DEPARTMENT OF DEFENSE

DEVELOPING CRITICAL TECHNOLOGIES/ SCIENCE & TECHNOLOGY

SECTION 18: SIGNATURE CONTROL TECHNOLOGY

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PREFACE

Developing Critical Technologies/Science & Technology (DCT/S&T) is a product of the Defense Critical Technologies Program (DCTP) process. This process provides a systematic, ongoing assessment and analysis of a wide spectrum of technologies of potential interest to the Department of Defense. DCT/S&T focuses on worldwide government and commercial scientific and technological capabilities that have the potential to significantly enhance or degrade U.S. military capabilities in the future. It includes new and enabling technologies as well as those that can be retrofitted and integrated because of technological advances. It assigns values and parameters to the technologies and covers the worldwide technology spectrum.

DCT/S&T is oriented towards advanced research and development including science and technology. It is developed to be a reference for international cooperative technology programs. A key component is an assessment of worldwide technology capabilities. S&T includes basic research, applied research and advanced technology development.

SECTION 18—SIGNATURE CONTROL TECHNOLOGY

Scope

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18.2 Multifunction Systems and Subsystems DCT-18-5

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Highlights

- Signature-control technology growth will accelerate as signature-control features become more affordable, more widely demanded, and easier to integrate into conventionally deployed and operated systems and subsystems for land, sea, and air.
- Signature-control capabilities will be supported by the expanded capabilities of materials emerging from programs that are only now providing mature products and solutions to exceptionally demanding cost requirements, operating parameters, and environments.
- Signature control will continue to benefit from advances in computational capabilities and information sciences as multifunctional segments of very complex systems become more capable.
- Multifunctionality will benefit signature control in windows, electronics, software, displays, and other components and subsystems. This will expand the opportunities to be signature compliant.
- More emphasis will be expected on balanced signature throughout the energy spectrum.

OVERVIEW

This section provides technology-development projections and selected concept evolution in signature-control and counter signature control technologies including integration with electronic warfare concepts for the future. The preponderance of trends indicates continued vigorous growth in signature technologies. These include mission planning, radar, threat avoidance, complex avionics and control, electronic warfare, electronic support, weapons systems interfaces, battle damage repair, signature verification, and many maintenance functions. This growth projection is coupled with other trends that support vigorous growth in signature control. Some of these trends are development of small and smart weapons better matched to signature-compliant carrier platforms than previous generations and multifunctional performance across selected activities in both combat and combat support. Unlike the other sections data sheets are not included in this section.

SECTION 18.1—TAILORED PROPERTY MATERIALS

Highlights

- Successful materials development will address broadband electromagnetic performance and frequently pace improvements in capabilities, supportability, and affordability.
- Materials developments for electronic and computational applications will parallel and support LO materials.
- Materials which achieve better cross-section performance and simultaneously function as structural components will have a key competitive advantage.
- Improved supportability is a key feature and may sometimes be the most important characteristic for tailored property materials.

OVERVIEW

Tailored property materials now in development will be signature compliant at levels at least as high as today's materials while being functionally able to simultaneously accommodate different kinds of activities in operational environments. A simple example is a signature-compliant window material able to allow energy for more than one frequency sensor to pass. This material will be easy to maintain and repair and will work without special treatments or conditions throughout the range of temperature, humidity, and corrosive exposure that will be encountered in worldwide deployments. In addition, it will be highly heat tolerant and able to function under the stresses expected at key points within an aeronautical vehicle. These materials may or may not be required to have balanced signature traits. Reduced infrared (IR) signature is a serious technical challenge for supersonic- and hypersonic-speed-capable systems.

SECTION 18.2—MULTIFUNCTION SYSTEMS AND SUBSYSTEMS

Highlights

- Sophisticated software is enabling for the integration of multiple functions critical to the LO platform and its CLO functions.
- Building-block hardware will increase the performer's ability to more quickly update, modify, and add to the capabilities required for success in combat.
- Electronically agile components will continue to replace mechanically driven systems and will bring increases in reliability and the ability to operate in degraded modes.
- Lower weight size and production costs will be realized for electronic elements, increasing integrated application areas per system.

OVERVIEW

Multifunction systems are those that host a variety of different capabilities and can accomplish multiple different tasks using either automatic or manual choices and selections. The intent is to include individual sensors that have multi-function capability as well as multi-sensors operating from a single cavity and lens.

Tools for multifunctional systems will be compound building blocks in flexible configurations which can be tailored in real time for the conduct of a specific mission set. Field modifications to meet specific threats will be possible in real time or near real time. Such features will reduce the requirement for the traditional armada of special-purpose aircraft, with many activities taking place simultaneously and automatically. Remaining special-purpose platforms will become more capable and robust because they will be signature compliant and will contain many of the features now found on general-purpose strike platforms. Information exchange among platforms will continue to improve, providing an opportunity to significantly reduce the time to complete the kill chain.

SECTION 18.3—SYSTEMS ENGINEERING AND INTEGRATION

Highlights

- Systems engineering and integration will be increasingly recognized as high-value-added capstone to the products and services offered in support of signature control.
- Systems engineering and integration produces the set of capabilities and traits designed to make LO, CLO, and other system features operate together in compatible and cooperative ways.
- More firms will be expected to enter into the sale of systems engineering and integration services which must include optimizers for analysis tools of EM solutions.
- Systems integration will increasingly feature tailored offerings which include electronics, software, and hardware. These offerings should be expected to expand the systems integration of their total customer base.

OVERVIEW

Systems engineering is a process. As a formal discipline, it ensures that all system elements and requirements are placed together during all design, production, and product-improvement activities. It is necessary to achieving a suite of capabilities that will endure throughout the system life cycle.

Systems engineering applies scientific and engineering efforts to:

- Transform a statement of operational need into a description of a system configuration that best satisfies that operational need;
- Integrate related technical design parameters and ensure compatibility of all physical, functional, and technical program interfaces in a manner that optimizes the total system definition and design; and
- Integrate the efforts of all engineering disciplines and specialties into the total engineering effort (using concepts of concurrent engineering).

The systems-engineering process is the iterative logical sequence of analysis, design, test, and decision activities required for production and fielding of all operational and support system elements. In spanning the cradle-to-grave life span, it makes possible the upgrades and modifications that keep the weapons system viable throughout an often extended life. Features as simple as the selection of metrics for engineering tradeoffs among competing requirements are key concepts in systems engineering. At a broad level, systems engineering embraces hardware, software, and data (see Figure 18.3-1). In this context, systems engineering for signature control involves placing together all subsystems such as radar altimeter, Pitot-static subsystem, and other components into the platform and maintaining survivability, functionality, supportability, and affordability. The key to U.S. superiority in this area is the ability to design, produce, and operate in a technically efficient way and to stay cost effective. Because all of these various systems fit together into a stealthy platform, the developers must be concerned about supportability and the acquisition cost of the ultimate system

Experience in both LO and CLO developments illustrate the importance of systems engineering. Attention is required throughout the life cycle of each system. Such efforts ensure that the capabilities and subsystems are compatible in essential ways and minimize any degradation embedded in tradeoffs. Systems engineering also reinforces synergism between systems whenever possible. Superior systems engineering reduces redesign, supports cost control, and instills scheduling discipline.

Systems engineering as used in signature control also includes integral design codes for optimization of control techniques used to manage the electromagnetic waves impinging on the platform. This requires detailed insights into the physics of system behavior. The design codes used will direct human attention to selecting both metrics and

SYSTEMS ENGINEERING PROCESS

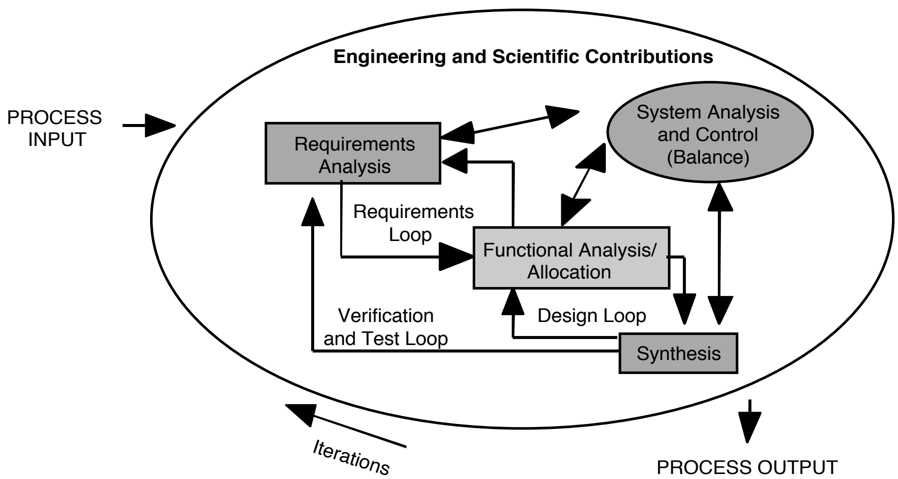

Figure 18.3-1. Those Responsible for Systems Engineering Capture Requirements, Engineering, and Scientific Contributions to Assemble the System in an Iterative Process of Prototype, Test, and Requirements Validation to Formally Make Tradeoff and Capability Decisions

values for optimization in design, production, and operation based upon the particular systems goals held to be of greatest value. A key feature that will be embedded in the future design process will be the explicit addressing of reparability, design to foster ease of repair, and operation and support (O&S) cost impact, specifically driving down these costs. Design processes (design loop) will be more critical in the future. They can yield unique concepts and approaches or solutions to signature control areas never before pursued. Protection of the long and vulnerable logistics infrastructure is an ongoing concern, one which could be helped with application of what is now understood about LO. This will require relatively little change in technology but significant effort to reduce costs and increase ease of handling.

As CLO becomes more pervasive, integration of supporting sensors on both new and retrofitted platforms will be of intense interest. Subsystem applications include high-performance radar, high-sensitivity IR sensors, and advanced acoustic subsystems. These subsystems must operate while maintaining structural and low-observable performance of the platforms on which they are mounted. They will be complementary and not interfere with communications, navigation, and other activities routinely performed in support of the weapons system.

Data activities will be critical for integrating sensors for CLO functions. High-speed, real-time processing, parallel onboard processing, and data sharing among subsystems and platforms will become highly refined and invaluable.

A conceptual illustration of systems integration shows the requirements reviewed above and makes a number of good instructional points with respect to the value of systems integration in a signature-control context (see Figure 18.3-2). Systems integration ensures that no one function or feature disables or blocks completely another vital function. As systems integration is refined, a balance in potential or real degradations is managed to optimize the entire system. Anti-tamper architectures should become an integral part of the systems engineering process. This is especially true as sensitive U.S. technologies, e.g., LO/CLO, comprise a greater percentage of system design capabilities. This is accomplished in a logical engineering tradeoff analysis versus requirements by the integration organization, government or contractor.

Systems integration applies to large systems, subsystems, and components, sometimes with equal payoff and intensity of interest. The simplified systems-integration challenge is to ensure that a component or subset works within a system, often a large one, with adaptations and accommodations necessary to minimize competition for resources such as electric power, operating space, and presentation priority on a multifunctional display. Distributed systems have been incorporated in increasing numbers of military systems. Integration ensures that items operating in different locations and with different assignments actually work in concert. In typical examples, an effort is made to shift the bulk of functional components to the site in which a subsystem of interest performs an assigned function.

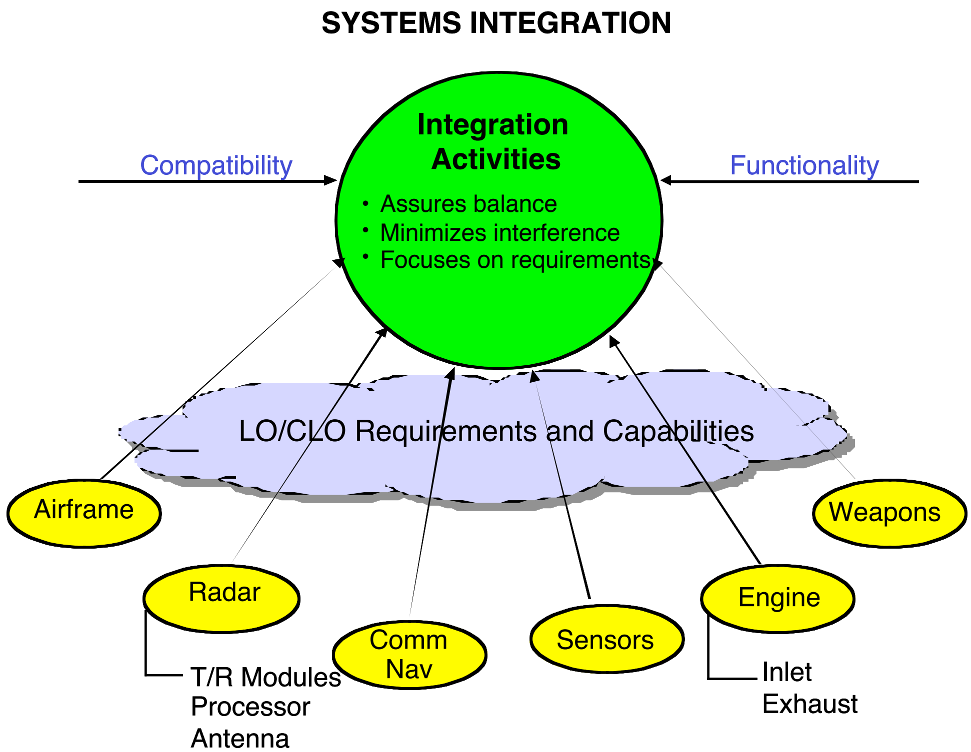

Figure 18.3-2. Systems Integration Ensures that the Form, Fit, and Function of the Components on a Platform (e.g., Ship, Missile, Aircraft, Land Vehicle) Perform Mission-Critical Functions Without Degradation to Any Subsystem, Specific Performance Parameters

Flight controls have undergone significant evolution toward fly by wire or fly by light in which the control, supporting actuators, and power supplies driving the actuators are all collocated near the actual deflecting surface. Such designs usually improve combat survivability, reduce complexity, and decrease the total weight of the total system. However, the system at each flight control must mutually support all other systems at all the other flight controls.