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ATMOSPHERIC INTERCEPTOR TECHNOLOGY (AIT)  
STATUS AND TECHNOLOGY OVERVIEW

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**Abstract**

The Atmospheric Interceptor Technology (AIT) program is the Ballistic Missile Defense Organization's (BMDO) core atmospheric technology program for providing technology insertion and pre-planned product improvements (P3I) for the theater Major Defense Acquisition Programs (MDAPs): THAAD, MEADS, Patriot and Navy theater ballistic missile defense. AIT is developing, integrating and demonstrating the critical and affordable technologies for high speed atmospheric flight in a light weight vehicle including, strapdown seeker, cooled windows/forebody, avionics, simulation and software, solid propellant divert and attitude control system (DACS) and composite materials. These technologies allow the warfighter significant increases in battlespace, footprint coverage and lethality. To date, AIT has made excellent progress in developing component and subsystem technologies that support high velocity TMD interceptors.

In the past AIT has been a technology-driven program and thus requirements have been focused on stressing the development of technology rather than supporting an operational need. In July of 1997, LtGen Lyles provided direction to begin aligning AIT more closely with technology insertion and P3I for TMD systems such as THAAD, NTW, MEADS and Boost Phase Interceptor.

This paper discusses the current status of AIT's technology development and future development activities, technology infusion activities and planned sts.

**Introduction**

AIT is the Ballistic Missile Defense Organization's (BMDO) core technology program used on supporting atmospheric interceptor systems. The goal of AIT is to revolutionize atmospheric interceptors by developing technologies

and achieving higher velocities, greater performance and lower costs than current systems, thus filling battlespace gaps. AIT is managed by the U.S. Army Space and Missile Defense Command (SMDC) in Huntsville, Alabama.

In the past, AIT has been a technology-driven program focused on developing and demonstrating critical stressing technologies. In July 1997, LtGen Lyles, BMDO Director, directed AIT to align closely with technology insertion and pre-planned product improvement (P3I) opportunities for Theater Major Defense Acquisition Programs (MDAPs). This re-alignment has been part of a continuing BMDO process in developing a technology master plan.

AIT is now developing concepts and technologies in cooperation with applicable service PEOs (Army PEO AMD and Navy PEO TAD) and government laboratory R&D programs. Through daily coordination, AIT and the PEOs have been identifying AIT technologies which are of interest to specific weapon system programs (see Figure 1).

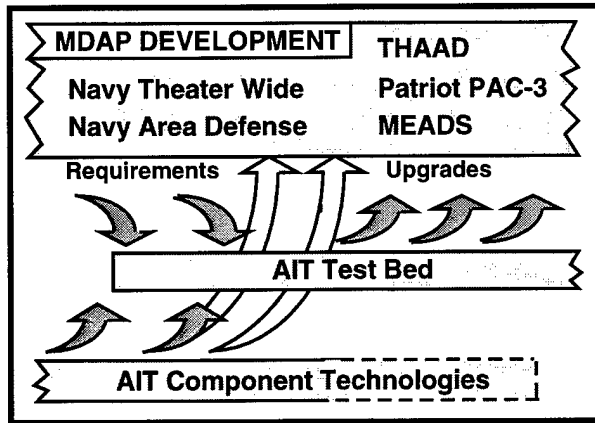
AIT will soon select a contractor to further develop and demonstrate component atmospheric

AIT Technology	Project Interest				
	THAAD	PAC-3	MEADS	NTW	NAW
Solid Divert	✓		✓	✓	✓
Batteries	✓	✓	✓	✓	✓
Discrimination	✓		✓	✓	
IR Seeker	✓		✓	✓	
Avionics	✓		✓	✓	
Jet Interaction	✓	✓	✓		✓
Solid State RF		✓	✓		✓
Window Technology	✓		✓	✓	✓
System Engineering	✓	✓	✓	✓	✓

Figure 1  
MDAP Technology Interest

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**Figure 2**  
MDAP Technology Insertion P<sup>3</sup>I

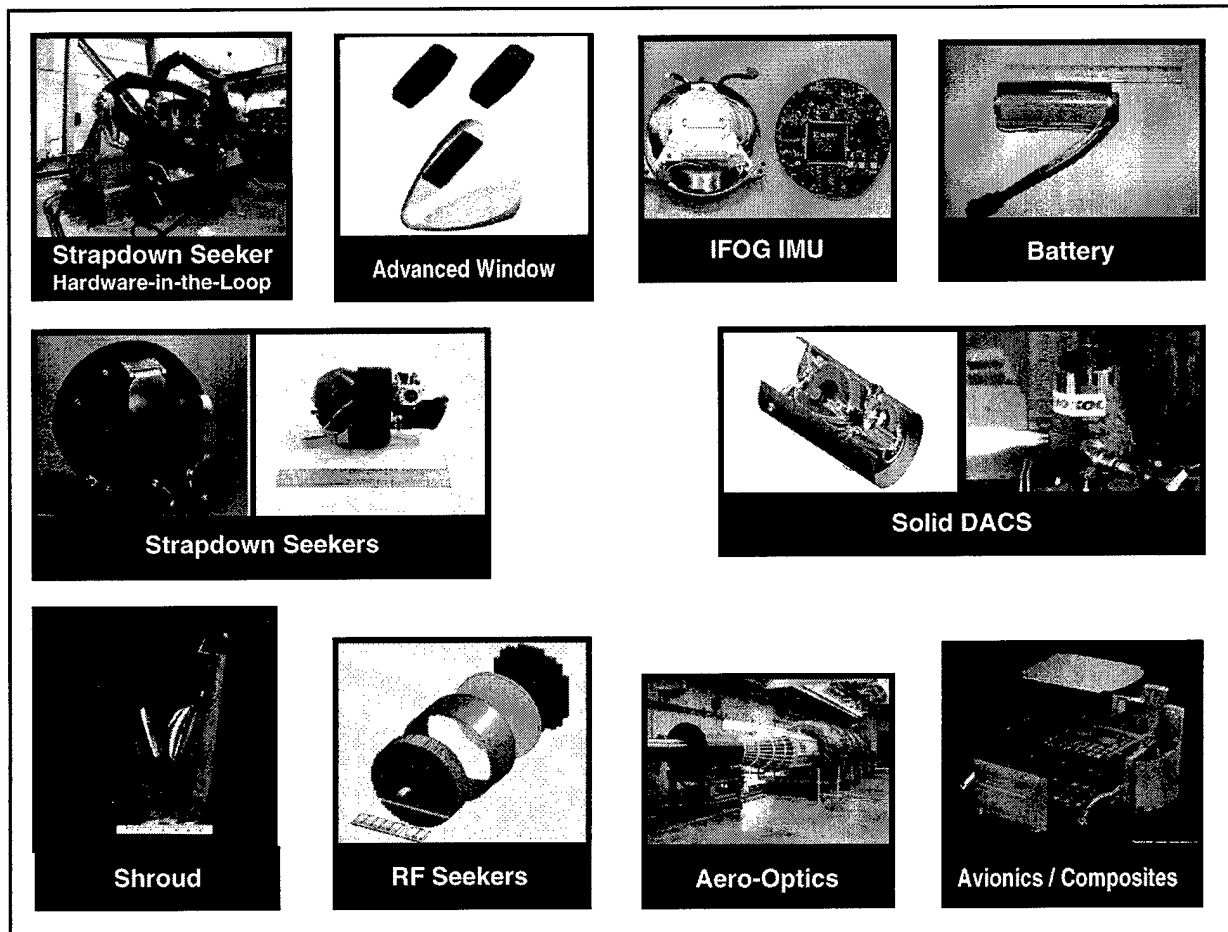
technology leading to an interceptor test bed design and testing. The interceptor test bed contractor will synthesize weapon system requirements from across the MDAPs and assist in developing and integrating technologies and designs for potential P3I upgrades. In

addition, AIT is separately funding critical component technology contracts that feed into the interceptor test bed and the MDAP development. The schedule (Figure 2) allows infusion of a series of technology advancements into the applicable system upgrade programs.

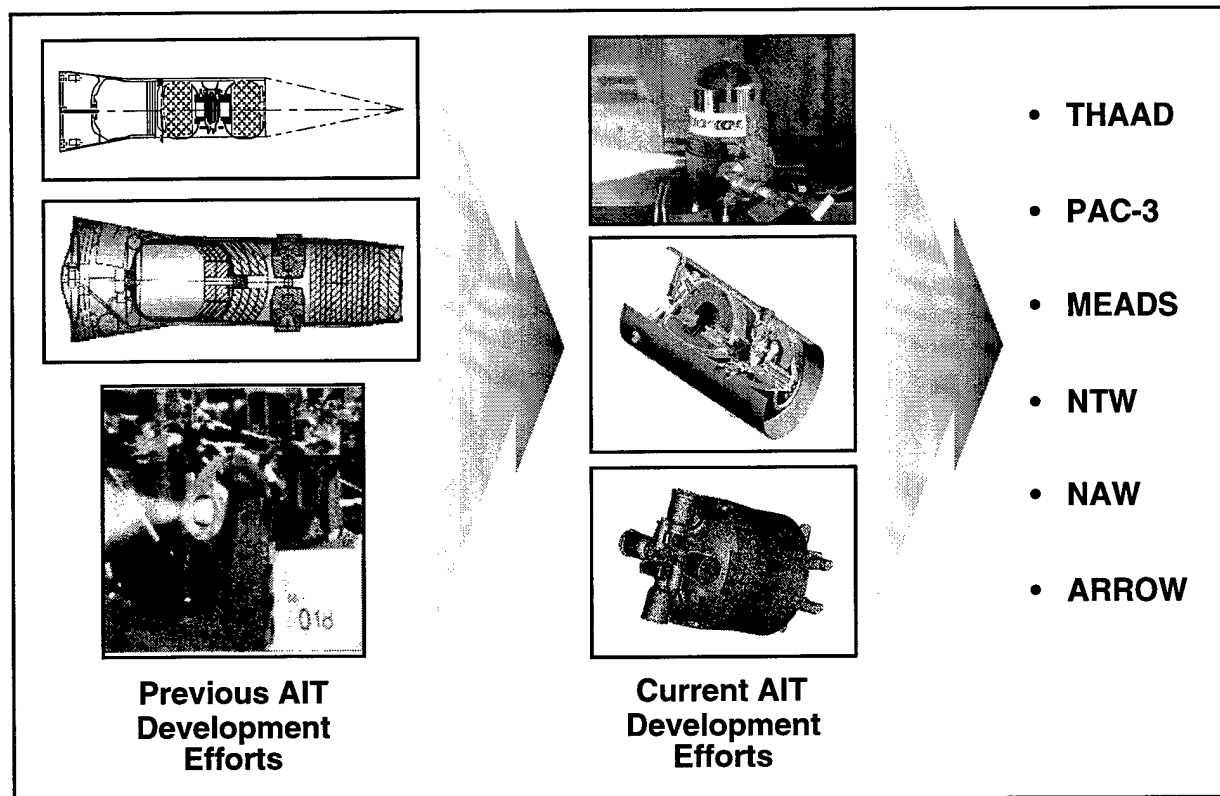
Through planned AIT technology insertion and upgrades, costs and schedules for system acquisition programs and associated block upgrades can be drastically decreased.

**Technology Accomplishments**

AIT is working with all services and government laboratory R&D programs to demonstrate critical interceptor technologies (Figure 3) to improve our future missile defense systems. These technologies will be integrated into an interceptor test bed and then validated in stressing ground test performance conditions. The AIT technologies incorporate the best ideas from numerous technology programs conducted over the past decade.



**Figure 3**  
AIT Technology Programs



**Figure 4**  
**AIT DACS Technology Programs**

Currently AIT has three solid propellant Divert Attitude Control technology efforts: a hot gas thruster concept, a proportional thruster concept and an integrated effort between AIT and the Navy to develop SM-3 divert technology. These DACS technologies will be used to build a design database that will allow missile design engineers to trade missile subsystem (DACs, structure, and seeker) design with the appropriate missile subsystem cost. AIT is also currently developing a Common Work Environment (CWE). The CWE provides a simulation environment that integrates all phases of simulation and flight software design and development from requirements analysis through test of flight software. This paper will concentrate on describing the status of the development and test of the AIT DACS systems and the CWE.

#### **AIT Divert Attitude And Control System Technology**

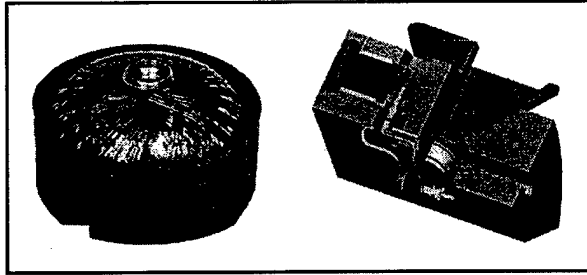
AIT is currently developing high thrust, lightweight solid divert and attitude control systems which can be used to support multiple TMD MDAP missions. By creating system engineering analysis agreements with some of the major MDAPs, AIT has been able to open the door to identifying critical DACS technology needs for these systems. An example of this

is the SM-3 DACS development effort, being jointly funded by the AIT and Navy Theater Wide (NTW) programs. In previous years, AIT had developed various DACS technologies and the knowledge gained from these previous efforts is being utilized in the development of the current AIT DACS technologies (Figure 4).

#### **AIT Solid Hot Gas Thruster Concept**

The AIT hot gas thruster concept is being developed to show that a non-proportional DACS system is viable for ACS pressure control for a variety of MDAP intercept scenarios. This effort is focusing on the design, development and demonstration of a lightweight compact regulator which can withstand severe thermal soak, while maintaining zero valve leakage. This non-proportional DACS technology concept has application in many of the TMD MDAPs including THAAD, NTW, MEADS and PAC-3.

The main components being designed for the current AIT effort include a composite case and a thruster valve (Figure 5); the remainder of the design will focus on technology designed and developed for the AIT prime contractor earlier in the AIT program. The composite case is being designed to minimize weight, minimize cost, optimize strength and stiffness



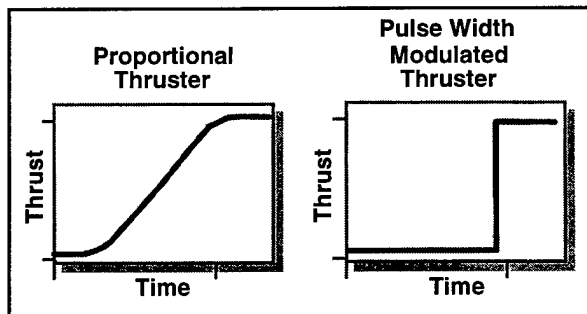
**Figure 5**  
**AIT Hot Gas Thruster Components**

and minimize stress around the thruster holes while the thruster valves will be high thrust, fast response and operable in high temperatures. Testing of the concept is planned for FY99.

**AIT Solid Proportional DACS Concept**

The objective of the solid proportional DACS technology concept is to develop a lightweight, high performance divert thruster and integrated case that is adaptable to multiple MDAPs. This technology effort utilizes unique pintle technology that allows for extended mission times (by conserving propellant with an extinguishable system), variable thrust profiles, variable divert-ACS impulse split, and adjusts for jet interaction effects. The current AIT technology effort will focus on developing port mounted divert thrusters and an integrated composite case. These components are being designed to provide significant weight reduction, and reduced part count and cost.

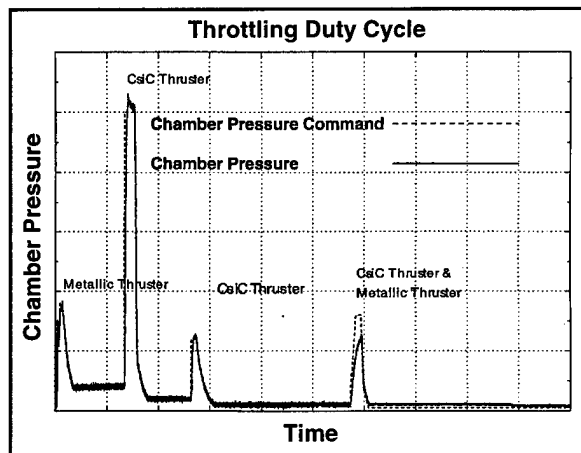
Proportional thruster technology imparts a linear thrust increase to the kill vehicle as opposed to the pulse width modulated thrust of a non-proportional DACS (Figure 6). This linear rise provides a smoother transition for the kill vehicle which reduces seeker jitter and improves aim point selection. The proportional thruster technology effort will exchange resources and data with the Navy SM-3 DACS technology program to capitalize on previously performed work. Testing of the concept is planned for FY99.



**Figure 6**  
**Thruster Performance**

**AIT SM-3 Divert Technology Assessment and Risk Reduction (TARR) Program**

The AIT program and the NTW Program are jointly funding the development of a proportional solid divert and attitude control system to meet NTW tactical requirements. The main focus of the effort will be to develop and test lightweight Carbon Silicon Carbide (C-SiC) thrusters and pintles which will provide high temperature DACS operation. The technology is mission flexible and will be scalable across design guidelines. Development of this technology will provide SM-3 Block 2 risk reduction and will lead to a minimum weight Block 2 DACS. Technology developed under this effort will be shared with and incorporated into the AIT proportional DACS technology program. The SM-3 TARR program has an aggressive schedule that will lead to a hover test in FY99. Figure 7 shows data from the successful throttling and C-SiC hot-fire test.



**Figure 7**  
**Hot Fire Test Data**

**Common Work Environment**

Typically, development of missile six degree-of-freedom (6-DOF) simulations is performed through a process that is disjointed, inefficient and very rarely integrated with other engineering disciplines (Figure 8). Configuration management (CM) of the simulation software is very important, as many 6-DOF modules are often used as flight software. However, CM is very difficult to perform in the typical development environment because documentation is used as the means for passing software modules and software module changes from one discipline to the other. Often times, large costs are incurred late in a development program because of inconsistencies between the flight software and the verified and tested missile 6-DOF algorithms. AIT is developing the CWE to provide an

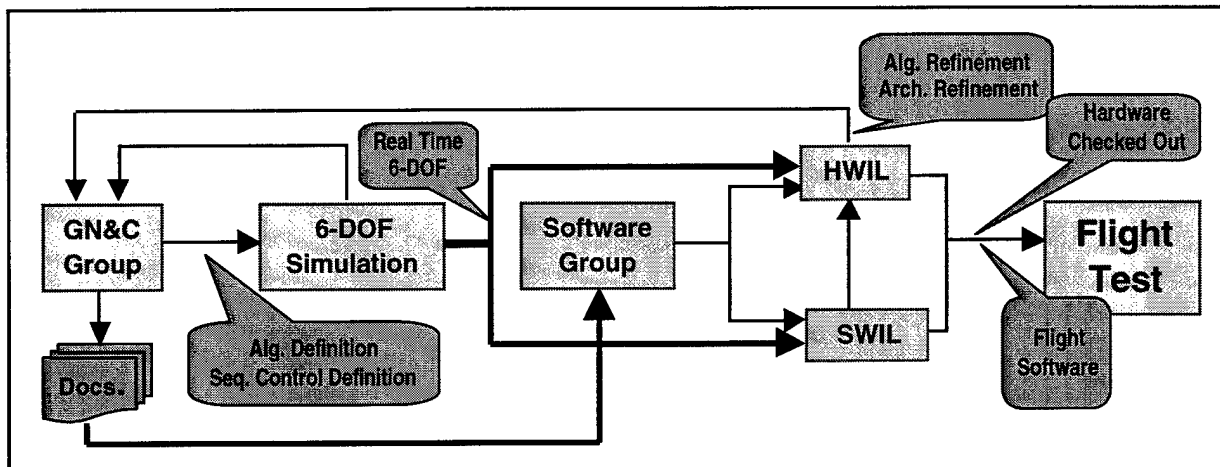


Figure 8  
Typical Missile Software Development Methodology

integrated simulation development environment to be used through all phases of simulation and software development. The CWE maintains traceability of software during development and enhances communication across the engineering disciplines guaranteeing that the 6-DOF algorithms and flights are identical.

The CWE eliminates the established communication barriers between the requirements, design, and software development phases by using a common set of high level tools on a common computer platform (Figure 9). The CWE will perform all configuration control internally by tracking archives within each group and by forcing the designers to use a

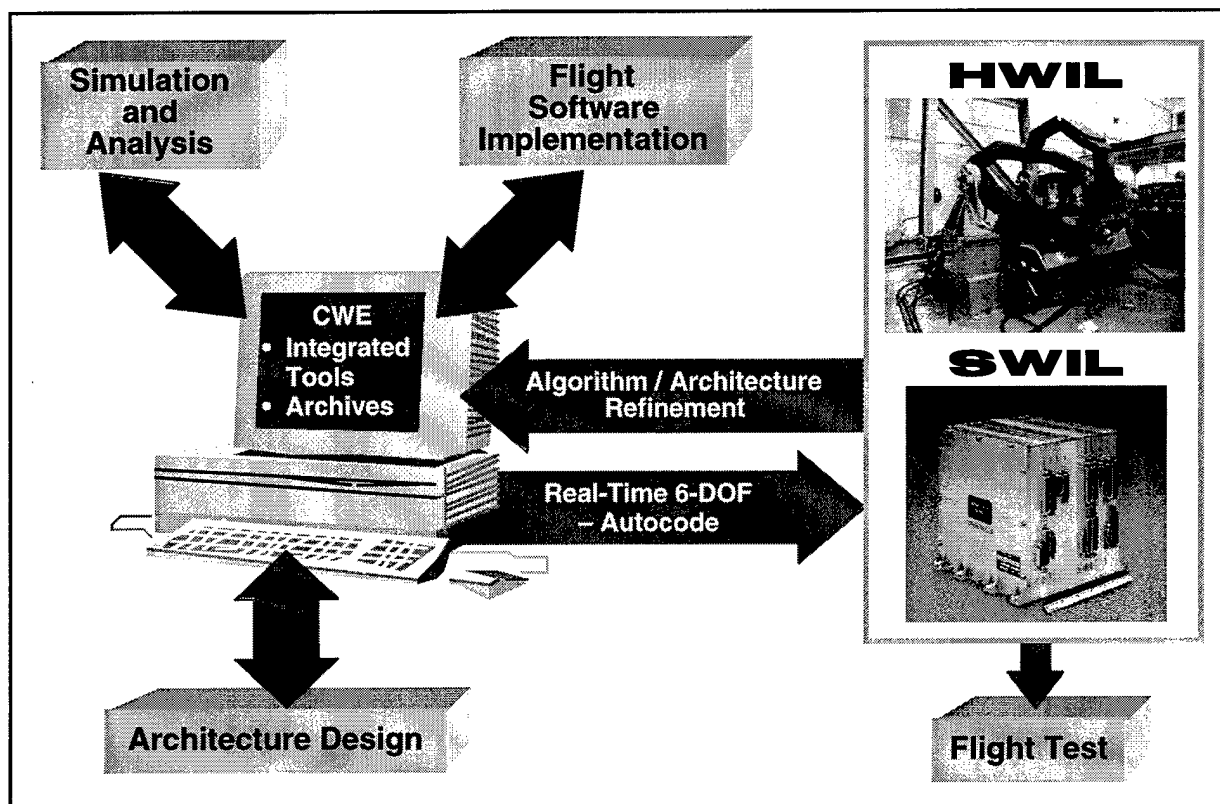


Figure 9  
Common Work Environment Methodology

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common set of algorithms. The choice of tools to be used in the CWE allows the architecture and algorithm relationship to be established early in the design process, and prior to HWIL and SWIL tests. In turn, this will eliminate the need for software redesigns and reduce overall system design costs. The CWE is being configured to operate with HWIL and SWIL facilities by performing autocoding of the simulation algorithms into C or Ada code. This will expedite implementation of the proper flight software during the tests.

The tools chosen for the CWE represent validated, verified and common tools currently utilized in the missile development community. These core tools, integrated via the CWE executive control, are MATLAB (the modeling tool), the Beacon Bridge (the code conversion tool), and MetaH (the architectural description tool). Matlab is a commercially available algorithm and simulation development environment that allows the user to develop algorithms in graphical form. The Beacon Bridge tool permits the user to create C or Ada simulation code from the algorithms developed in Matlab format and is not a commercially available auto-code generation tool. The heritage of the Beacon Bridge stems from HWIL testing, where efficient and traceable coding practices are mandatory. Commercially available auto-code utilities do not meet

these requirements. The MetaH tool set allows the user to specify processor information, memory allocation and bus structure of the actual hardware to be used in the design. The executive control of the CWE ensures that these tools share the algorithms under development, allowing for risk reduction studies to be performed before the design is complete. The integrated tools environment also promotes a natural Integrated Product Team structure during design of the missile and missile simulation/software.

Figure 10 shows the functional process within the CWE. The process begins with the development of a Matlab simulation model. The Beacon Bridge tool is used to convert the graphical representation of the simulation to C or Ada and the model is then stored in the CWE library. Auto-code generation of the model eliminates personal preference coding techniques, and maintains consistency from the analysis model to the flight algorithm. The Beacon Bridge is also used to transfer the algorithms into the MetaH tool set environment, where the algorithms are interfaced with a computer representation of the designed hardware architecture. Within MetaH, the user can perform system analysis by testing multiple processor architectures and thus determine if real-time requirements can be achieved. After real-time

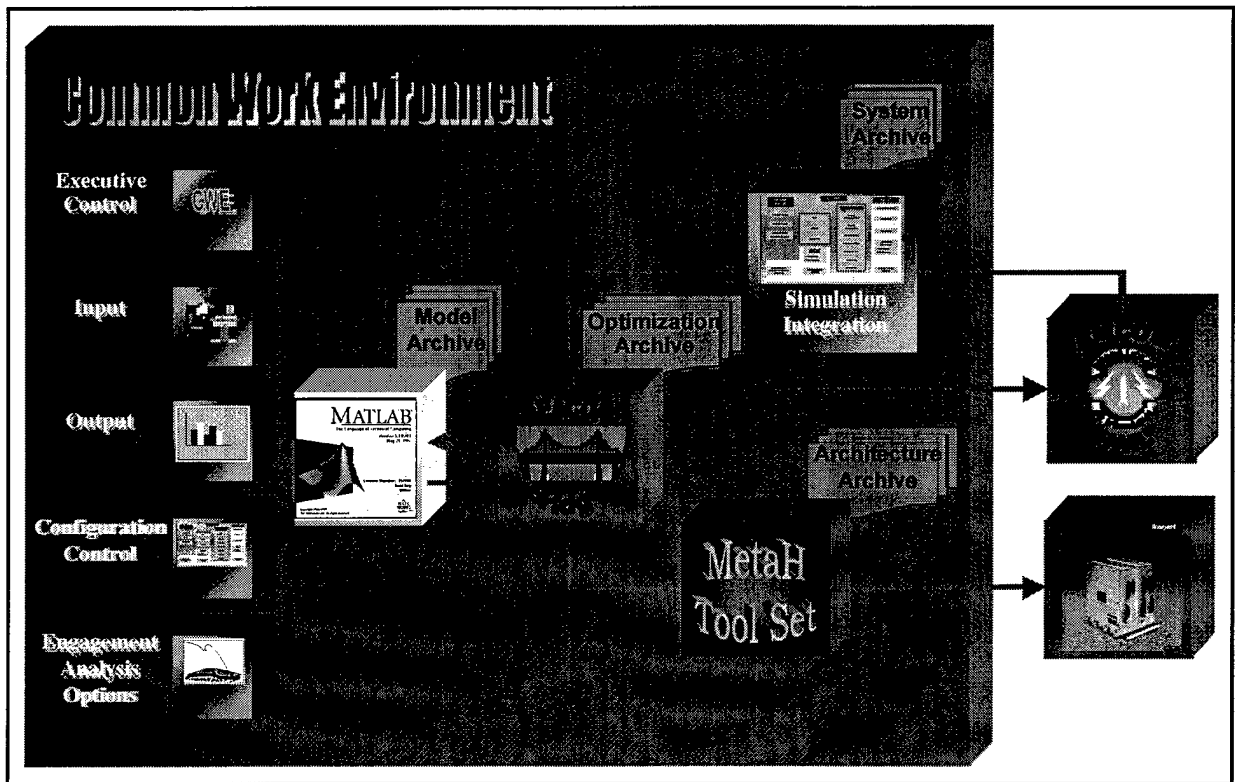


Figure 10  
Common Work Environment Functional Process

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requirements are attained, MetaH is invoked to generate a kernel to be used in the operating system of the flight computer. This kernel describes all of the processor and inter-processor communication requirements to the operating system and is directly downloadable to the actual missile hardware.

An easy to use graphical user interface (GUI) is also being developed for the CWE. The GUI will contain paths to all of the algorithm libraries available to the designer and will allow the designer to build and link all of the simulation modules needed in a missile simulation. As algorithms are developed, they are stored in the library which will permit the designer to incorporate legacy models into new systems under development. The CWE tool set will be integrated with the CWE GUI allowing point-and-click operation. After development of the CWE, initial tests will be performed in support of the HWIL testing of the AIT strapdown seeker design.

**Summary**

AIT is a technology testbed program to develop component technologies that could be applied to current acquisition programs as part of a P3I program. The payoffs of AIT technology are substantial: providing technical solutions to theater missile defense interceptor capabilities for contingencies and against advanced threats not currently addressed by the TMD systems programs and reducing technical risks and costs in support of current acquisition programs through direct technology insertions.

To date, AIT has made excellent progress in developing component and subsystem technologies that support high velocity interceptors. AIT is continuing to implement its strategy of developing and validating components and integrated subsystems through extensive ground testing and simulation activities and then providing the technologies for infusion into multi-service system applications.