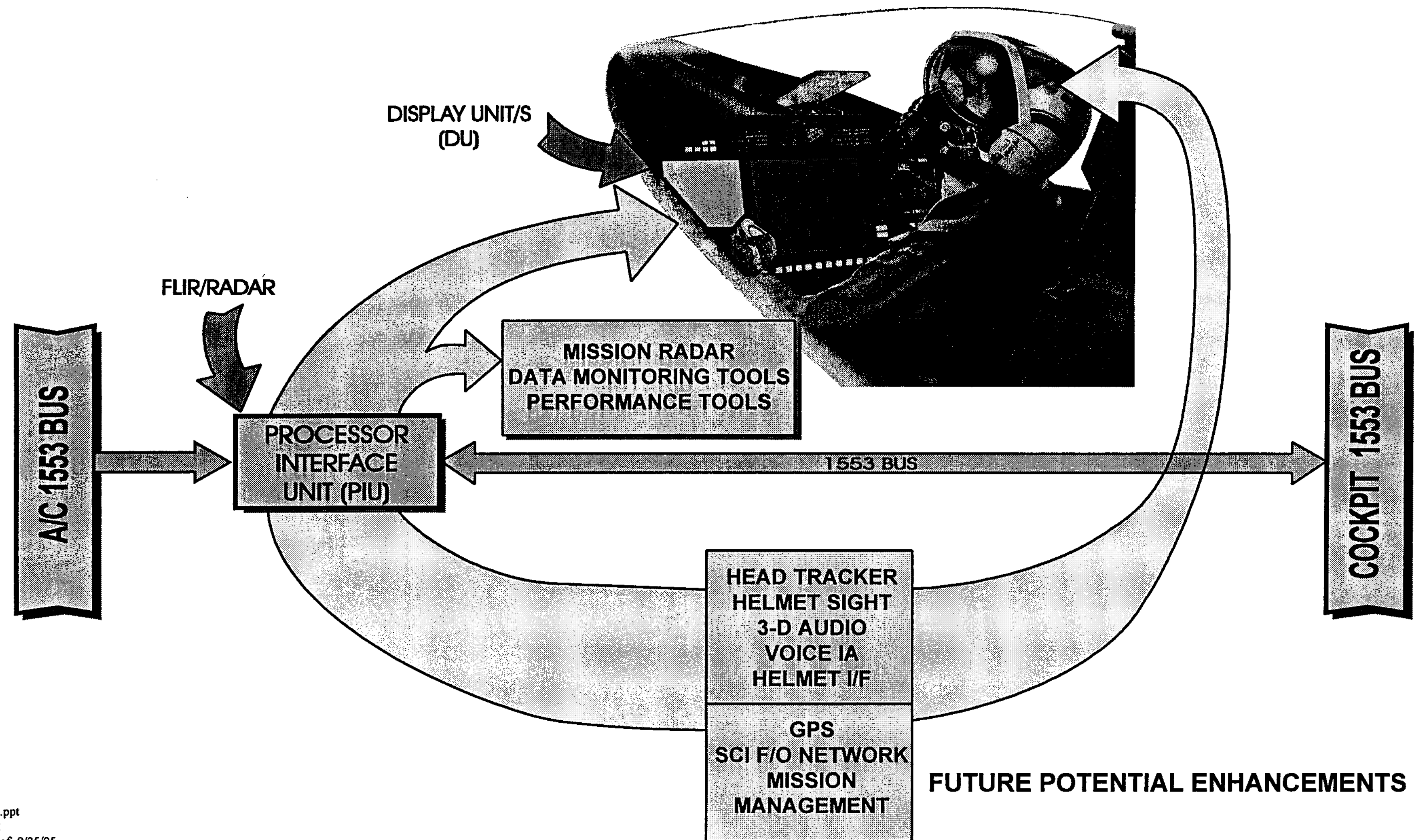
BASELINE WITH ADJUNCT SYSTEMS



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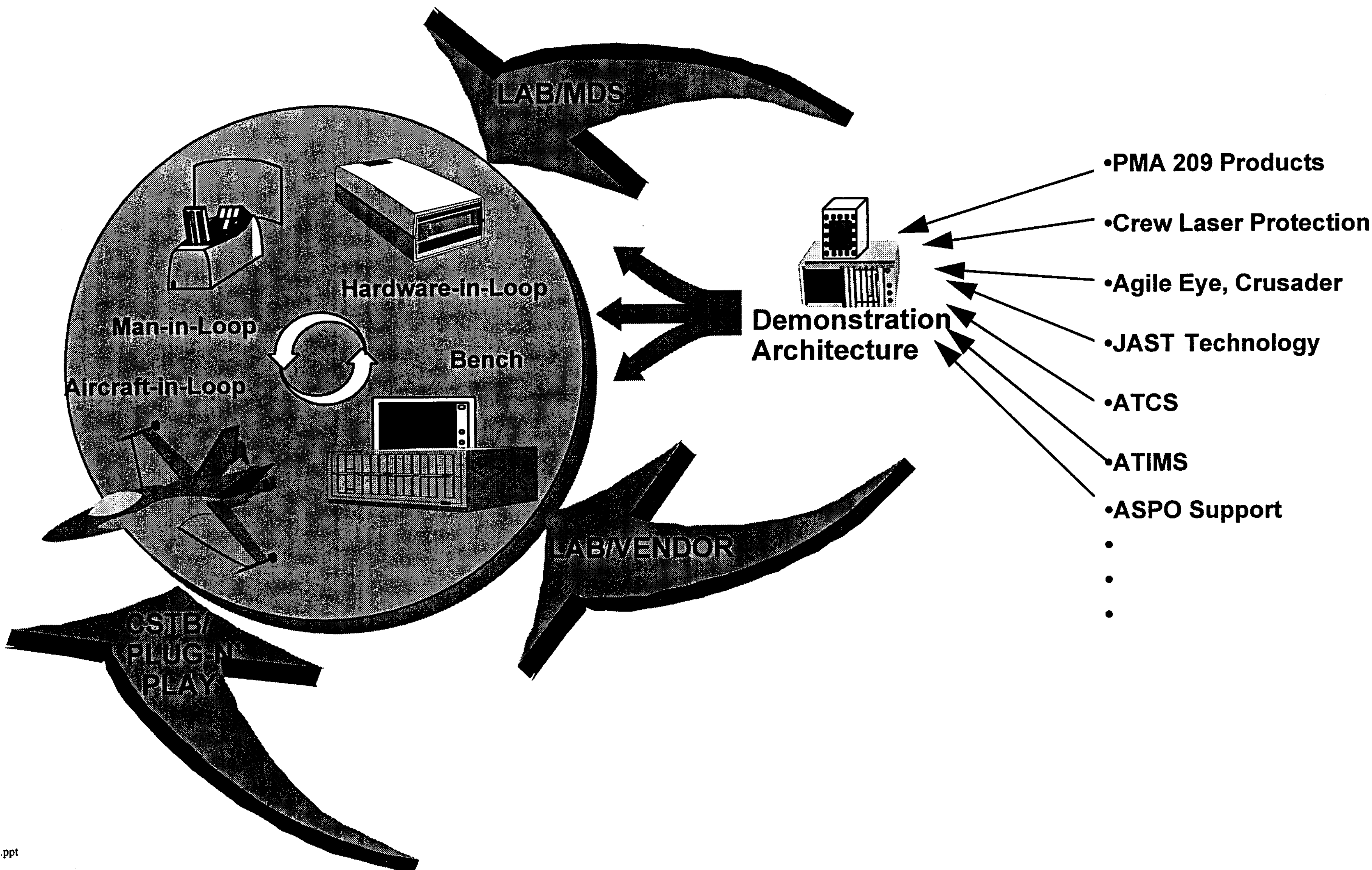
CORE DEMON STRATION ARCHITECTURE INSERTION OPPORTUNITIES



LEVERAGE EXISTING TOOLS & INFRASTRUCTURE

- Utilize Existing Simulation/Modeling Tools; Provide To Industry & Government Players
  - SGI Based Graphics Simulation to be Utilized; COTS RISC & CISC uProcessors, C, C++
  - Models Currently Available From Navy, Airforce, & Industry to be made available
    - » Flight Simulation
    - » Sensor Simulation - Visual, FLIR, RADAR, IRST (Statistical Det & Video)
      - Targets & Background (air, ground); Database Driven
    - » Out-The-Window Scene Generation
    - » Cockpit Modeling, AMLCD Displays, 3D Audio
    - » VR Display Systems, Helmets
  - Database Driven Models, ODBC
  - Use of COTS Equipment, Modules & Components, Software (Exec & application)
  - Use of Standard & High Speed Standard Interfaces, Scalable Coherent Interfaces
  - Rapid Migration of Systems & Software to Vehicle
    - » VAPS Displays/Software >> Real System Displays & Software

FY96 Plan

- Baseline DA system
  - Define configuration
  - Integrate baseline DA system components at NAWC lab
  - Link with MFS F/A-18 cab at ACETEF and exercise simulation/stimulation
- $(QO)^2$ Flight Demonstration
  - Select test scenario from JAST ASAP profiles - host in DA
  - Develop instrumentation and flight plans for selected asset
  - Perform installations and checkout in ground environment
  - Perform piggyback checkout or flight demonstration
- Mobile Simulation System (MSS)
  - Investigate options and select preferred implementation
    - » Contractor or Government
    - » Choice of vehicle(s)
    - » Display system specifications
  - Obtain vehicle and install infrastructure
  - Demonstrate stand-alone and linked operation

Benefits of DA-based approach

- Enhances acquisition program risk reduction / requirements validation by providing a parallel-path vendor-neutral definition/demonstration forum
- Facilitates transition of systems-level cockpit-intensive technology programs (e.g. ATCS, ATIMS) from airframer's labs to customer
- Supports WSSA integration/V&V of new hardware and software functions
- Provides a direct path to integration facilities for subsystem-level vendors
- Takes advantage of the co-location of engineers, aircrew, prototyping facilities, flight simulation, and aircraft at the NAWC
- Leverages existing RDT&E aircraft and DoD/industry laboratory infrastructure
- Is potentially the most cost-effective combination of services throughout DoD, industry, Allies