Advanced Battlespace Information System (ABIS)  
Task Force Report  
Volume IV  
Sensor-to-Shooter Working Group Results

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Task Force Report
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Sensor-to-Shooter Working Group Results

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Preface

This is Volume IV of the final report of the Advanced Battlespace Information System (ABIS) Task Force. The entire final report is organized into six separately bound volumes:

I. Executive Summary
II. Major Results
III. Battle Management Working Group Report
IV. Sensor-to-Shooter Working Group Report
V. Grid Capabilities Working Group Report
VI. Supporting Annexes

This volume is the full report of the Sensor-to-Shooter Working Group. It contains an executive summary of the major findings and conclusions and a detailed discussion of the specific areas that were considered by the working group.
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1. Coordinate Multiple Sensor-to-C2-to-Shooter Missions
2. Assure Timely Execution of Missions

Need:
- Tasking
- Priorities

Sensors
Provide Information

Shooters
Need:
- Tasking
- Targeting Information
  - Location and Identification
  - Situation Awareness
  - Clearance to Shoot

Battle Management
Generates:
- Objectives
- Targets
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Executive Summary...

Definition and Scope
The Challenge

Effectively executing combat operations in a joint force environment involving many ground, air, space, and shipboard resources entails two key challenges:

1. From within a universe of many joint force resources, individual sensors and shooters must be tasked and provided with the necessary priorities and targeting information needed to carry out multiple specific missions against multiple specific targets to achieve all of the battle manager’s objectives. The development and maturation of processors to assist in decision making and optimization of finite sensor and weapons assets is the first of two key challenges. This challenge is referred to in this report as coordination of missions.

2. For each individual mission, the information linkages must be established between sensors and shooters to enable the timely execution of missions, especially time-critical missions. Because, ideally, the sensors can be time shared among many shooters (in addition to the battle manager), effective and efficient implementation of these linkages and the ability to pass information through them will inevitably require the establishment of execution controllers performing real-time or near real-time C2 operations. The development of this operational architecture is discussed subsequently in the context of the needed development timeline.

In this environment, the key operational concept required is one of distributed command and control, with an execution controller for each sensor-to-shooter execution team (which is really a sensor-to-C2-to-shooter team) performing many of the same functions that the battle manager performs. However, the sensor-to-shooter team plans how the mission is to be executed, whereas the battle manager plans what will be executed. Thus, the C2 for each sensor-to-shooter team requires functional capability similar to that of the battle manager, but for an increased depth of detail spanning a reduced breadth of area of interest and having a much stronger focus on the timeliness of the information versus its completeness.
Operational Concept
Integrated, Target-Focused Operations

Exeuctive Summary...

Battle Management
(Minutes to Hours)

Sensor-to-Shooter
(Seconds to Minutes)

Long Cycle—Battle Management Outer Loop for Planning

Short Cycle—Sensor-to-Shooter Inner Loop for Execution

- Autonomous Operations for Fleeting and Maneuvering Targets
- Synchronized Operations for Fixed and Slower Targets
Executive Summary...

Operational Concept
Integrated, Target-Focused Operations

This nested loop flow model of the Sensor-to-Shooter (STS) Operational Concept will be used in subsequent discussions of STS operations. The outer loop, which represents the longer cycle of battle management operations, splits into two branches, one branch containing the inner loop of sensor-to-shooter operations as a special case. Key observations about the nature of the STS operations follow:

- Sensor-to-shooter operations include many of the same functions in battle management operations (e.g., sensor tasking and information acquisition). This is so because the sensor-to-shooter operations begin when the mission is assigned to the mission leader. At this point, the sensor-to-shooter execution team (sensors, shooters, and execution controllers) must perform the same functions in planning how the mission is to be executed that the battle managers performed in planning what will be executed. Therefore, the sensor-to-shooter team requires the same functional capability as the battle manager, but for an increased depth of detail spanning a narrower area of interest. Although it has a different emphasis on timeliness and level of detail, this functional commonality with battle management is the essence of the sensor-to-shooter challenge.

- Sensor-to-shooter operations are basically of two types, those that are executing the preplanned ATO (that is, the outer loop including the lower branch) and those that are providing assets for highly responsive and autonomous operations against fleeting targets (that is, the fast, seconds to minutes, inner loop). These are discussed in detail in subsequent sections.

- Although it is not obvious from the figure, a key element of integrated sensor-to-shooter operations is the fact that there are multiple cases of these executing elements operating simultaneously. This means the battle manager must plan the synchronized operations of several hundred missions while enabling dozens of highly responsive and autonomous missions against fleeting targets.

- None of the elements of any specific sensor-to-shooter team are necessarily dedicated to a single mission for an entire sortie. On the contrary, for maximum effectiveness in the entire battlespace, sensor sorties in particular will be time shared across many missions.
## Operational Architecture Development Timeline

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- **Operational Architectures**
- **C4ISR DSC & JBC**
- **Ground Maneuver**
- **Cooperative Defense**
- **Technology Roadmap**
- **Precision Strike Architecture**
- **Sensor Integration**
- **STS III**
- **ABIS**
- **STS II**
- **STS I**
Executive Summary...

Operational Architecture Development Timeline

This figure presents the overall schedule for developing operational architectures. As illustrated, the precision strike architecture has been completed and is in the process of being implemented. Subsequent steps are to include ground maneuver and cooperative defense operations in the operational architecture for implementation. Also depicted are the ABIS study’s integration with these efforts and the eventual use of the C4ISR Decision Support System and Joint Battle Center for follow-on technical assessments.
Executive Summary...


The future Precision Strike Architecture is a product of previous J6 Sensor-to-Shooter series of ongoing studies as shown in the preceding figure. For each mission, the information linkages, such as those recommended in this chart, must be established between sensors and shooters to enable the timely execution of missions, especially time-critical missions against combat situations (against fleeting targets such as multiple rocket launchers and Theater Ballistic Missile TELs). Ideally, national, theater, and tactical sensors can be time shared among many shooters (in addition to the battle manager). Effective and efficient implementation of these linkages and passing information through them will inevitably require the establishment of information/collection managers performing real-time or near real-time C2I operations. The development of this operational sensor-to-target pairing architecture is discussed subsequently in the context of the needed development as one of the critical technology focus areas.
System Attributes
Parallel, Fast, Dynamic

- Generates Sensor-to-Shooter Relationships and Linkages
- C2 Provided With Sensor Retasking Capability According to Warfare Commander's Intent and Direction
- Shooters and C2 Provided With Automated Tools To Use Any Available Sensor Data, Regardless of Ownership, for Real-Time Target Recognition and Identification
- Shooters Obtain Latest Targeting Information in Displays Suitable for Immediate Execution
- Shooters Provide BDA to Grid for Fusion and Dissemination

Legend:
- Command
- Information
Executive Summary...

System Attributes

The key attributes of the proposed sensor-to-shooter system concept are that they are parallel, fast, and dynamic, versus the current characterization as serial, slow, and nonresponsive. These capabilities will be enabled largely by key elements of the Grid concept, providing battlespace awareness, that is, simultaneous access to battlespace information by shooters and execution controllers as well as by battle managers. With the black arrows indicating command and the other arrows indicating information flow, the figure shows that future operations will separate the information flow from the command cycle. This is necessary to achieve the desired responsiveness. Furthermore, this characteristic is also a major driver in the need for dynamic planning capabilities and parallel operations.

In the proposed system concept, the sensors will continuously input new information into battlespace awareness databases while both executing elements (shooters and controllers) and battle managers will simultaneously be able to retrieve information or have it automatically retrieved and formatted into the appropriate applications/displays. In this manner, today's conflict of competing sensor tasking will be resolved using integrated sensor management techniques. Although the battle manager is seeking battlefield information throughout the entire battlespace, the shooters are seeking targeting information. This means that the shooter needs target location and identification, situation awareness in the target area, and clearance to shoot. Primarily, current shooters do not have adequate situation awareness in the target area. The connectivity and access achieved through implementation of the Grid will provide situational awareness, thus enabling shooters to execute the sensor-to-shooter operations successfully.
Sensor-to-Shooter Important Capabilities

- Execution Control Is the Critical Function for Conducting Effective Sensor-to-Shooter Operations, Requiring Two Operational Capabilities:
  - Coordination of Missions—Preplanned and Time Critical
    » Delegated Execution to Linked Force Package of C2, Sensors, Platforms, and Weapons Operating As Coordinated Units
    » Command Authority and Targeting Information Focused on Generating and Supporting These Executing Elements
  - Execution of Time-Critical Missions
    » Mission-Oriented C2/Strike Force Package Elements Work Inside Enemy Optempo Cycle Against Time-Critical Targets
    » Battle Manager Retains Real-Time Ability To Redirect Force Package as Situation Changes
Executive Summary...

Sensor-to-Shooter Important Capabilities

By considering system concepts like those shown in the figure, the 38-member ABIS Sensor-to-Shooter Working Group developed a crosswalk of required operational capabilities for precision strike operations, coordinated air defense operations, and ground maneuver operations. In this process, six detailed vignettes of operational capabilities were developed and assessed to ensure the identification of technologies needed to execute critical operational capabilities. Each of these vignettes represents a situation that will be replicated many times in an operational environment; a number of these vignettes are discussed in this report.

Integrating these required operational capabilities for the three mission areas yielded two critical operational capabilities for execution of sensor-to-shooter operations: the ability to coordinate multiple simultaneous missions (including preplanned execution of the ATO/ITO and the highly responsive, autonomous missions against time-critical targets), and the ability to execute time-critical operations. In both cases, the need for parallel, fast, and dynamic operations remains a key consideration. Both of these operational capabilities are specifically addressed in subsequent figures, but first the mapping process using four key technology demonstrations is illustrated.
Key Opportunities for Near-Term Demonstrations
Key Opportunities for Near-Term Demonstrations

The four key technology demonstrations form key cross-service and cross-mission themes of technologies needed to solve operational limitations. As depicted in the figure, these demonstrations will enhance the shooter's effectiveness by giving the execution controller the tools and capabilities needed to enable time-critical, shooter-focused decisions and to execute these decisions in a joint environment.

These demonstrations take several forms. Some will be new demonstrations proposed for consideration with other proposed FY 97 ACTDs. Others will leverage existing proposed demonstrations with endorsements and, in selected instances, expansion of scope to include both multiple services and expanded mission areas.

The key characteristics of the proposed demonstrations are that they allow tactical warfighters to address targets in parallel, and employ dynamic and fast breaking tactical situations that will be typical of local regional conflicts, major regional conflicts and contingency operations of the future.

In the proposed demonstrations, sensors will continuously input new information into battlespace awareness databases that both executing elements (shooters and controllers) and battle managers will be able to access.

The following figures expand each of these areas into a technology roadmap that provides a candidate initial plan of action (defining each phase with target class, weapons systems, and key junctures along the critical path). These roadmaps are not unique—any of several approaches could achieve the same ends. However, to fulfill the goal of the ABIS study, at least one approach to achieve the desired ends is presented for each case.
Automated Weapon-to-Target Pairing Technology Demonstration Roadmap

Objective: Against a Highly Mobile Target Set, Demonstrate Automated Pairing With Weapons Systems Optimized to Destroy Ground and Air Targets

Challenges:
- Resource Allocation/Optimization
- Collaborative/Distributive Planning
Automated Weapon-to-Target Pairing
Technology Demonstration Roadmap

The first recommended demonstration is Weapon-to-Target Pairing. This capability will enable the execution controller to quickly select and allocate joint force weapons that are available, can reach the target in both range and in timeliness, and have adequate lethality to achieve the commander’s intent. Because the execution controller must execute several sensor-to-shooter missions essentially simultaneously, the capability to execute against multiple target sets is necessary.

It is recommended that the demonstration have three phases:

- Phase 1—Single weapon versus a single ground target set
- Phase 2—Multiple weapons versus multiple ground target sets
- Phase 3—Multiple weapons versus multiple ground and air target sets.

The first phase is essentially the same demonstration capability planned by the Army’s Precision–Rapid Counter MRL ACTD against 240 mm multiple rocket launchers. Therefore, the primary purpose of this recommendation is to initiate early planning for logical extensions of the ACTD into joint force capabilities against multiple arrays of ground targets, followed by an extension enabling an integrated force versus both ground and air targets.
Executive Summary...

Automated Sensor-to-Target Pairing Technology Demonstration Roadmap

Overall Objective: Demonstrate Simultaneous Provision of Near Real-Time Sensor Information Directly to Shooters for Assigned Targets While Maintaining Coverage of Surveillance Areas for Battle Management

Challenges:
- Decision and Estimation Theory
- Constrained Resource Allocation

Three Phases

Phase 1:
- Joint Service
- Single Sensor

Target: Ground Targets in Single Sensor Area of Interest
Weapon: Army MLRS and Navy Tomahawk
Sensor: UAV with SAR

Phase 2:
- Joint Service
- Single Sensor Type
- Multiple Platforms

Target: Ground Targets in Theater
Weapon: Army ATACMS, A/C, Navy TLAM, etc.
Sensor: UAVs, U-2s, and NTM With SAR

Phase 3:
- Joint Service
- Single Sensor Types
- Multiple Platforms

Target: Fleeting and Dynamic Ground Targets
Weapon: Army ATACMS, A/C, TLAM, etc.
Sensor: Multiple Platforms with SAR, MTI, SIGINT, etc.

FY97 FY98 FY99 FY00 FY01
Executive Summary...

Automated Sensor-to-Target Pairing
Technology Demonstration Roadmap

The second demonstration is similar to the first, but focuses on the problem of competition for sensors, that is, a Sensor-to-Target Pairing demonstration. This capability will enable the execution controller to select and allocate time slots of sensor capabilities and dedicate them, for a specific period of time, to individual missions in which shooters need current situation awareness. However, while the shooter support must be achieved in a timely manner, the impact of dynamic sensor retasking must be minimized so that the overall surveillance coverage of the target area is still achieved, thereby achieving the battle manager’s information requirements.

This demonstration is inherently a joint demonstration because all key theater sensors are joint service sensors. Therefore, three phases are suggested:

- Phase 1—Single sensor (imagery) and single platform (UAV)
- Phase 2—Single sensor type (imagery) and multiple platforms (UAVs, U-2s, and overhead assets)
- Phase 3—Multiple sensor types (imagery, SIGINT, MTI, etc.) and multiple platforms.

Phases 1 and 2 include elements similar to several proposed ACTDs. These are strongly endorsed. However, several dimensions must be added to address all of the relevant issues: for example, sensor pointing only versus redirecting flight paths, multiple orbit and multiple day optimization of target information.
Executive Summary...

Integrated Fusion/Target Tracking Technology Demonstration Roadmap

Objective: Demonstrate the Ability To Correlate and Fuse a Diversity of Sensor Information and Generate Birth-to-Death Target Tracks Spanning the Range of Target Behaviors (Emission, Moving, or Stationary)

Challenges:
- Model-Based Reasoning
- Bayesian Decision/Estimation
- Multihypothesis Tracking
- Case-Based Reasoning
- Expert Systems
- Statistical Prediction/Correction
- Multispectral Decisions
- Data Representation Structures

Three Phases

Phase 1: Air Targets
Target: Friendly and Hostile Aircraft and Cruise Missiles
Weapon: Army, Navy, Air Force, and Marine Corps Counterair Systems
Sensor: Multiple Service Radars

Phase 2: Time-Critical Ground Targets
Target: Time-Critical Ground Targets (e.g. TBM TELS)
Weapon: Army, Navy, Air Force and Marine Corps Strike Systems
Sensor: Multiple Service Radars, Sensors, UAVs, and NTM

Phase 3: All Theater Targets
Target: Aircraft/Cruise Missiles and Moving Ground Target
Weapon: Multiple Service/Joint Service and Allied
Sensor: Multiple Service, UAVs, and NTM

FY97 | FY98 | FY99 | FY00 | FY01

* ABIS STS review designated Navy CEC as foundation for Phase 1. 
Integrated Fusion/Target Tracking
Technology Demonstration Roadmap

The Integrated Fusion/Target Tracking demonstration focuses on developing birth-to-death tracks of hostile targets. This capability entails correlation of tracks from different sensors of the same type and different types of sensors tracking the entire spectrum of target behaviors. A key capability is the development and maintenance of a single, unique-track ID. Through the CEC program, the Navy is already developing these capabilities for air targets. Consequently, these track management methods should be extended to ground targets and eventually integrated into a complete air-ground display of the battlespace by mission areas.

As illustrated in the accompanying figure, it is proposed that the demonstration have three phases:

- Phase 1—Air targets
- Phase 2—Ground targets
- Phase 3—Integrated air–ground targets.
Executive Summary...

Automated Target Recognition
Technology Demonstration Roadmap

Overall Objective: Against a High Value Target Set, Demonstrate Automated Target Recognition Linked With Weapons Systems

Challenges:
- Image Understanding
- Pattern Recognition
- Moving Target Recognition
- Spatial Reasoning
- Template Matching
- Model-Based Recognition
- Temporal Reasoning
- Probabilistic Reasoning

Target: TBM in Open, Stationary
Weapon: Army ATACMS, A/C, Navy Tomahawk, etc.
Sensor: FLIR, MMW SAR, and NTM

Phase 1: Joint DARO/ARPA/NRO/Services

Target: TBM in Open, Moving
Weapon: Army ATACMS, A/C, Navy Tomahawk, etc.
Sensor: SAR, MMW FLIR, EO (Prelim), and NTM

Phase 2: Joint Service ACTD

Target: Fleet and Dynamic Targets (TBM and Tanks)
ACTD: Joint
Weapon: Army ATACMS, A/C, Tomahawk, etc.
Sensor: SAR, MMW, FLIR EO (Initial), and NTM

Phase 3: Joint Service ACTD

FY97 FY98 FY99 FY00 FY01

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Automated Target Recognition Technology Demonstration Roadmap

The Automated Target Recognition demonstration focuses on the problem of rapid detection and recognition of target behaviors in multispectral signature regimes. Key MOEs are the time to detect and recognize relevant targets with high probabilities of success and low false alarm probabilities. An integrated measurements and target behavior characterization program is also a requirement for building a meaningful library of target signatures that can be used at any of several nodes in the end-to-end sensor-to-shooter “kill chain.” The recommended demonstration program is focused primarily on the technology itself, not on the implementation architecture. Thus, this capability can be resident onboard sensors, at intelligence/fusion nodes, and at C2 nodes as well as with the execution controller. Depending on the theater architecture chosen for implementation, this overall capability may be distributed or centralized, parallel or serial, or any of several other alternatives. These implementation issues are not specifically recommended to be addressed in this demonstration. However, when the architecture has been selected, the technology implementation can be partitioned as appropriate.

The demonstration is suggested in three phases, based on complexity of target behaviors and the diversity of spectral signatures and sensors available:

- Phase 1—Temporarily stationary targets, imaging signatures
- Phase 2—Moving and stationary targets, imaging signatures
- Phase 3—Moving and stationary targets, imaging and other signatures.
Key Observations

- The Key Problem Is Competition for Sensor Coverage Between Battle Managers and Shooters
- The Key Solution Is Enabling Distributed Command and Control of Available Sensor Coverage Through:
  - Automated Processing for Management of Time-Intensive Tasks
  - Common Links To Share Coverage by Those Resources
Key Observations

After assessing precision strike, coordinated defense, and ground maneuver operations, the Sensor-to-Shooter Working Group determined that the primary problem hampering sensor-to-shooter operations is the competition for sensors between battle managers and shooters. Historically, the battle manager wins, leaving the shooter with inadequate information to carry out the mission effectively.

As a result, many proposals are under consideration to provide the shooter with real-time imagery. However, the findings of this working group indicate that another answer, that is, enabling a distributed command and control approach, will provide the shooter with the targeting information that is really needed, thereby making the shooter more effective than can be accomplished through inundation with additional information. This solution entails two elements: the development of revised processes (and the tools to support them), and the identification and development of architectures and links providing the needed connectivity. Because a parallel, complementary effort is being conducted under J6I sponsorship, the efforts of the ABIS STS Working Group were focused on the technologies necessary to implement the revised processes.
2. Results
Sensor-to-Shooter Working Group Objectives

- Develop CONOPS and Capability Objectives for Processing, Links, and C2 To Provide:
  - Dynamic Targeting and Cueing
    » Accurately
    » Timely
  - Situational Awareness
    » Localized
    » Tailored to Shooters' Needs
- Identify Key Packages of Enabling Technologies
  - Emerging Information Technologies Related Services
  - Current Demonstrations and Prototypes
  - Additional Future Needs
Sensor-to-Shooter Working Group Objectives

As shown in the figure, the objectives of the ABIS Sensor-to-Shooter Working Group were as follows:

- Initially, develop a concept of operations and operational capability objectives that would be compatible with and would stimulate the implementation of combat operations as conceived in Vision 2010 by the VCJCS.

- Subsequently, identify the key enabling technologies needed to ensure that implementation of Vision 2010 will not be technology limited.

To achieve these objectives, the initial concepts of Vision 2010 were broadened. With the other two working groups, the Battle Management Working Group and the Grid Working Group, compatible, loosely integrated system concepts were developed. Although some unavoidable overlap resulted, in essence, the Sensor-to-Shooter Working Group was responsible for assessing the actual execution of the combat operations, whereas the Battle Management and the Grid Working Groups were responsible for planning and execution management and for information management and dissemination, respectively.
Results...

Sensor-to-Shooter Working Group Goals

Identify Key Packages of Enabling Technologies
• Emerging Information Technology Related Services
  — Current Demonstrations and Prototypes
  — Additional Future Needs
Time-Phased Technology Roadmap
• Sensor-to-Shooter Improvement
• Executing in System-of-Systems Operations Concept
Sensor-to-Shooter Working Group Goals

The specific goals that the Sensor-to-Shooter Working Group undertook for the ABIS study were to identify packages of enabling technologies and then develop an initial set of technology roadmaps. It was envisioned that the roadmaps would stimulate integrated technology-operational thought processes and accelerate C4I technology development in the DoD S&T community. These roadmaps and their supporting logic are the working group’s primary products.
Sensor-to-Shooter Working Group Deliverable: Technology Roadmaps

Master Roadmap

Technology Package #1
Technology Package #2
Technology Package #3
Technology Package #4

Technology Package
Name: __________________________
Objective: _____________________
Description: ___________________

Milestone
Name: __________________________
MOE: __________________________
CONOP: ________________________
Sensor-to-Shooter Working Group Deliverable: Technology Roadmaps

The purpose of the technology roadmaps is to stimulate the creation of service and DDR&E demonstration programs, specifically focused on developing the operational capabilities necessary to accelerate Vision 2010 implementation. These roadmaps are not intended to be program plans. Rather, they indicate one of several possible rational, systematic approaches to a sequential development of key capabilities. Key capability objectives and associated measures of effectiveness are provided to spur discussion within the science and technology (S&T) community.
Sensor-to-Shooter Working Group Approach

Operational Context
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Broad Concepts
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Important C2I Operational Capabilities
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Mapping of S&T Program

Technology Roadmaps
Sensor-to-Shooter Working Group Approach

The working group’s focus for the initial 3 months was to assess possible operational concepts and to simultaneously develop broad concepts for the three mission areas of interest: precision strike, cooperative defense, and ground maneuver. Important C2I operational capabilities needed to achieve the revised operations concepts were defined in operational and functional terms. The working group then crosswalked, or mapped, the current S&T program to identify needed technological thrusts. Finally, technology roadmaps were developed.
Definition and Scope
The Challenge

The Sensor-to-Shooter Challenge
1. Coordinate Multiple Sensor-to-C2-to-Shooter Missions
2. Assure Timely Execution of Missions

Need:
- Tasking
- Priorities

Provide Information

Sensors

Shooters
Need:
- Tasking
- Targeting Information
  - Location and Identification
  - Situation Awareness
  - Clearance to Shoot

Battle Management
Generates:
- Objectives
- Targets
- Missions

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Definition and Scope
The Challenge

Effectively executing combat operations in a joint force environment involving many ground, air, space, and shipboard resources entails two key challenges:

1. From within a universe of many joint force resources, individual sensors and shooters must be tasked and provided with the necessary priorities and targeting information needed to carry out multiple specific missions against multiple specific targets to achieve all of the battle manager’s objectives. This challenge is referred to in this report as coordination of missions.

2. For each mission, establish the information linkages between sensors and shooters necessary to enable the timely execution of missions, especially time-critical missions. Because, ideally, the sensors can be time shared among many shooters (in addition to the battle manager), effective and efficient implementation of these linkages and passing information through them will inevitably require the establishment of execution controllers performing real-time or near real-time C2 operations.

In this environment, the key operational concept required is one of distributed command and control, with an execution controller for each sensor-to-shooter execution team (which is really a sensor-to-C2-to-shooter team) performing many of the same functions that the battle manager performs. However, the sensor-to-shooter team plans how the mission is to be executed whereas the battle manager plans what will be executed. Thus, the C2 for each sensor-to-shooter team requires functional capability similar to that of the battle manager, but for an increased depth of detail spanning a narrower area of interest and having a much stronger focus on the timeliness of the information versus its completeness.
Key Study Findings

- The Key Problem Is Competition for Sensors Between Battle Management and Shooters
- The Key Solution Is Enabling Distributed Command and Control Through:
  - Automated Processing for Management of Time-Intensive Tasks
  - Common Links To Share Optimization of Those Resources
- Four High-Payoff Technology Demonstrations Necessary To Advance Toward the Solution Were Identified
Key Study Findings

After assessing precision strike, coordinated defense, and ground maneuver operations, the Sensor-to-Shooter Working Group determined that the primary problem hampering current sensor-to-shooter operations is the competition for sensors between more senior battle managers and shooters. Historically, the battle manager has monopolized tasking of special sensors, leaving the shooter with inadequate information to carry out the mission effectively.

To address that problem, many proposals are under consideration to provide the shooter with real-time imagery. However, the findings of this working group indicate that another answer, that is, enabling a distributed command and control approach, will provide the shooter with the targeting information really needed, thereby making the shooter more effective than can be accomplished through inundation with additional information. This solution entails two elements—developing revised processes (and the tools to support them), and identifying and developing architectures and links that provide the needed connectivity. Because a parallel, complementary operational architecture effort is being conducted under J6I sponsorship, the ABIS STS working group focused on the technologies necessary to implement the revised processes.

The working group found that the best way to increase the effectiveness of the shooter was through enabling enhanced effectiveness of the execution controller. Consequently, four areas for technology demonstrations are recommended, each of which will make the execution controller in the sensor-to-C2-to-shooter loop more effective in executing the two key operational capabilities identified: coordination of multiple missions and execution of time-critical missions.
Sensor-to-Shooter Important Capabilities

Execution Control Is the Critical Function for Conducting Effective Sensor-to-Shooter Operations, Requiring Two Operational Capabilities:

- Coordination of Missions—Preplanned and Time-Critical
  - Delegated Execution to Linked Force Package of C2, Sensors, Platforms, and Weapons Operating as Coordinated Units
  - Command Authority and Targeting Information Focused on Generating and Supporting These Executing Elements

- Execution of Time-Critical Missions
  - Battle Manager Retains Real-Time Ability To Redirect Force Package as Situation Changes
Sensor-to-Shooter Important Capabilities

Considering systems concepts like those shown, the 38-member ABIS Sensor-to-Shooter Working Group devoted 2 months to developing a crosswalk of required operational capabilities for precision strike operations, coordinated air defense operations, and ground maneuver operations. In this process, six vignettes of operational capabilities were developed in some detail and assessed to ensure the identification of technologies needed to execute critical operational capabilities. Each of these vignettes represents a situation that will be replicated many times in an operational environment.

Integrating and summarizing these required operational capabilities for the three mission areas listed above yielded two critical operational capabilities needed to execute sensor-to-shooter operations: the ability to coordinate multiple simultaneous missions (including both preplanned execution of the ATO/ITO as well as the highly responsive, autonomous missions against time-critical targets) and the ability to execute time-critical operations. In both cases, the need for parallel, fast, and dynamic operations remains a key consideration. Both of these operational capabilities are specifically addressed in subsequent figures, but first the mapping process is addressed with an example used for illustration.
## Sensor-to-Shooter
### Execution of Time-Critical Missions

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<th>Goal</th>
<th>Critical New Functional Capabilities</th>
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| Provide a dedicated force package of shooters with sufficient timely and relevant information to enable successful prosecution of time-critical targets. | - Theater Intelligence Processing for Broadcast  
- Rapid, Accurate Targeting  
- Rapid, Accurate BDA  
- Real-Time Collaborative Planning  
- Force Status and Execution Following  
- Automatic Weapon Target Pairing  
- ISR Management and Integration |

<table>
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<tr>
<th>Current Limitations</th>
<th>Needed Technology</th>
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| - Targets Appear After Force Package Commitments, Pop-Up Targets, Movements Cycles  
- Execution Status Unknown  
- Inability for Timely Counteraction to Target Reaction  
- Inadequate Coordination  
- Battle Management Reluctant To Release Information  
- Different Information Needs for Different Users  
- Simultaneous Pulls on Sensors  
- Insufficient Connectivity  
- Lack of Sensors  
- Man-Intensive BDA  
- Sensor Management Not Tied to Commander’s intent | - Wideband Communications and Interconnectivity  
- Real-Time, Cognition Aiding Displays  
- Automated Planning/Decision Support Tools  
- Data Interoperability/Synchronization  
- Automated IPB Processes  
- Fusion and Integrated Target Tracking  
- Automatic Target Recognition  
- Multilevel Security  
- ISR Management and Integration Tools |
Results...

Sensor-to-Shooter
Execution of Time-Critical Missions

This figure summarizes the Sensor-to-Shooter Working Group's assessment of the operational capability Execution of Time-Critical Missions. Note that the technologies are identical to those listed in Coordination of Missions. Although specific quantitative capabilities may differ for the two critical operational capabilities, the overall categories are identical. Details can be found in the remainder of this volume.
# Sensor-to-Shooter Coordination of Missions

<table>
<thead>
<tr>
<th>Goal</th>
<th>Critical New Functional Capabilities</th>
</tr>
</thead>
</table>
| Provide a collaborative decision making and planning environment between execution controllers, sensors, and shooters that ensures the coordinated execution of all missions assigned by the Battle Management—from the initial tasking through the execution of the missions. | - Parallel Dissemination of Intel/BDA to C2 and Shooter  
- Theater Intelligence Processing for Broadcast  
- Rapid, Accurate BDA  
- Force Status and Execution Monitoring  
- Rapid, Accurate Target Information (Target Location and Recognition, Situation Awareness in Target Area)  
- Automated Weapon to Target Pairing  
- Automated Mission to Target Pairing  
- ISR Management and Integration |

## Current Limitations

- Slow Decision and Resource Allocation Process With Regard to Target Cycle Times
- Poor Detection of Fleeting Target Entities in Crowded Battlespace
- Slow Fusion Process
- Best Sensor Information Not Incorporated
- Lack of Sensors
- Man-Intensive BDA
- Sensor Management Not Tied to Commander's Intent

## Needed Technology

- Wideband Communications and Interconnectivity
- Real-Time, Cognition Aiding Displays
- Automated Planning/Decision Support Tools
- Data Interoperability/Synchronization
- Automated IPB Processes
- Fusion and Integrated Target Tracking
- Automatic Target Recognition
- Multilevel Security
- ISR Management and Integration Tools
Sensor-to-Shooter
Coordination of Missions

In developing the assessments that led to the definition of the critical operational capabilities, the Sensor-to-Shooter Working Group defined the required operational capabilities (goal), identified current limitations, defined critical new functional capabilities, and subsequently defined critical needed technologies. These steps were followed for each of the six operational vignettes. The anticipated status and maturity of the technologies were assessed by evaluating summary information about currently approved ACTDs and selected information on service ATDs and TAPs made available to the working group. The summary results for Coordination of Missions are presented here.
Sensor-to-Shooter Operational Capability—Technology Mappings

- Operational Concept
  - Coordination of Missions
  - Execution of Time-Critical Missions

- Functional Capabilities
  - Dynamic, Joint Sensor Tasking
  - Dynamic, Joint Weapon Assignment
  - Cross Sensor Cueing
  - Cross Sensor Tracking
  - Rapid Target Identification
  - Communications Connectivity

- Technology Base
  - Constrained Resource Allocation
  - Decision and Estimation Theory
  - Multispectral Pattern Recognition/Selection

- Demonstrations
  - Target Weapon Pairing
  - Sensor Target Pairing
  - Integrated Fusion and Tracking
  - Automatic Target Recognition
Sensor-to-Shooter Operational Capability—Technology Mappings
Top Four Demonstrations

Following the process specified by the Secretariat, the Sensor-to-Shooter Working Group assessed those functional capabilities required to execute the two operational capabilities of the operational concept. These functional capabilities were then further decomposed and/or grouped into technology areas needing operationally oriented demonstrations to focus the technology into applications that would clearly support the shooter. This was a critical step because many of the technologies are well developed, but are not oriented toward shooter timeframes and areas of interest. Note that the mappings for all of the technologies assessed are not presented in this figure. Only the key technologies that map to the four proposed demonstrations that have applications across battlespace operations are presented.
Results...

Major Challenges

Execute Four High-Payoff Technology Demonstrations To Advance Toward the Solution:

- Automated Weapon-to-Target Pairing
- Automated Sensor-to-Target Pairing
- Automated Target Recognition
- Integrated Fusion and Target Tracking
Major Challenges

The working group’s findings indicate that the most effective way to enhance the shooter’s performance is to enable a distributed command and control approach, that is, implement an execution controller. This approach provides the shooter with the needed targeting information in the most effective manner, without inundating him with irrelevant information.

The working group recommended four areas for technology demonstrations, each of which will make the execution controller in the sensor-to-C2-to-shooter loop more effective in executing the two key operational capabilities identified—coordination of multiple missions and execution of time-critical missions. Technology roadmaps were developed for each of these four areas. Development of these capabilities will enhance the overall ability of shooters to execute the intentions of the battle commander by enabling the prosecution of more targets, faster, and more effectively, thereby shortening any hostile engagements significantly. The eventual implementation and fielding of these capabilities will be the real enduring value of these technology demonstrations.

Consequently, four areas for technology demonstrations are recommended: Automated Weapon-to-Target Pairing, Automated Sensor-to-Target Pairing, Automated Target Recognition, Integrated Fusion and Target Tracking. Each of these will make the execution controller in the sensor-to-C2-to-shooter loop more effective in executing the two key operational capabilities.
Sensor-to-Shooter Working Group Approach

Operational Context
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Broad Concepts
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Important C2I Operational Capabilities
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Mapping of S&T Program

Technology Roadmaps
Sensor-to-Shooter Working Group Approach
Definition of Operational Context and Broad Concepts

The details of the working group’s approach follow, beginning with definition of the operational context.
Integrated, Target-Focused Operations

Battle Management
(Minutes to Hours)

Sensor-to-Shooter
(Seconds to Minutes)

Start of Campaign Phase

Operational Appraisal

Operational Objectives Definition

Sensor Tasking and Management

Information Acquisition

Situation Assessment

Allocation of Resources

Operational Planning

Tactical Planning

Targeting Information Acquisition

Strike Tasking

Strike

Direct Immediate Restrike

BDA and Status Reporting

Monitoring and Adjustment

Short Cycle—Sensor-to-Shooter Inner Loop for Execution
- Autonomous Operations for Fleeting and Maneuvering Targets
- Synchronized Operations for Fixed and Slower Targets

Long Cycle—Battle Management Outer Loop for Planning
Sensor-to-Shooter Operational Context

This nested loop flow model of the Sensor-to-Shooter Operational Context is used in subsequent assessments of STS operations. The outer loop, which represents the longer cycle of battle management operations, splits into two branches, one branch containing the inner loop of sensor-to-shooter operations as a special case. Some key observations about the nature of the STS operations are as follows:

- Sensor-to-shooter operations include many of the same functions in battle management operations (e.g., sensor tasking and information acquisition). This is so because the sensor-to-shooter operations begin when the mission is assigned to the mission leader. At this point, the sensor-to-shooter execution team (sensors, shooters, and execution controllers) must perform the same functions in planning how the mission is to be executed that the battle managers performed in planning what will be executed. Therefore, the sensor-to-shooter team requires the same functional capability as the battle manager, but for an increased depth of detail spanning a narrower area of interest. Although it has a different emphasis on timeliness and level of detail, this functional commonality with battle management is the essence of the sensor-to-shooter challenge.

- Sensor-to-shooter operations are basically of two types, those that are executing the preplanned ATO (i.e., the outer loop including the lower branch) and those that are providing assets for highly responsive and autonomous operations against fleeting targets (i.e., the fast, seconds to minutes, inner loop). These are discussed in detail in subsequent sections.

- Although it is not obvious from the figure, a key element of integrated sensor-to-shooter operations is the fact that there are multiple executing elements operating simultaneously. This means the battle manager must plan the synchronized operations of several hundred missions while enabling dozens of highly responsive and autonomous missions against fleeting targets.

- None of the elements of any specific sensor-to-shooter team are necessarily dedicated to a single mission for an entire sortie. On the contrary, for maximum effectiveness in the entire battlespace, sensor sorties in particular will be time shared across many missions.
Sensor-to-Shooter Working Group Approach

Operational Context

Precision Strike
Cooperative Defense
Ground Maneuver

Broad Concepts

Precision Strike
Cooperative Defense
Ground Maneuver

Important C2I Operational Capabilities

Precision Strike
Cooperative Defense
Ground Maneuver

Mapping of S&T Program

Technology Roadmaps
**System Attributes**
**Parallel, Fast, Dynamic**

- **Generates Sensor-to-Shooter Relationships and Linkages**

**LEGEND**
- Command
- Information

**Execution C2**
- C2 Provided With Sensor Retasking Capability According to Warfare Commander's Intent and Direction
- Shooters and C2 Provided With Automated Tools To Use Any Available Sensor Data, Regardless of Ownership, for Real-Time Target Recognition and Identification
- Shooters Receive Latest Targeting Information in Displays Suitable for Immediate Execution
- Shooters Provide BDA to Grid for Fusion and Dissemination
Sensor-to-Shooter System Attributes

The key characteristics of the proposed sensor-to-shooter system concept are that they are parallel, fast, and dynamic, versus the current characterization as serial, slow, and nonresponsive. These capabilities will be enabled largely by key elements of the Grid concept, providing battlespace awareness, that is, simultaneous access to battlespace information by shooters and execution controllers as well as by battle managers. With the black arrows indicating command and the other arrows indicating information flow, the figure directs future operations as separate from the information flow from the command cycle. This is necessary to achieve the desired responsiveness. Furthermore, this characteristic is also a major driver in the need for dynamic planning capabilities and parallel operations.

In the proposed system concept, the sensors will continuously input new information into battlespace awareness databases while both executing elements (shooters and controllers) and battle managers will simultaneously be able to retrieve information. Much of the current conflict of competing sensor tasking will be resolved using integrated sensor management techniques. While the battle manager is seeking battlefield information throughout the entire battlespace, and when in common battlespaces, the shooters are seeking targeting information. This means that the shooter needs target location and identification, situation awareness in the target area, and clearance to shoot. Primarily, current shooters do not have adequate situation awareness in the target area. The connectivity and access achieved through implementation of the Grid will provide situational awareness, thus enabling shooters to execute the sensor-to-shooter operations successfully. The following three figures illustrate that current service operations can be envisioned in this context, although all of the desired capabilities are certainly not yet present.
Results...Broad Concepts...

Army Call for Fire

Fire Support Teams

Sensors

Execution C2

BN TOC

Weapons

MRLS

Infantry

Artillery

Joint Battle Management

CJTF

JFACC

JFMCC

USMC

USN

USA

USAF
Naval Air Defense
Air Force Strike

Sensors

CJTF
JFLCC
JFMCC
USMC
USN
USA
USAF
JFACC
NTM
ABCC
JSTARS
E-3
Fwd Air Cont

Execution C2

ABCC/AOC

Weapons
Sensor-to-Shooter Working Group Approach

**Operational Context**
- Precision Strike
- Cooperative Defense
- Ground Maneuver

**Broad Concepts**
- Precision Strike
- Cooperative Defense
- Ground Maneuver

**Important C2I Operational Capabilities**
- Precision Strike
- Cooperative Defense
- Ground Maneuver

**Mapping of S&T Program**

**Technology Roadmaps**
Important Operational Capabilities
Are Characterized in These Combat Vignettes

- Prosecution of Fleeting Targets
- Synchronized Execution of Preplanned ITO
- Prosecution of Maneuvering Targets
- Battle Damage Assessment
- Defensive or Offensive Counterair
- Dynamic, Deep Targets
Important Operational Capabilities Are
Characterized in These Combat Vignettes

As illustrated in the two-loop model, sensor-to-shooter operations span timeframes typically characterized in terms of seconds, minutes, and tens of minutes. The working group used operational combat vignettes to access key relevant characteristics of these operations. The six vignettes presented here encompass most key aspects of sensor-to-shooter operations. Furthermore, each vignette is repeated many times in various types of conflicts—hundreds of times in major regional conflicts, and dozens of times in lesser regional conflicts. Only a few vignettes occur in operations other than war. Nevertheless, the operational capabilities required are relativelyunchanging.

- **Prosecution of Fleeting Targets** presents one of the most challenging situations. These targets, such as Scud launchers and multiple rocket launchers, were not successfully prosecuted during the Gulf War, nor has the capability been demonstrated consistently since then. The challenge for sensor-to-shooter operations involves both timeliness of specific actions and effective coordination of assets.

- **Synchronized Execution of the Preplanned Integrated Tasking Order (ITO)** presents a different challenge. Current systems are serial, are oriented toward single service execution, and are slow (taking days) while fast, continuous and dynamic, true joint operations are desired.

- **Prosecution of Maneuvering Targets** is the primary vignette involving the individual soldier, both as shooter and as sensor.

- **Battle Damage Assessment** (BDA) improvements are a much-desired and long-awaited capability, but are not yet a reality of combat operations. Ideally, each shooter will also become a BDA sensor, providing inputs to the Battlespace Awareness Grid.

- **Defensive or Offensive Counterair** capabilities are segmented and isolated from other operations. True integrated capability with other combat operations will result in a substantial advantage to our forces.

- **Prosecution of Dynamic, Deep Targets**, such as a column of tanks, involves a different challenge than fleeting targets—easier detection and location, but emphasizing dynamic retargeting capabilities.
Prosecution of Fleeting Targets

Battle Management
(Minutes to Hours)

Sensor-to-Shooter
(Seconds to Minutes)

Start of Campaign Phase

Operational Objectives Definition

Monitoring and Adjustment

BDA and Status Reporting

Situational Assessment

Strike

Information Tasking

Direct Immediate Restrike

Tactical Planning

Allocation of Resources

Operational Planning

Operational Appraisal

Information Acquisition

Sensor Tasking and Management

Sensor Tasking

Strike Tasking

Strike

Tactical Planning

Volume IV
Prosecution of Fleeting Targets

The first vignette is the most challenging operational situation. As depicted in the flow figure, this vignette involves the inner loop in the most time-critical fashion, with the extremely short target cycle times permitting only seconds to minutes for the entire sensor-to-shooter process from initial target detection through strike, BDA, and restrike if necessary.
Prosecution of Fleeting Targets
Current Operations and Limitations

Current Operations
Sensor
Control
Weapon

Detect
Targeting
Reacquire Kill

Current Limitations
Timeline Too Long To Prosecute Time-Critical Targets

TEL Operations
Launch
Tear Down

hide move set up move hide move resupply move hide move set up

Launch

Individual Firing Cycle
Prosecution of Fleeting Targets
Current Operations and Limitations

Assessing current operations against fleeting targets such as transportable erectable launchers (TEL) for tactical ballistic missiles reveals that the primary shortfall is the timelines are too long, meaning the time to detect the threat, assess the situation and decide to take action, respond to the tasking by a shooter, and hand off the information between the elements of the sensor-to-shooter. In all cases, the time to take the necessary actions is longer than the exposure of the target while executing a single firing cycle. The desired sensor-to-shooter operations under the future vision are illustrated in the next figure.
Prosecution of Fleeting Targets
Revised Operations and C4I Technology Challenges

**Current Operations**
- Sensor
- Control
- Weapon

**Dynamic Tasking**
- Challenges:
  - Automated Decision Aids
  - Forward and Local Control

**Operate Faster**
(Execute Time-Critical Missions)

**Tel Operations**
- Launch
  - Tear Down

**Revised Operations**
- Prelaunch Detection and Strike
  - Challenges:
    - Integrated Sensor Tasking
    - Integrated Processing
    - Auto Target Recognition

**Infrastructure and Post Launch Strike**
- Challenges:
  - Integrated Sensor Tasking
  - Integrated Processing
  - Target ID, Tagging, and Tracking
  - Target Handoff
  - Integrated Force Packages

**Expand the Battlespace**
(Coordinate Missions)
Prosecution of Fleeting Targets
Revised Operations and C4I Technology Challenges

Under the proposed sensor-to-shooter operations of Vision 2010, two types of solutions will enable prosecution of fleeting targets:

1. To execute essentially the same functions as current operations, but to do so substantially faster, that is, to execute time-critical missions.

2. To expand the battlespace into pre- and post-launch TEL operations, that is, to coordinate missions.

In both cases, technology challenges must be overcome and a revised CONOPS must be developed. These advances in operational thinking and technologies must be developed simultaneously. Key challenges, stated primarily as functional areas of improvement or change, are noted in the figure.
Technology Packages

<table>
<thead>
<tr>
<th>Common Technology Themes Across Mission Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Wideband Communications and Interconnectivity</td>
</tr>
<tr>
<td>• Real-Time, Cognition Aiding Displays</td>
</tr>
<tr>
<td>• Automated Planning/Decision Support Tools</td>
</tr>
<tr>
<td>• Data Interoperability/Synchronization</td>
</tr>
<tr>
<td>• Automated IPB Processes</td>
</tr>
<tr>
<td>• Fusion-Sensor Fusion as Well as Information Fusion</td>
</tr>
<tr>
<td>• Automatic Target Recognition and Acquisition</td>
</tr>
<tr>
<td>• Integrated Target Tracking</td>
</tr>
<tr>
<td>• Multilevel Security</td>
</tr>
<tr>
<td>• Dynamic ISR Resource Management</td>
</tr>
</tbody>
</table>
Technology Packages  
Common Technology Themes Across Mission Areas

In each of the six combat vignettes, the Working Group first identified the **Current Limitations**, then defined the **Causes** for those limitations, then identified the **Critical FunctionalCapabilities** required to overcome these causes, and finally determined the **Technology Challenges** that must be solved to provide the Critical Functional Capabilities. Although there were also doctrinal, acquisition, operational, and other issues that had to be addressed, the working group’s charter was limited to identifying the technology challenges; therefore, these nontechnological issues were left largely unaddressed. The technology challenges were then grouped into the 10 technology areas listed here. The working group related each of these technology areas to the combat vignettes in which the important C2I operational capabilities were characterized. This was a critical step because many of the technologies are well developed, but are not oriented toward shooter timeframes and areas of interest.
### Operations—Technology Crosswalk

**Prosecution of Fleeting Targets**

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>• STS Timeline Too Long</td>
<td>• Slow Decision and Resource Allocation Process With Respect To Target Cycle Times</td>
<td>• Highly Responsive (Less Than a Minute) Ability To Match Target With Constrained Resource Package</td>
<td>• Preplanned and Dynamic Responses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Rapid, Continuous IPB With Joint Processing and Dissemination</td>
<td>• Preplanned and Dynamic Prioritization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Detect and Classify Targets In Fraction of Cycle Time</td>
<td>• Automated Target Weapon Pairing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• QRC Decision Aids</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Joint Fusion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Automatic Target Recognition For Fleeting Target Behaviors</td>
</tr>
</tbody>
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| | | | C |
| | | | F |
| | | | G |
Operations—Technology Crosswalk
Prosecution of Fleeting Targets

The Operations—Technology Crosswalks used for assessment purposes by the working group are illustrated in this figure and the following two figures for the fleeting target vignette. The working group first identified the Current Limitations inherent in executing the operations depicted in the vignette, then defined the Causes for those limitations, then identified the Critical Functional Capabilities required to overcome these causes, and finally, determined the Technology Challenges that must be solved to provide the Critical Functional Capabilities. Because the working group's charter was to identify the technology challenges, nontechnological issues, such as doctrinal, acquisition, and operational, were largely not addressed. The letter references along the right-hand margin of the facing figure provide a cross reference from the specific technology challenges identified for each of the vignettes to the 10 technology areas identified by the working group and summarized at the beginning of this section.
# Operations–Technology Crosswalk

**Prosecution of Fleeting Targets (Continued)**

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
</tr>
</thead>
</table>
| • STS Timeline Too Slow | • Poor Detection of Fleeting Target Entities In Crowded Battlespace | • Integrated Tasking and Processing of Sensors (Tactical, Theater, National) and Weapons for Prelaunch and Multicycle Detection and Prosecution | • Sensor Cross Cueing  
• Data Validity Tags  
• Automated Data Validation  
• Tactical Tasking Of Sensors  
• Integrated, Dynamic Sensor and Weapon Tasking  
• Integration of Non-Conventional and Cross Mission Sensors  
• Target Infrastructure ID  
• Continuous Target Tracking (Cross-Sensor) |

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>K</td>
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<td>F</td>
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<tr>
<td>C&amp;K</td>
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</tr>
<tr>
<td></td>
<td>K</td>
<td>E,F&amp;G</td>
<td>H&amp;K</td>
</tr>
</tbody>
</table>
## Operations–Technology Crosswalk

**Prosecution of Fleeting Targets (Continued)**

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>• STS Timeline Too Long</td>
<td>• Slow Fusion Process</td>
<td>• Provision of Targeting Information in Real Time</td>
<td>• Transmit Track Quality Data Directly to Weapon and Weapons Platform</td>
</tr>
<tr>
<td>• Best Sensor Information Not Incorporated</td>
<td></td>
<td>• Integrated Processing Across Sensor and Other Information Sources</td>
<td>• Positive ID—Hostiles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Sensor Fusion Across Spectrum and ISR Disciplines (i.e., SIGINT, ELINT, IMINT, MASINT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Data Fusion To Incorporate Other Information</td>
</tr>
</tbody>
</table>
Synchronized Execution of Preplanned ITO
Synchronized Execution of Preplanned ITO
Current Operations and STS Limitations

ISR Assets:
- HAE
- U2
- JSTARS
- SIGINT
- IMINT
- Other Sensors

136,000 Targets
- 500 TCTs
- 68,000 Movers
- 800 Emitters

Operational STS Limitations:
- Poor, Slow JTF Coordination
- Inflexible Retargeting
- Situation Awareness Not Shared

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Synchronized Execution of Preplanned ITO
Revised Operations and C4I Challenges

STS C4I Challenges:
- Collaboration on Planning and Rehearsal
- Timely, Coordinated JTF Execution
- Flexible and Timely Retargeting
- Shared Situation Awareness
### Operations–Technology Crosswalk
Synchronized Execution of Preplanned ITO

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Inflexible Retargeting</td>
<td>• Targets Appear After Force Package Commitment:</td>
<td>• Maintaining Continuous Awareness of Target Activity by Shooter Elements</td>
<td>• Unique Target ID Across Sensors</td>
</tr>
<tr>
<td>Against Dynamic Targets</td>
<td>- Pop-up Targets</td>
<td>• Implement Air–Ground Decide-Detect-Deliver CONOPS and Real-Time Target Acquisition C2 Structure</td>
<td>• Real-Time Target Location Updates</td>
</tr>
<tr>
<td></td>
<td>- Movement Cycles</td>
<td>• Provide Real-Time Status Information on Force Elements (i.e., by Tail Number)</td>
<td>• Continuous Observation of Target After Detection</td>
</tr>
<tr>
<td></td>
<td>• Execution Status Unknown</td>
<td></td>
<td>• Timely Loading of Target Information Into Weapon</td>
</tr>
</tbody>
</table>

| H                                    | H                                           | H&K                                                        | A                                                            |
| A, B, & C                             |                                              |                                                            |                                                              |
### Operations–Technology Crosswalk

Synchronized Execution of Preplanned ITO (Continued)

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
</tr>
</thead>
</table>
| • Inflexible Retargeting Against Dynamic Targets | • Inability for Timely Counteraction to Target Reaction  
• Inadequate Coordination for Timely Response | • Real-Time Force Package and Weapon Retasking as Target Status Changes (Within Inventory Constraints)  
• Enable Real-Time, On-line Coordination Between Elements of Force Package (i.e., Shooter-to-Controller, Ground Shooter-to-Air Shooter) | • Real-Time Update of Target-Weapon Pairing To Achieve Strategic Objectives  
• Providing Sufficient Video-Voice-Graphics Capability Without Distracting Shooters |

C&D  
A&B
### Operations–Technology Crosswalk

**Synchronized Execution of Preplanned ITO (Continued)**

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situational Awareness Not Shared:</td>
<td>BM Reluctant To Release</td>
<td>Timely Release of Best Available Information Indicating Expected Updates</td>
<td>Providing Joint Commanders' Intent and Guidance On-line in NRT</td>
</tr>
<tr>
<td>Across Missions</td>
<td>Different Information Needs for Different Users</td>
<td>Tailoring Common Picture to Individual Needs of Multiple Users</td>
<td>Fusion on INT Data for OB Track History</td>
</tr>
<tr>
<td>Across Services</td>
<td>Simultaneous Pulls on Sensors</td>
<td>Integration of Data From All Sensors (i.e., Active Defense, Recce)</td>
<td>Development of Common Ground-Air-Naval Picture and Symbology</td>
</tr>
<tr>
<td>Between Allies</td>
<td>Insufficient Connectivity</td>
<td>Enable Targeting Data to Shooters and SA Data to BMgrs</td>
<td>NRT Mission/User-Based Extraction</td>
</tr>
<tr>
<td>Between BM and Shooters</td>
<td></td>
<td>Sufficient Bandwidth, Links, and Trust To Enable Coalition Connectivity To Ground Shooter</td>
<td></td>
</tr>
</tbody>
</table>

- **A,B,&D**
- **F**
- **B,D,&F**
- **B&D**
- **C&K**
- **K**
- **D**
Prosecution of Maneuvering Targets
Prosecution of Maneuvering Targets
Current Operations and STS Limitations

Operational STS Limitations:
- Current C4I System Too Slow; Inhibits Initiative
- Allows Enemy to Enter Maneuver Force Decision Cycle
- Connectivity Inadequate For Ground Maneuver Shooters

National, Theater, and Tactical Sensors

Threats in MRC-E
- 3,800 Tanks
- 2.1M Men

CJTF
JIC
Prosecution of Maneuvering Targets
Revised Operations and C4I Challenges

Operational STS Challenges:
- Speeds C2I Guidance and Battlespace Awareness to Lowest Tactical Echelons
- Direct C4I Connectivity Supports Decentralized Ground Maneuver
- Accelerates Maneuver Element's Responsiveness and Incorporates Ground Shooter BDA Feedback
**Operations–Technology Crosswalk**

**Prosecution of Maneuvering Targets**

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>• STS Timeline Too Long</td>
<td>• Slow Communications and Information</td>
<td>• Highly Responsive Ability for Ground Shooter To Pull and Receive Highly Perishable</td>
<td>• Tactical Man-Portable C4I Systems</td>
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<tr>
<td></td>
<td>Processing Capability at Command Echelons</td>
<td>STS Information</td>
<td>• BA and C2I Direct Connectivity</td>
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<tr>
<td>• STS Information Passes</td>
<td>• Lack of Command by Negation</td>
<td>• Ability for User To Directly Receive Fused Intel and C2 Information</td>
<td>• Transmit Track Quality Data Directly to</td>
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<td>Through Too Many Command</td>
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<td>• Sufficient Links and Bandwidth to Lowest Level of Tactical Shooter</td>
<td>Weapon and Weapons Platform</td>
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<tr>
<td>Echelons</td>
<td>• Insufficient Connectivity</td>
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<td>• Positive ID-Hostiles</td>
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<tr>
<td>• No Timely Ground Shooter</td>
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<tr>
<td>BDA</td>
<td></td>
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</table>
Battle Damage Assessment
Current Operations and Limitations

BDA Current Limitations:
- Not Integral Part of Planning Cycle
- Often Not Enough Sensor Data
- Too Slow, Often Linear
- Not Comprehensive or Conclusive
- Contradictory With Other Sensors/Sources
Battle Damage Assessment
Revised Operations and C4I Technology Challenges

BDA Technology Challenges:
- Geostationary Remote Sensors
- Automated Multilevel Security
- Sensor Collaboration/Optimization
- Automated Change Detection
- Sensor Management Across Sensors
## Operations–Technology Crosswalk
### Battle Damage Assessment

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
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<tbody>
<tr>
<td>• BDA Not Matched to Optempo</td>
<td>• Lack of Sensors</td>
<td>• Integrate Tactical Sensors</td>
<td>• Connectivity</td>
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<td>• Man-Intensive BDA Analysis</td>
<td>• Integrate Allied Sensors</td>
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<td>• Sensor Management Not Tied Directly to Commander's Intentions</td>
<td>• Long Dwell Sensors</td>
<td>• Automated Multilevel Security</td>
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<td></td>
<td></td>
<td>• Automate Processes</td>
<td>• High Revisit Rate</td>
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<tr>
<td></td>
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<td>• Sensors Integrated Into Operational Objectives</td>
<td>• Geostationary Sensors</td>
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<td>• Automated Change Detection</td>
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<td>• Automate Sensor Optimization Across Joint Objectives</td>
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<td>• Multilevel Security</td>
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<td>• Sensor Management Across All Sensor Types</td>
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A&K  
J  
K  
G  
C&K  
J  
C&K
### Operations–Technology Crosswalk
**Battle Damage Assessment**

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<tr>
<th>Current Limitations</th>
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<td>BDA Not Matched to Optempo</td>
<td>Lack of Sensors</td>
<td>Integrate Tactical Sensors From All Mission Areas (Including Individual Soldier)</td>
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<td>Automated Change Detection</td>
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<td>Sensor Management Across All Sensor Types</td>
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Defensive or Offensive Counterair
Defensive or Offensive Counterair
Current Operations and STS Limitations

Operational STS Limitations:
- Heavy Dependence on UHF Radio
- Situational Awareness
  - Combat ID
  - Communications
  - Force Allocation
- Joint Engagement Zones
- Detection of "Unconventional" Targets
  (e.g., Cruise Missiles)
Defensive or Offensive Counterair
Revised Operations and C4I Technology Challenges

Optimum Counterair Scenario:
- Cueing by Any Sensor With Capability (Including AD)
- Rapid, Filtered, and Unambiguous Target Display
- Targeting Data May Be Own Sensor or Optimized Sensor Data in Area
- Rapid, Automatic, and Collaborative Target-Weapon Pairing (Contingent With Command by Negation)
# Operations–Technology Crosswalk
## Counterair Operations

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
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<tr>
<td>Nonintegrated Air and Ground Defense (Joint Engagement Zones)</td>
<td>Inability To Communicate Adequately Between Defensive Systems</td>
<td>Mutual Support Between Ground and Air Defense Systems</td>
<td>Interactive Ground/Air Situational Awareness</td>
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<td>Inability To Maintain Positive Hostile ID in Dynamic Battle</td>
<td>Maintain Track ID on Contacts in Maneuvering Flight</td>
<td>Interactive Ground/Air Tracking and Weapons Status</td>
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<td>Dynamic Translation of Legacy Systems Data Into Standardized Data Formats</td>
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<td>Interactive Ground/Air Tracking of Counterair Contacts With Designated Area</td>
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A,B,F  
A,B,D,H  
D&H  
A,B,F
### Operations–Technology Crosswalk

#### Counterair Operations (Continued)

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<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
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<tbody>
<tr>
<td>Nonintegrated Air and Ground Defense (Joint Engagement Zones)</td>
<td>Force Allocation Is Time Consuming</td>
<td>Adequate Information for Battle Management/Execution</td>
<td>Development of Common Ground-Air-Naval Picture and Symbology</td>
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<td></td>
<td>Force Allocation Is Not Optimized</td>
<td>Adequate Information for Battle Execution Target-Weapons Allocation</td>
<td>Automated, Dynamically Updated Target Prioritization Against Commander's Objectives</td>
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<td>Automated, Dynamically Updated Weapons Availability</td>
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<td>Automated, Optimization of Weapons-Target Pairings</td>
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Operations–Technology Crosswalk
Counterair Operations *(Continued)*

<table>
<thead>
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<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
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<tbody>
<tr>
<td>Situational Awareness Does Not Permit Rapid Decision-Making</td>
<td>Inadequate Information Available to Shooter</td>
<td>Integrated Sensors That Provide Real-Time Information to Shooters Tailored to Their Needs</td>
<td>Sensors, Processing, and Links Capable of Providing Information in Suitable Formats in a Real-Time Environment</td>
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<tr>
<td></td>
<td>Inadequate Ability To Display Information</td>
<td>Easily Interpreted SA Displays With Continuous Real-Time Updates</td>
<td>3D Display (From Above) Showing Local Airborne Objects CID and Track Information</td>
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<td>Data Fusion To Incorporate Other Information</td>
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A,D,F,&H

A,B,&H

A&F
## Operations–Technology Crosswalk
### Counterair Operations (Continued)

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<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
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<tbody>
<tr>
<td>Situational Awareness Does Not Permit Rapid Decision-Making</td>
<td>Information Saturation, Misinterpretation</td>
<td>Unambiguous Information Transmission, Filtered and Tailored, Easily Displayed and Interpreted</td>
<td>Positive ID-Hostile Target</td>
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<tr>
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<td>Adequate Information About Status of Threat and Friendly Assets</td>
<td>Capability To Know the Combat Potential of Both Friendly Assets and Enemy Targets</td>
<td>Data Validity Tags</td>
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<td>Data Validation, Done Automatically</td>
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<td>Dynamic Fusion/Filtering</td>
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<td>Target Status and Infrastructure ID</td>
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<td>Automate Sensor Optimization Across Joint Objectives</td>
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<td>A, F, G, C &amp; K</td>
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## Operations–Technology Crosswalk
### Counterair Operations (Continued)

<table>
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<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>- Proliferation of &quot;Gray&quot; Threat</td>
<td>- Ability To Distinguish Friendly Aircraft, Even When Similar Type Flown by Adversary (Without Reliance on Interactive Systems)</td>
<td></td>
</tr>
</tbody>
</table>

A,D,F,H

E&F

F

A,B,D
## Operations–Technology Crosswalk

### Counterair Operations (Continued)

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
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<tbody>
<tr>
<td>• Situational Awareness Does Not Permit Rapid Decision-Making</td>
<td>• Information Transmission Is UHF Dependent</td>
<td>• Convey Information Needed Via Data Link</td>
<td>• Sensor Grid, Processing, and Links/Grids Capable of Providing Information in Suitable Formats in a Dynamic Environment</td>
</tr>
<tr>
<td></td>
<td>• Absence of Data Link Standard and Cross-Transliteration</td>
<td>• Ability To Communicate Freely Between All Elements of Counter Force</td>
<td>• Development of Common, Distributed, and Composite Air-Ground-Naval Track Database</td>
</tr>
</tbody>
</table>

A,D,F,&H

A,B,D,F,&H
Dynamic, Deep Targets

Battle Management
(Minutes to Hours)

Sensor-to-Shooter
(Seconds to Minutes)

- Start of Campaign Phase
- Operational Appraisal
- Operational Objectives Definition
- Sensor Tasking and Management
- Information Acquisition
- Situation Assessment
- Allocation of Resources
- Operational Planning
- Direct Immediate Restrike
- Tactical Planning
- Strike Tasking
- Strike
- Targeting
- BDA and Status Reporting
- Monitoring and Adjustment
- Monitoring and Adjustment

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Dynamic, Deep Targets
Current Operations and STS Limitations

Targeting and Attacks Slow and Inflexible:
- Targeting Data Too Slow to Weapon System
- Stovepipe Targeting by Services
- Accuracy Affected by Different Geo, Timing, and Charting Standards
- Sensor-to-Shooter Management Too Linear
Dynamic, Deep Targets
Revised Operations and C4I Technology Challenges

Fast, Distributed Targeting and Attack:
• Tracks have Common Formats, Coordinates, Maps Across JTF
• Tactical Access to all Databases
• Mission Planning Collaboration Across JTF
• JTF Complementary Sensor Tasking
## Operations–Technology Crosswalk
### Dynamic, Deep Targets

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
</tr>
</thead>
</table>
| • STS Timeline Too Slow | • Time Delay Caused by Man-in-the-Loop Processing, Correlation, and Fusion Enroute to Shooter | • Automated and Semi-Automated Processing, Exploitation, Fusion, and Dissemination | • Automated Sensor Tasking/Nomination (Dynamically Updated) by Changing Battle Management Objectives  
• Automated Target Recognition and Nomination for Priority Dissemination  
• Automation Loading of Priority Target Data Into Weapon/Platform |

| Validity | A,C,G,&K |
| Validity | A,D,C,&G |
| Validity | A,F,&J |
### Operations–Technology Crosswalk

#### Dynamic, Deep Targets *(Continued)*

<table>
<thead>
<tr>
<th>Current Limitations</th>
<th>Causes</th>
<th>Detailed Critical Functional Capabilities</th>
<th>Technology Challenges</th>
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</thead>
<tbody>
<tr>
<td>• STS Timeline Too Slow</td>
<td>• Time Delay Caused by Man-in-the-Loop Sanitization of Targeting Data</td>
<td>• Ability to Set Declassification/Sanitization Rules, Then Have Rule-Based Logic Software/Firmware Auto-Sanitize Targeting Data Stream in Real-Time</td>
<td>• Automated Sanitization of Highly Classified Targeting Data in Real-Time</td>
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<td>• Automated Modification of Classified Formats to Different Formats at Equal and/or Lower Classifications</td>
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<td>• Automated Translation Form One Language to English and Simultaneously Declassify Data Stream</td>
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## Operations–Technology Crosswalk
### Dynamic, Deep Targets (Continued)

<table>
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<th>Current Limitations</th>
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<th>Technology Challenges</th>
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<tr>
<td>• STS Timeline Too Slow</td>
<td>• Time Delay Caused by Broadcast/Transmission Delays</td>
<td>• Ability to Allow Head-of-the-Queue Privileges for Selected Targeting Data</td>
<td>• Automated Tagging of Targeting Data With Both Perishability and Broadcast Priority Codes</td>
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<td></td>
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<td>• Provide Sufficient Bandwidth and Broadcast Management Schema To Ensure No Delays of Targeting Data in Broadcast Cues</td>
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## Operations–Technology Crosswalk
### Dynamic, Deep Targets (Continued)

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<tr>
<td></td>
<td></td>
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<td>• Automated Transliteration, Multilevel Sanitization, and Format Transliteration Software/Firmware</td>
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</tbody>
</table>

D&J
Sensor-to-Shooter Working Group Approach

Operational Context
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Broad Concepts
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Important C2I Operational Capabilities
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Mapping of S&T Program

Technology Roadmaps
### Mapping of S&T Program

#### Current Operational Demonstrations

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<td>ARMY ATDs</td>
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<td>NAVY ATDs</td>
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<td>AIR FORCE ATDs</td>
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* Totals Appear Low
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<tr>
<th>Technology</th>
<th>ACTD</th>
<th>Advanced Joint Planning</th>
<th>HAE UAV</th>
<th>MAE UAV</th>
<th>Precision Rapid Counter MRL</th>
<th>Precision Signals Intel Tgtng</th>
<th>Synthetic Theater of War</th>
<th>BADD</th>
<th>Combat Identification</th>
<th>Joint Logistics</th>
<th>Mill Ops in Built-up Areas</th>
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<td>Real-Time, Cognition Aiding Displays</td>
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<td>Automated Planning/Decision Support Tools</td>
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<td>Data Interoperability/ Synchronization</td>
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<td>Automated IPB Processes</td>
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<td>Fusion—Sensor Fusion as Well as Information Fusion</td>
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**Legend**
- ? - possibly addressing some aspect
- / - addressing some aspect
- X - focused on specific technology
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<th>Army ATDs</th>
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Legend:
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- / : addressing some aspect
- X : focused on specific technology
Sensor-to-Shooter Working Group Approach

Operational Context
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Broad Concepts
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Important C2I Operational Capabilities
- Precision Strike
- Cooperative Defense
- Ground Maneuver

Mapping of S&T Program

Technology Roadmaps
## Technology Package Demonstrations Recommended

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- **X**: Focused Technology Investments Recommended To Support Sensor-to-Shooter Operations
- **XX**: Operational Application Investments Recommended, Integrated With Other Appropriate Technologies
Technology Package Demonstrations Recommended

The 10 areas identified in the preceding section were assessed to define key objectives and their potential for accomplishment in the near term versus the long term. This figure and the following four figures provide an overview of the technology demonstrations that the working group believes are necessary. Subsequently, these areas were assessed for their overall contribution to the military effectiveness of sensor-to-shooter operations and were ranked in order of priority.
### Recommended STS Demonstrations

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<th>Technology</th>
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<th>Future Objectives</th>
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| • Wideband Communication and Interconnectivity | • Interactive, Group Connectivity From Sensors to Shooters for Targeting and Situation Awareness Information | • Bandwidth and Connectivity for Precision Strike/Air Defense Operations  
• Bandwidth and Connectivity Enabling Mission Planning and Execution Collaboration | • Bandwidth and Connectivity Enabling Multimission Operations and Collaboration |
| • Real-Time Cognition Aiding Displays          | • Video-Voice-Graphics Displays Providing 3-D, Red and Blue, Multiservice Multiechelon Remote Collaboration Capability | • AF-Army Integrated Precision Strike/Air Defense Common Air Picture  
• Mission Tailorable Displays  
• Situation Awareness R&D  
• Two-Site VTC Without Graphics Interaction | • All Service, All Mission Common Picture of Battlespace  
• Mission Tailorable Displays  
• Full Capability Group Interaction |
| • Auto Planning and Decision Support Tools     | • Increased Strike Execution Effectiveness Through Dynamic Target List Updating and Real-Time Retasking | • NRT All Service Precision Strike Strategy To Task ITO Generation  
• NRT Mobile Target Position Updates and Strike Retasking | • RT All Service, All Mission Strategy To Task ITO Generation  
• RT Mobile Target Position Updates and Strike Retasking |
## Recommended STS Demonstrations (Continued)

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<td>• PS Data Interoperability From Sensor to Shooter</td>
<td>• Multinational Systems Data Interoperability</td>
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<td>• Integration of All Source Sensor Data With Other Target Knowledge</td>
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<td></td>
<td></td>
<td>• Common Composite Track Database for All Theater Sensors (Track ID and Geolocation)</td>
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</table>
Recommended STS Demonstrations *(Continued)*

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
<th>Near-Term Objectives</th>
<th>Future Objectives</th>
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<tbody>
<tr>
<td>Multilevel Security</td>
<td>• Integration and Exploitation of All Source Sensor Data With Other Target Knowledge</td>
<td>• Automated Sanitization of Highly Classified Formatted Targeting Data in Real Time</td>
<td>• Automated Sanitization of Formatted and Unformatted English and Non-English Targeting Data in Real Time</td>
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<td>• Automated Sanitization of Classified Imagery Chips to Secondary Imagery in Near Real-Time</td>
<td>• Automated Sanitization of Classified Imagery With and Without Annotations (Including Metadata That Allows Mensuration) in Real-Time</td>
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<td>ISR Management and Integration</td>
<td>• Automated, Integrated Tasking and Management of Tactical and National ISR Assets</td>
<td>• Coordinated Tasking Of Tactical MTI and IMINT Assets</td>
<td>• Coordinated Tasking of MTI, SIGINT,IMINT, and Other Assets</td>
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<td>• Planning for 24-Hour Cycle of Tasking</td>
<td>• Planning for 72-Hour Cycle of Tasking</td>
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<td>• Multiorbit Sensor and Route Planning</td>
<td>• Integrated Planning and Tasking of Tactical and National Assets</td>
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<td></td>
<td></td>
<td>• NRT Retasking of Sensor Plans</td>
<td>• RT Retasking and Optimization of Sensor/Route Plans</td>
</tr>
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</table>
Sensor-to-Shooter Top-Priority Technologies

- First, the Technical Framework Must Provide Rapid, Universal Access to Targeting Data Between Sensors and Shooters

- Then, the Top Priority Technologies Focus on:
  - Shooter-Focused Automated Planning/Decision Support Tools
    - Real-Time Target-Weapon Pairing
    - Real-Time Sensor-Target Pairing
  - Shooter-Focused Rapid Knowledge Enhancement
    - Automated Target Recognition
    - Integrated Fusion and Target Tracking

- Other Key Technologies of Importance Are:
  - Automated IPB Processes
  - Real-Time, Cognition Aiding Displays
  - Data Interoperability/Synchronization
  - Wideband Communications and Interconnectivity
  - Multilevel Security
  - Dynamic ISR Resource Management
Sensor-to-Shooter Top-Priority Technologies

The top priorities needed to enable the proposed sensor-to-shooter operations are as follows:

1. A technical system framework must be put in place that will provide rapid universal access to targeting data (this means target location and identification, situation awareness in the target area, and clearance to shoot). Although implementation of the Grid can clearly satisfy this priority, it is not the only solution. The requirement is for complete sensor-to-shooter connectivity and the ability to exchange data, whether these capabilities are achieved through technological development, procedural change, or some combination of the two. When this framework is ensured, the sensor-to-shooter operations concept can capitalize on the benefits of technology advances.

2. Although progress in all of the identified technologies is desirable, the Sensor-to-Shooter Working Group recognized that all 10 technologies could not be simultaneously pursued because it would not be affordable. Consequently, the working group prioritized the technologies required for achieving the critical operational capabilities, as follows:

   - Automated planning/decision support tools, such as real-time target-weapon pairing and target-sensor pairing.
   - Rapid battlespace knowledge enhancement—a combination of automated (or aided) target recognition combined with fusion and integrated target tracking technologies. Although these areas are distinct, they were combined into a single thrust area because their integrated product is the desired result. Integrating decision and tracking technologies may prove useful in addressing this area.

In both cases, the working group noted that very similar technologies exist for battle management applications. Therefore, a shooter focus must be retained with these priorities to ensure that the appropriate timeliness and responsiveness are achieved. Moreover, these capabilities must not be traded off for additional depth or breadth that may be valuable for battle managers, but are not the top priority for the shooter.
Expected Operational Impact** of Key Technologies

- Automated Weapon-to-Target Pairing
  - Dynamic Targeting Times in Minutes (Versus Tens of Minutes to Hours)
  - Enabling Weapon Launches in Under 5 Minutes
  - Resulting in Reasonable Effectiveness (30–50 Percent) Against Time-Critical Targets (Versus Current 0 Percent)

- Automated Sensor-to-Target Pairing
  - Dynamic Tasking Times in Minutes (Versus Hours)
  - Enabling Near Real-Time Info for BDA and Shoot-Look-Shoot CONOPS
  - Resulting in Substantial Increase (20–30 Percent) in Sortie Effectiveness

- Automated Target Recognition
  - Near Real-Time Target ID and False Target Rejection Through Entire Spectrum of Target Environments
  - Enabling BDA and/or Dynamic Targeting
  - Resulting in Increased Sortie Effectiveness

- Integrated Fusion and Target Tracking
  - Birth to Death Target Identification and Tracking
  - Expanding Target Windows of Vulnerability by 200–300 Percent
  - Resulting in Substantial Effectiveness Versus Time-Critical Targets (30–60 Percent)

** Based on Related Studies and Analyses
Expected Operational Impact of Key Technology Demonstrations

In operational terms, this is the expected impact of investing in the four technology demonstration areas. The format for each of the four areas is the same: first define the expected performance improvement produced through the technology demonstration, then identify the functional capability improvement enabled by the performance improvement, finally anticipate the increase in operational effectiveness resulting from the enhanced functional capabilities. Although specific analyses were not performed under the auspices of the ABIS study to develop these quantitative impacts, they do reflect an overall aggregation of the results of dozens of current detailed studies with which the Sensor-to-Shooter Working Group members are familiar. It is recommended that specific results for these technology areas be investigated through detailed studies when the overall architecture has been defined.
Key Opportunities for Near-Term Demonstrations

Execution C2

Sensors

Auto Target Recog Demo

Sensor-Target Pairing Demo

Fusion and Tracking Demo

Weapon-Target Pairing Demo

Joint Battle Management

CJTF

JFLCC

USMC

USN

JFACC

JFMCC

USA

USAF

Weapons
Key Sensor-to-Shooter Technology Demonstrations

- Automated Weapon-to-Target Pairing
- Automated Sensor-to-Target Pairing
- Automated Target Recognition
- Integrated Fusion and Target Tracking
Key Sensor-to-Shooter Technology Demonstrations

The four key technology demonstrations form key cross-service and cross-mission themes of technologies needed to resolve operational limitations (discussed previously in this section and expanded with specifics in the sensor-to-shooter appendix). As depicted in the figure, these demonstrations will enhance the shooter's effectiveness by giving the execution controller the tools and capabilities needed to enable time critical, shooter focused decisions and to execute these decisions in a joint environment.

These demonstrations take several forms. Some will be new demonstrations proposed for consideration along with other proposed FY97 ACTDs. Others will leverage off existing proposed demonstrations with endorsements and, in selected instances, expansion of scope to include both multiple services and expanded mission areas.

The key characteristics of the proposed demonstrations are that they allow tactical warfighters to address targets in parallel, and employ dynamic and fast-breaking tactical situations that will be typical of lesser regional conflicts, major regional conflicts, and contingency operations of the future.

In the proposed demonstrations, sensors will continuously input new information into battlespace awareness databases that both executing elements (shooters and controllers) and battle managers will be able to tap.

The following figures expand each of these four areas into a technology roadmap providing a candidate initial plan of action (defining each phase with target class, weapons systems, and key junctions along the critical path). Note that these roadmaps are certainly not unique—any of several approaches could have been taken to achieve the same ends. However, to fulfill the original intent of the ABIS study, at least one approach to achieve the desired ends is presented for each case to illustrate and clarify the intention of the effort.
Automated Weapon-to-Target Pairing
Technology Demonstration Roadmap

Objective: Against a Highly Mobile Target Set, Demonstrate Automated Pairing
With Weapons Systems Optimized To Destroy Ground and Air Targets

Challenges:
- Resource Allocation/Optimization
- Collaborative/Distributive Planning

Phase 1:
- Single Weapon
- Single Ground Target Set

Target: TBM
Weapon: Army ATACMS, A/C, Navy Tomahawk, etc.
ACTD: Joint
Sensor: Multiple Service and NTM

Phase 2:
- Multiple Weapons
- Multiple Ground Target Sets

Target: 240mm MRL
Weapon: Army MLRS
ACTD: Army's Precision / Rapid Counter - MRL
Sensor: UAV and NTM

Phase 3:
- Multiple Weapons
- Multiple Air/Ground Target Sets

Target: Fleeting and Dynamic Gnd/Air Targets
Weapon: Army ATACMS, A/C, Tomahawk, etc.
ACTD: Joint
Sensor: Multiple Service and NTM

Three Phases:

FY96 FY97 FY98 FY99 FY00
Automated Weapon-to-Target Pairing
Technology Demonstration Roadmap

The first recommended demonstration is Weapon-to-Target Pairing. This capability will enable the execution controller to quickly select and allocate joint force weapons that are available, can reach the target in both range and in timeliness, and have adequate lethality to achieve the commander’s intent. Because the execution controller must execute several sensor-to-shooter missions essentially simultaneously, the capability to execute against multiple target sets is necessary.

It is recommended that the demonstration have three phases:

- Phase 1—Single weapon versus a single ground target set
- Phase 2—Multiple weapons versus multiple ground target sets
- Phase 3—Multiple weapons versus multiple ground and air target sets.

The first phase is essentially the same demonstration capability planned by the Army’s Precision-Rapid Counter MRL ACTD against 240 mm multiple rocket launchers. Therefore, the primary purpose of this recommendation is to initiate early planning for logical extensions of the ACTD into joint force capabilities against multiple arrays of ground targets, followed by an extension enabling an integrated force versus both ground and air targets.
Army’s Precision/Rapid Counter—MRL ACTD

Phase 1

Guardrail

Target and BDA Reports

HTACC BCE

XX

KCOIC

Target and BDA Reports

U2/UAV

DPRK MRLs

Automatic TAC/DMAINS Application

Target and BDA Reports

MLRS

Firefinder Radar

Automatic TAC / DMAINS Application
Proposed Joint Precision/Rapid Counter—TBM TEL ACTD

Phase 2

Automatic TAC/DMAINS Application

HTACC BCE

KCOIC

Target and BDA Reports

Target and BDA Reports

FLIGHT SCHEDULED ATTACK A/C

WING OPS CENTER

AIR OPS CENTER

JFACC STAFF

Automatic TAC/DMAINS Application

ATTACK A/C

AWACS

Guardrail

U2 / UAV

DPRK TBM TELs

MLRS

Firefindar Radar

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Proposed Joint Automated Weapon-to-Target Pairing Technology Demonstration

MOEs:
- Times—for Targeting, Until Launch, Until Impact
- Lethality—Probability of Kill/Rounds Required
Automated Sensor-to-Target Pairing
Technology Demonstration Roadmap

Overall Objective: Demonstrate Simultaneous Provision of Near Real-Time Sensor Information Directly to Shooters for Assigned Targets While Maintaining Coverage of Surveillance Areas for Battle Management

Challenges:
- Decision and Estimation Theory
- Constrained Resource Allocation

Phase 1:
- Joint Service
- Single Sensor

Target: Ground Targets in Single Sensor Area of Interest
Weapon: Army MLRS & Navy Tomahawk
Sensor: UAV With SAR

Phase 2:
- Joint Service
- Single Sensor Type
- Multiple Platforms

Target: Ground Targets in Theater
Sensor: Uavs, U-2S, and NTM With SAR

Phase 3:
- Joint Service
- Multiple Sensor Type
- Multiple Platforms

Target: Fleetling and Dynamic Ground Targets
Sensor: Multiple Platforms With SAR, MTI, SIGINT, Etc.

Three Phases

FY97 FY98 FY99 FY00 FY01
Automated Sensor-to-Target Pairing
Technology Demonstration Roadmap

The second demonstration, while similar to the first, focuses on the problem of competition for sensors, that is, a Sensor-to-Target Pairing demonstration. This capability will enable the execution controller to select and allocate time slots of sensor capabilities and dedicate them, for a specific period of time, to individual missions in which shooters need current situation awareness. However, although the shooter support must be achieved in a timely manner, the impact of dynamic sensor retasking must be minimized so that the overall surveillance coverage of the target area is still achieved, thereby achieving the battle manager’s information requirements.

This demonstration is inherently a joint demonstration because all key theater sensors are joint service sensors. Therefore, it is suggested that the demonstration have three phases:

- Phase 1—Single sensor (imagery) and single platform (UAV)
- Phase 2—Single sensor type (imagery) and multiple platforms (UAVs, U-2s, and overhead assets)
- Phase 3—Multiple sensor types (imagery, SIGINT, MTI, etc.) and multiple platforms

Phases 1 and 2 include elements similar to those of several proposed ACTDs. These are strongly endorsed. However, several dimensions need to be added to address all of the relevant issues, for example, sensor pointing only versus redirecting flight paths, multiple orbit, and multiple day optimization of target information.
Auto Sensor-Target Pairing Demonstration

- **Overall Objective:** Demonstrate Simultaneous Provision of Near Real-Time Sensor Information Directly to Shooters for Assigned Targets While Maintaining Coverage of Surveillance Areas for Battle Management.

- **Phase 1:** Maximize Wide Area Surveillance Coverage of Battlefield Using Single Sensor Plus NTM, and Simultaneously Provide Imagery to Shooter Via Dynamic Sensor Retasking.

- **Phase 2:** Achieve Specific Wide Area Surveillance Coverage Objectives (75–90 Percent) of Battlefield Using Multiple Sensors of Same Type, With Dynamic Sensor and Flight Path Retasking.

- **Phase 3:** Achieve Specific Wide Area Surveillance and Target Coverage Objectives Despite Changing Target Behaviors, Using Multiple Sensors of Multiple Types With Dynamic Sensor and Flight Path Retasking.
Auto Sensor-Target Pairing Demonstration
Multiorbit, Multisensor, Plus NTM Coverage With Dynamic Retasking

Phase 1

Multiple Passes of Single Platform Repeating Orbit

No Revised Flight Pathway Points to Achieve Recce

Dynamic Retasking for Shooter

MOEs
1. Time To Achieve Dynamic Retasking
2. Time To Receive Image by Requester
3. Percentage Surveillance Achieved
Auto Sensor–Target Pairing Demonstration  
Progressive Incorporation and Integration of Sensors

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<td>EO/IR</td>
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<td>Yes</td>
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</table>
Automated Target Recognition Demonstration Roadmap

Overall Objective: Against a High Value Target Set, Demonstrate Automated Target Recognition Linked With Weapons Systems

Challenges:
- Image Understanding
- Pattern Recognition
- Interactive Recognition
- Spatial Reasoning
- Template Matching
- Model-Based Recognition
- Temporal Reasoning
- Probabilistic Reasoning

Three Phases

Phase 1: Joint DARO/ARPA/NRO/Services
- Target: TBM in open, stationary
- Weapon: Army ATACMS, A/C, Navy Tomahawk, etc.
- Sensor: FLIR, MMW SAR and NTM

Phase 2: Joint Service ACTD
- Target: TBM in open, moving
- Weapon: Army ATACMS, A/C, Navy Tomahawk, etc.
- Sensor: SAR, MMW, FLIR, EO (Prelim) and NTM

Phase 3: Joint Service ACTD
- Target: Fleeting and Dynamic Targets (TBM & Tanks)
- Weapon: Army ATACMS, A/C, Navy Tomahawk, etc.
- Sensor: SAR, MMW, FLIR EO (Initial) and NTM
Automated Target Recognition  
Technology Demonstration Roadmap

The Automated Target Recognition demonstration focuses on the problem of rapid detection and recognition of target behaviors in multispectral signature regimes. Key MOEs are the time to detect and recognize relevant targets with high probabilities of success and low false alarm probabilities. An integrated measurements and target behavior characterization program is also a requirement for building a meaningful library of target signatures that can be used at any of several nodes in the end-to-end sensor-to-shooter “kill chain.” The recommended demonstration program is focused primarily on the technology itself, not on the implementation architecture. Thus, this capability can be resident onboard sensors, at intelligence/fusion nodes, and at C2 nodes as well as with the execution controller. Depending on the theater architecture chosen for implementation, this overall capability may be distributed or centralized, parallel or serial, or any of several other alternatives. These implementation issues are not specifically recommended to be addressed in this demonstration. However, when the architecture has been selected, the technology implementation can be partitioned as appropriate.

It is suggested that the demonstration have three phases, based on complexity of target behaviors and the diversity of spectral signatures and sensors available:

- Phase 1—Temporarily stationary targets, imaging signatures
- Phase 2—Moving and stationary targets, imaging signatures
- Phase 3—Moving and stationary targets, imaging and other signatures.
# ATR Capabilities Goals and Timelines

<table>
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<th>Capability</th>
<th>1995</th>
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<th>2005</th>
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<tbody>
<tr>
<td>Surface Targets</td>
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<tr>
<td>- Large, Stationary, High Volume Target (Bridge)</td>
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<td>- Ship at Sea, or in Harbor</td>
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<td>- Unobscured Stationary Land Target, Low Clutter (Tank in Desert)</td>
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<td>- Moving Targets in Traffic</td>
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<td>- Stationary Tgt, Strong Clutter, Partial Masking, and CCD (SCUD in Trees)</td>
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<td>Wide Area Search Exploitation (HAE and ASARS)</td>
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<td>Classification</td>
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<td>Identification</td>
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</table>

Source: ISR ATR Assessment

- Technology Not Available
- Marginally Available
- Available

*User Defines Focus, Developers Define Technology Maturity*
Automated Target Recognition Imagery Problem

Year 2000
Imagery Load = 21,000 man-hrs/day
Capacity = 9,500 man-hrs/day

Sensor-Weapon Kill Chain:
IMINT Choke Points

MOEs:
- Times—To Achieve Target ID
- Percentage Targets Identified

IMINT Balance Trends
(Terapixel Capacity)

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Automated Target Recognition ATDs
Directly in Sensor-to-Weapon Kill Chain

MOEs:
1. Decrease Time To Achieve Target Identification Inside 6 Minutes for TBM TEL-Type Target
2. IDs Achieved Over Total Existing Within Delimited Search Area

Focus on:
• Limited fleeting and Dynamic Target Sets
• Delimited Search Area

Focus DDR&E's Strategic Plan on Operational Requirements
Integrated Fusion/Target Tracking Demonstration Roadmap

Objective: Demonstrate the Ability To Correlate and Fuse Diverse Sensor Information and Generate Birth-to-Death Target Tracks Spanning the Range of Target Behaviors (Emission, Moving, or Stationary)

Challenges:
- Model-Based Reasoning
- Multihypothesis Tracking
- Expert Systems
- Multispectral Decisions
- Bayesian Decision/Estimation
- Case-Based Reasoning
- Statistical Prediction/Correction
- Data Representation Structures

Phase 1: Air Targets *
- Target: Friendly and Hostile Aircraft and Cruise Missiles
- Weapon: Army, Navy, Air Force and Marine Corps Counterair systems
- Sensor: Multiple Service Radars
- Track Correlation Methods

Phase 2: Time-Critical Ground Targets
- Target: Time-Critical Ground Targets (e.g. TBM TELS)
- Weapon: Army, Navy, Air Force and Marine Corps Strike Systems
- Sensor: Multiple Service Radars, Sensors, UAVs, and NTM
- Ground Target Tracking
- Air Target Tracking

Phase 3: All Theater Targets
- Target: Aircraft/Cruise Missiles and Moving Ground Target
- Weapon: Multiple Service / Joint Service and Allied
- Sensor: Multiple Service, UAVs and NTM

Three Phases

FY97 FY98 FY99 FY00 FY01

* ABIS STS Review Designated Navy CEC as Foundation for Phase 1
Integrated Fusion/Target Tracking Technology Demonstration Roadmap

The Integrated Fusion/Target Tracking demonstration focuses on the development of birth-to-death tracks of hostile targets. Accomplishment of this capability entails correlation of tracks from different sensors of the same type and different types of sensors tracking the entire spectrum of target behaviors. A key capability is the development and maintenance of a single, unique-track ID. The Navy is already developing these capabilities for air targets through the CEC program. Consequently, these track management methods should be extended to ground targets and eventually integrated into a complete air-ground display of the battlespace by mission areas.

As illustrated in the figure, it is suggested that the demonstration have three phases:

- Phase 1—Air targets
- Phase 2—Ground targets
- Phase 3—Integrated air–ground targets.
Integrated Sensor Fusion/Tracking Demonstration

MOEs:
- Accuracy—Probabilities of Correct Correlation and Miscorrelation Total Location Error
- Timeliness—Times to Correlate, Time To Fuse
- Percentage Time That Track Is Not Maintained
## Integrated Fusion/Target Tracking Demonstration

### Suggested Phasing

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Summary

- The Key Problem Is Competition for Sensors Within the Same Coverage Area Between Battle Managers and Shooters
- The Key Solution Is Enabling Distributed Command and Control Through:
  - Automated Processing for Management of Time-Intensive Tasks
  - Common Links To Share Optimization of Those Resources
- Four High-Payoff Technology Demos To Advance Toward the Solution Identified
Study Summary

The Sensor-to-Shooter Working Group assessed precision strike, coordinated defense, and ground maneuver operations, using six combat vignettes as a mechanism to focus on the needed operational capabilities. Through this process, the working group determined that the primary problem hampering sensor-to-shooter operations is competition for sensors between battle managers and shooters. Historically, the battle manager has won this competition, leaving the shooter with inadequate information to carry out the mission effectively.

The findings of the working group indicate that the most effective way to enhance the shooter's performance is to enable a distributed command and control approach, that is, implement an execution controller. This approach will provide the shooter with the needed targeting information in the most effective manner, without inundating him with irrelevant information as would other proposals to provide the shooter with real-time imagery.

Finally, the working group recommended four high-priority areas for technology demonstrations, each of which will make the execution controller in the sensor-to-C2-to-shooter loop more effective in executing the two key operational capabilities identified—coordination of multiple missions and execution of time-critical missions. Technology roadmaps were developed for each of these four areas. Development of these capabilities will enhance the overall ability of shooters to execute the intentions of the battle commander by enabling the prosecution of more targets, faster, and more effectively, thereby shortening any hostile engagements significantly. The eventual implementation and fielding of these capabilities will be the real enduring value of these technology demonstrations.
3. Glossary
<table>
<thead>
<tr>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>ABCC</td>
<td>Airborne Command and Control</td>
</tr>
<tr>
<td>ABCCC</td>
<td>Airborne Command and Control Communications</td>
</tr>
<tr>
<td>ABIS</td>
<td>Advanced Battlespace Information System</td>
</tr>
<tr>
<td>ACTD</td>
<td>Advanced Concept Technology Demonstration</td>
</tr>
<tr>
<td>AD</td>
<td>Air Defense</td>
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<tr>
<td>AOC</td>
<td>Air Operations Center</td>
</tr>
<tr>
<td>AOR</td>
<td>Area of Responsibility</td>
</tr>
<tr>
<td>App</td>
<td>Application (usually refers to automated applications)</td>
</tr>
<tr>
<td>ARPA</td>
<td>Advanced Research Projects Agency</td>
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<tr>
<td>ATACMS</td>
<td>Army Tactical Missile System</td>
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<td>ATD</td>
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<tr>
<td>ATM</td>
<td>Asynchronous Transfer Mode</td>
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<td>ATO</td>
<td>Air Tasking Order</td>
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<td>ATR</td>
<td>Automated Target Recognition</td>
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<td>AWACS</td>
<td>Airborne Warning and Control System</td>
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<tr>
<td>B-ISDN</td>
<td>Broadband Integrated Services Digital Network</td>
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<tr>
<td>BADD</td>
<td>Battlefield Awareness and Data Dissemination</td>
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<td>BDA</td>
<td>Battle Damage Assessment</td>
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<td>BM</td>
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<td>bpp</td>
<td>Bits Per Pixel</td>
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<td>C2</td>
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<td>CEOI</td>
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<tr>
<td>CINC</td>
<td>Commander-in-Chief</td>
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<td>CJTF</td>
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<td>CMA</td>
<td>Collection Management Authority</td>
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<tr>
<td>CMW</td>
<td>Compartmented Mode Workstation</td>
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<tr>
<td>COA</td>
<td>Course(s) of Action</td>
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<tr>
<td>COE</td>
<td>Common Operating Environment</td>
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<td>CONOPS</td>
<td>Concept of Operations</td>
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<td>CONUS</td>
<td>Continental United States</td>
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<td>CORBA</td>
<td>Common Object Request Broker Architecture</td>
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<td>Database Management System</td>
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<tr>
<td>DCE</td>
<td>Distributed Computing Environment</td>
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<td>Defense Information Systems Agency</td>
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<td>DMS</td>
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<td>Defense Support Program</td>
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<td>Electromagnetic Interference</td>
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<td>EO</td>
<td>Electro-Optical</td>
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<td>FLIR</td>
<td>Forward Looking Infrared</td>
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<tr>
<td>FST</td>
<td>Fire Support Team</td>
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<td>Field Training Exercise</td>
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<td>GBS</td>
<td>Global Broadcast System</td>
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<td>Government Off the Shelf</td>
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<td>HAE UAV</td>
<td>High-Altitude Endurance Unmanned Aerial Vehicle</td>
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<td>HCI</td>
<td>Human-Computer Interface</td>
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<td>HTACC</td>
<td>Hardened Tactical Air Command Center</td>
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<tr>
<td>IAW</td>
<td>In Accordance With</td>
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<tr>
<td>ID</td>
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<td>IFF</td>
<td>Identification, Friend or Foe</td>
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<td>Imagery Intelligence</td>
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<td>Information Security</td>
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<td>IP</td>
<td>Internet Protocol</td>
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<td>Intelligence Preparation of the Battlefield</td>
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<td>ISAR</td>
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<td>ISDN</td>
<td>Integrated Services Digital Network</td>
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<td>ISR</td>
<td>Intelligence, Surveillance, Reconnaissance</td>
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<td>IT</td>
<td>Information Technology</td>
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<td>Integrated Tasking Order</td>
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<td>Information Warfare</td>
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<td>JCPMS</td>
<td>Joint Communications Planning and Management System</td>
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<td>JIC</td>
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<td>JIT</td>
<td>Just in Time</td>
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<td>Definition</td>
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<td>JPEG</td>
<td>Joint Photographic Experts Group (Standard)</td>
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<td>Joint Requirements Oversight Council</td>
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<td>JSTARS</td>
<td>Joint Surveillance and Target Acquisition Radar System</td>
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<td>KCOIC</td>
<td>Korean Command Operations/Intelligence Center</td>
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<td>LRC</td>
<td>Lesser Regional Conflict</td>
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<td>M&amp;S</td>
<td>Modeling and Simulation</td>
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<td>MASINT</td>
<td>Measurements and Signatures Intelligence</td>
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<td>MC&amp;G</td>
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<td>MILSATCOM</td>
<td>Military Satellite Communications</td>
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<tr>
<td>MLRS</td>
<td>Multiple Launch Rocket System</td>
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<td>MLS</td>
<td>Multilevel Security</td>
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<tr>
<td>MMW</td>
<td>Millimeter Wave</td>
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<tr>
<td>MOE</td>
<td>Measure of Effectiveness</td>
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<td>MRC</td>
<td>Major Regional Conflict</td>
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<td>MRL</td>
<td>Multiple Rocket Launcher</td>
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<td>MTI</td>
<td>Moving Target Indicator</td>
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<tr>
<td>NRT</td>
<td>Near Real-Time</td>
</tr>
<tr>
<td>NTM</td>
<td>National Technical Means</td>
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<tr>
<td>O&amp;M</td>
<td>Operations and Maintenance</td>
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<td>OIW</td>
<td>Operations/Intelligence Workstation</td>
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<td>OPLAN</td>
<td>Operation Plan</td>
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<td>OPSEC</td>
<td>Operations Security</td>
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<tr>
<td>OTAR</td>
<td>Over-the-Air Rekeying</td>
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<td>OTH</td>
<td>Over the Horizon</td>
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<td>PGM</td>
<td>Precision Guided Weapon</td>
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<td>POM</td>
<td>Program Objective Memorandum</td>
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<td>RDT&amp;E</td>
<td>Research, Development, Test, and Engineering</td>
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<td>Description</td>
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<td>REECE</td>
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<td>Revolution in Military Affairs</td>
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<td>ROE</td>
<td>Rules of Engagement</td>
</tr>
<tr>
<td>RT</td>
<td>Real-Time</td>
</tr>
<tr>
<td>S&amp;T</td>
<td>Science and Technology</td>
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<tr>
<td>SA</td>
<td>Situational Awareness</td>
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<td>SAR</td>
<td>Synthetic Aperture Radar</td>
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<td>SAS</td>
<td>Survivable, Adaptable System</td>
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<td>Satellite Communications</td>
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<td>Signals Intelligence</td>
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<td>SOF</td>
<td>Special Operations Force</td>
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<td>SONET</td>
<td>Synchronous Optical Network</td>
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<td>SSCN</td>
<td>Secure, Survivable Communications Network</td>
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<td>STS</td>
<td>Sensor-to-Shooter</td>
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<tr>
<td>TAC</td>
<td>Tactical Air Controller</td>
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<tr>
<td>TAP</td>
<td>Technology Action Plan</td>
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<tr>
<td>TBM</td>
<td>Theater Ballistic Missile</td>
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<tr>
<td>TCP</td>
<td>Transaction Communications Protocol (used with IP)</td>
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<tr>
<td>TCT</td>
<td>Time-Critical Target</td>
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<tr>
<td>TEL</td>
<td>Transportable Erectable Launcher</td>
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<tr>
<td>TFCC</td>
<td>Task Force Command and Control</td>
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<tr>
<td>TLAM</td>
<td>Tomahawk Land Attack Missile</td>
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<tr>
<td>TOC</td>
<td>Tactical Operations Center</td>
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<tr>
<td>TOT</td>
<td>Time Over (or On) Target</td>
</tr>
<tr>
<td>UAV</td>
<td>Unmanned Aerial Vehicle</td>
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<tr>
<td>VCJCS</td>
<td>Vice Chairman Joint Chiefs of Staff</td>
</tr>
<tr>
<td>VTC</td>
<td>Video Teleconference</td>
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4. Working Group Membership
**Co-Chairmen**

<table>
<thead>
<tr>
<th>Dr. Bruce Deal</th>
<th>OUSD (A&amp;T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPT Stephen M Soules</td>
<td>JS / J6I</td>
</tr>
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**Secretariat Representative**

| Dr. Klaus Dannenberg | Booz•Allen & Hamilton |

<table>
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<tr>
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<th><strong>Participant</strong></th>
<th><strong>Organization</strong></th>
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<tr>
<td>Maj Michael S. Balog</td>
<td>HQAF/XORC</td>
<td>Mr. James T. Holt</td>
<td>OASD (PA&amp;E)</td>
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<tr>
<td>Mr. Walter E. Boge</td>
<td>USA/EC</td>
<td>Mr. Steve Holt</td>
<td>NVESD</td>
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<tr>
<td>CAPT Dan Bowler</td>
<td>JS/J8/JNAD</td>
<td>Mr. John R. Hutto</td>
<td>HQAF/XORC</td>
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<tr>
<td>Mr. Ken Chin</td>
<td>USA CECOM</td>
<td>LTC Tony Jimenez</td>
<td>OUSD (A&amp;T) DARO</td>
</tr>
<tr>
<td>Mr. Greg Cilia</td>
<td>OUSD (A&amp;T) DARO</td>
<td>LtCol Timothy J. Knutson</td>
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<td>MAJ Raymond E. Coia</td>
<td>HQMC/C4I</td>
<td>Mr. Peter Krueger</td>
<td>DMA (ATSS)</td>
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<tr>
<td>COL Ray Cole</td>
<td>JS/J8/JWAD</td>
<td>Mr. Vincent Mazzola</td>
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<tr>
<td>LCDR Chris Cook</td>
<td>USN/N6C</td>
<td>RADM (ret) Charles McGrail</td>
<td>Johns Hopkins/APL</td>
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<tr>
<td>Mr. Mark Coy</td>
<td>USA CECOM</td>
<td>Mr. Joseph J. Palermo</td>
<td>USAF/Rome Labs</td>
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<td>LTC John Dunham</td>
<td>USA/DASA BL</td>
<td>CDR Linda Paul</td>
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<td>Mr. Anthony Garret</td>
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<td>Mr. Robert Stoddert</td>
<td>Booz•Allen &amp; Hamilton</td>
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<td>Johns Hopkins / APL</td>
<td>Maj Xavier Streeter</td>
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<td>USA/DAMO-FDJ</td>
<td>Mr. Robert J. Tarcza</td>
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<td>LtCol Joseph Hawkins</td>
<td>JS/J2</td>
<td>Dr. Anne Vopatek</td>
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<td>LTC Robert J. Hepp</td>
<td>HQDA SAIS-C4I</td>
<td>Mr. William Watkins</td>
<td>ARES</td>
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<td></td>
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<td>Maj Dick Wright</td>
<td>DMA (ATCF)</td>
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</table>
Sensor-to-Shooter Working Group Participants

To achieve the objectives of the ABIS Sensor-to-Shooter Working Group, a balance was needed between operators and technologists. The operators needed vision to consider new, "out of the box" ways of prosecuting combat objectives, while the technologists needed to be able to understand the real operational issues. The resulting working group membership included operators and technologists from all of the military services.