# STANDARDS RELATED DOCUMENT

# AEP-82.1

# GUIDELINES FOR THE INTEGRATION OF WEAPONS ON UNMANNED PLATFORMS

**EDITION A VERSION 1**

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**NORTH ATLANTIC TREATY ORGANIZATION**

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## 1.0 INTRODUCTION

1. Weapons have been deployed by various nations and to a greater extent tested, on Unmanned Aircraft Systems (UAS) since the 2001 deployment of armed Predators in Afghanistan. While these weaponised UAS have proven to be highly effective, to date only relatively few weapons have been integrated on UAS. Five major factors limiting the broader development and production of weaponised UAS are:

a. The unique design challenges associated with these systems;

b. The size and weight of current weapons;

c. The issues of integrating the operation of unmanned systems both with manned military forces and operations in civilian airspace;

d. The high costs currently associated with armed UAS design and development; and

e. The lack of political will to introduce unmanned weaponised platforms into armed forces.

2. The most significant design challenges faced in developing armed UAS are related to ensuring system safety. While safety issues have been resolved for manned aircraft, UAS do not have the on-board crew oversight of the platform and weapon utilization. Physical safety mechanisms (crew activated hardwired switches) must be replaced with ground controller decisions which are then processed by software on the ground, relayed by data link to the UAS and again processed by software on the UAS to initiate weapon activation and deployment. Measures and equipment must be developed and certified which will enable safe operation of armed UAS.

3. Operational suitability must be managed to make armed UAS more broadly useable, exchangeable, understandable and acceptable among military forces and civilian airspace users and airworthiness authorities. Integrating the operations of manned and unmanned systems brings additional challenges to achieve the best effects in the field while minimizing investment. These challenges can be mitigated by developing common standards for UAS which ensure the interoperability of these systems with other UAS and manned platforms.

4. Costs associated with developing, integrating and certifying armed UAS is currently high in large measure due to a lack of standardisation between the various UAS. Each developer or weapon integrator generates systems with proprietary interfaces and architectures. Thus, employment of a single weapon type on different UAS platforms necessitates expensive weapon integration programs for each aircraft type. By developing North Atlantic Treaty Organisation (NATO) standards for UAS weapon interfaces (including UAS Control Station (UCS) to

Platform and Platform to Weapon) a single integration activity (for each weapon type) should demonstrate most of the integration requirements for all other UAS following, given that the standards have been satisfied. This will go a long way in reducing both the time and cost for weaponising UAS. The operational capability of armed UAS will also broaden as additional nations integrate weapons on more existing and developmental UAS.

## 1.1 BACKGROUND

1. Armed UAS standards will be aligned with existing standards for UAS and aircraft. Weaponising unmanned systems is an added capability, similar to equipping an attack aircraft for reconnaissance or adding surface attack weapons to a maritime patrol aircraft. The addition of weapons presents challenges. In engineering terms the challenges can be identified and met through the definition of nodal exchanges of data.

2. Several aspects of Unmanned Aircraft (UA) require changes to the assumptions made for arming manned aircraft. The most prominent is that, although there is a “man in the loop” there is no one located on the weapon launch vehicle who can initiate or acknowledge the decision to launch the weapon. Relevant information upon which to base decisions and actions must be relayed off board to the ground control station. Then, the decisions and actions themselves must be relayed back to the UAS. It is expected that, as is the case with manned aircraft, due to current operational doctrine, Law of Armed Conflict and Rules of Engagement (ROE) constraints, fully automated weapons release by UAS on identified or self-detected targets is not expected, though elements of autonomy may play a role (e.g., adjustment of a release point based on existent winds in the target area). As a minimum, the capability for “man in the loop” to intervene and prevent weapon release will need to be maintained. Another factor that is new for aviation ordnance on UAS is that the smallest UAS are much smaller than any manned aircraft, and may drive requirements for smaller physical interfaces and smaller ‘smart’ weapons than have been used on manned aircraft.

3. Today’s cruise missiles and precision weapons can fly extended profiles to the target and in some cases can be reprogrammed in flight for options not even considered at launch. The doctrinal and operational issues associated with the remote control of weapons in these precision strike systems demonstrate that unmanned warhead employment can be accomplished and the operational mission development process can be replicated for an object that serves as a launch platform, that is remotely operated and that can be returned to an operating base.

## 1.2 PURPOSE

This document:

a. Reviews Weapon System Architecture and concepts for armed manned aircraft;

b. Identifies the functional and organizational structure of a joint, coalition force employing armed manned aircraft in support of various missions and the associated operational doctrine as specified in the applicable Allied Joint Publications (AJPs);

c. Identifies the expected impacts of using armed UAS in support of the joint coalition missions in lieu of and/or in conjunction with armed manned aircraft, including impacts on current operational doctrine; and

d. Provides information on weapon integration on and operations of manned platforms which can be useful to the integration of similar weapons on unmanned platforms.

## 1.3 SCOPE

Although the operational and safety issues may apply to different weapon types (e.g., directed energy, kinetic energy, etc.), the focus of this document is only Air-to-Ground Kinetic Effects weapons.

## 1.4 WEAPONISATION SPECIALIST TEAM (WST) OBJECTIVES

1. Identification and description of armed UAS interfaces is basic to the objective/purpose of this Weaponisation Specialist Team (WST). Participation and cooperation by nations and industries as well as NATO organizations such as NATO Industrial Advisory Group (NIAG), Allied Command Transformation (ACT), Research and Technology Organisation (RTO), Joint UAS Panel (JUASP), and others provide a balance and scope of experience that will allow the evolution of weapons deployed from UAS to become more widespread, rapid and affordable. Key to this future is a transition from proprietary design, development and integration, into the use of standardised weapon interfaces on UAS. Demand for systems using NATO standard interfaces should be greater, allowing NATO and NATO member nations to field them at the rate and at the number to meet the commitments required and expected for NATO forces. Development of these systems should be accompanied by development of related military organization, tactics, techniques and procedures so that they can be fielded as more powerful, valuable tools in the hands of operationally integrated and qualified operators and planners.

2. The Objectives of the group will be accomplished through the following actions:

a. Recommend changes as appropriate, to applicable requirements documents for the use of weapons on UAS, in conjunction with the NSO;

b. Identify interfaces that are critical in the targeting-to-weapon release chain for UAS;

c. Define the sets of technical standards to support the weapon's employment process from mission planning to weapon delivery;

d. Identify interfaces that are not being addressed and recommend solutions when possible; and

e. Identify and coordinate with other NATO authorities for interfaces outside of JCGUAS.

3. In line with NATO's plan for transformation, the weaponisation of UAS must be underpinned by a comprehensive pan-NATO logistics system.

## 1.5 INTERACT WITH GROUPS AND STANDARDS

There are several groups in NATO related to the process of placing weapons on aircraft. These groups and the standards they sponsor are a basis to advance armed UAS and to determine how the UAS may emulate the progress of those groups and standards. NATO Universal Armament Interface (NUAI) is an example of the type of information from manned aircraft that will be useful in developing a similar capability for UAS. In order to facilitate interoperability, whatever information or standards that are used, should be available to everyone and be as open as possible.

### 1.5.1 Industry

1. At the request of JCGUAS, the NATO Industrial Advisory Group (NIAG) approved and initiated a study via Study Group 125 (S/G 125), to:

a. Develop a common domain model, for a weapons-equipped UAS;

b. Identify all Interface Exchange Requirements (IERs) between the system nodes, for example, external command and control (C2) system, the mission planning system, UAS Control System (UCS), the UA/weapon, etc.; and

c. Recommend a weaponised UAS Architecture in the form of generic operational views and system views.

2. The study gave consideration to architectures supporting NATO network enabled capability (NNEC) for UAS and recommended one that best supports the NNEC "vision" and at the same time is compatible with STANAG 4586 architecture and requirements.

3. The WST worked very closely with S/G 125 during the course of the study to ensure that the study supports and addresses the appropriate military missions and the corresponding concepts of employment/employment principals. The study results and recommendations were reviewed and as appropriate incorporated into this technical report.

### 1.5.2 NATO Organizations

1. NATO Air Force Armaments Group (NAFAG) Aerospace Capability Group 2 (ACG 2), on Effective Engagement, is developing an NUAI defining a standard interface (based on US Universal Armaments Interface (UAI), Miniature Mission Store Interface (MMSI)), between an air platform and its weapons. To ensure that the efforts of the WST in defining the interfaces and interface exchange requirements between the various nodes involved in the targeting and weapon release process are compatible with and supporting of the NUAI interface, close working

relationship and information exchange was established and maintained with ACG 2 during the course of this study.

2. The Joint UAS Panel (JUASP) was the organisation that represented the NATO Strategic Command Nations (operational forces) who would be the employers of weaponised UAS. To ensure that the operational users' requirements and concepts of employment were supported, a close working relationship and open information exchange policy with the JUASP was established.

3. NSA Air Armaments Panel (AAP) develops standards in the area of air armaments. It includes aircraft conventional stores and associated equipment such as guns, ammunition, bombs, rockets, missiles, cartridges, pyrotechnics, fuses and arming systems. The focus of the group is on interface standards. Liaison between the WST and the AAP was established and is important in order to ensure that all pertinent standards under AAP jurisdiction were taken into consideration in defining the weaponised UAS architecture and in the definition of IERs.

4. NATO Naval Armaments Group (NNAG), Joint Capability Group on UAS (JCGUAS), has developed and maintains an interface standard for UAS Control Systems (UCS), STANAG 4586, which specifies the UCS architecture and interfaces between the UCS and the UA, UCS and external Command, Control, Communications, Computers and Intelligence (C4I) nodes and UCS and the UAS Operators. This standard will need to be updated in order to incorporate the weapons related IERs into the UCS interfaces. Thus, close working relationships and participation of STANAG 4586 technical personnel was established and continued interface between the WST and STANAG 4586 Custodian Support Team (CST) is critical in the weaponisation effort.

### 1.5.3 NATO Nations

To ensure that all member nations' requirements were addressed, interface with national representatives, empowered to "speak" for the nation was required. All nations of JCGUAS were invited and encouraged to participate in this effort. National participation and input continued to be solicited throughout this effort.

## 1.6 ORGANISATION OF REPORT

1. As described in Section 1.4, the objective of the WST is to serve as the body responsible for identifying the differences that exist, or may exist, between employment of weapons from manned and from UA. Based on this evaluation, an objective is to help identify requirement documents which may require changes and identify interfaces that are critical for the use of weapons on UAS.

2. The structure of this document echoes the team objective by first reviewing manned platforms in terms of: a) System Descriptions; b) Joint Operational Structure; c) System Architecture (Hardware/Software); d) System Operations; and e) Safety Implementations. This review is presented in Section 2, and where there is commonality between manned and unmanned platforms this is noted along with the descriptions.

3. Section 3 of the report concentrates only on those items/issues for armed UAS

which differ from the approach for armed manned aircraft and which also differ from the approach for unarmed UAS. For example, firing commands for a weapon on a UAS must be transmitted up the data link from ground control to UA. This necessitates that the data link must be secure so that weapons cannot be operated by unauthorized entities. Issues regarding the security of the data link have already been addressed for unarmed UAS to prevent unauthorized entities from taking control of the UA itself, and the addition of weapons to the UAS may not necessitate changes to already existing requirements.

4. An overall armed UAS architecture including a Common Domain Architecture (CDA) and associated IERs for arming UAS was developed and reported on by the NIAG-125 SG. Goals of this architecture included developing standards for weaponised UAS with the aim of reducing proprietary system designs and thereby enhancing system interoperability with reduced development time and acquisition costs. A summary of the key findings of this group is presented in Section 4 of this report.

5. Section 5 is concerned with lessons learned from applicable trials and demonstrations. This section will be promulgated as trial results become available. Section 6 is recommendations derived as a result of this technical document. Annex 1 contains supplementary information on manned aircraft doctrine and employment. It is meant to complement Section 2. Annex 2 details the IERs derived from the various domain models and their interactions concerning the weaponisation of UAS.

| Chapter 2 | WEAPON SYSTEM CONCEPT AND ARCHITECTURE FOR MANNED AIRCRAFT |
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## 2.0 OVERVIEW

As illustrated in Figure 2-1, the key element of the weaponised manned platform is the human operator on the aircraft who monitors the weapon status, controls the weapon states and initiates the power up and launches sequences. He initiates all of the critical actions in the sequence from powering up the weapon to weapon release. Thus he is the “strong link” in the resultant weapon safety chain of the weaponised manned platform system. All of the other elements (e.g., stores management system and the

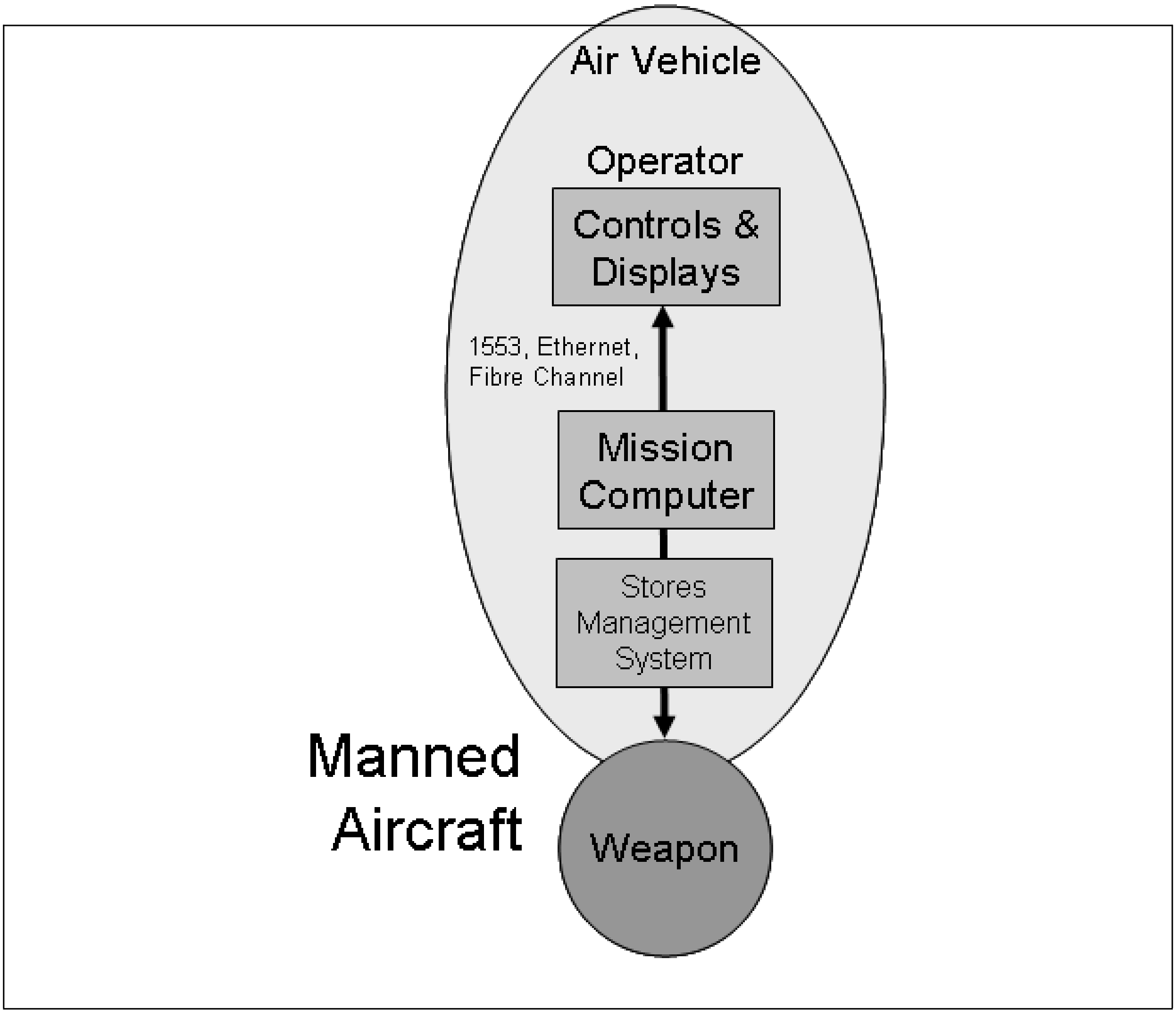


**Figure 2-1: Weaponised Manned Platform Architecture**

Weapon), including their respective interface standards, are potential candidates for use in an unmanned platform.

## 2.1 SYSTEM DESCRIPTION

### 2.1.1 Stores Management on Manned Aircraft

1. This section describes weapon management techniques used in current manned aircraft. It should be noted that although the general principles of weapons management are the same for most aircraft types, each aircraft type often has slightly different implementations from other aircraft. Similarly, the terminology used with each aircraft type may well differ. The following description is therefore a generic description of operation and should not be taken as the definitive method by which all weapons are operated on current aircraft.

2. Aircraft contain many systems designed for specific tasks, such as the flight control system, navigation system, sensor system, and for store control, a store management system (SMS). The SMS may be used to control stores that may or may not be weapons. The SMS will control power, data and commands exchanged between the aircraft and stores, as well as controlling the jettison or launch of stores. The commands associated with jettison and launches are under the executive control of the aircrew in order to provide an additional level of safety. In addition to the software controls, the aircrew uses discrete switches that either permit or carry out discrete safety-related functions. Typically, these are:

a. Master Arm Safety Switch (MASS): This is a panel-mounted hardware switch operated by the aircrew that isolates the electrical power used to deploy weapons. Typically the switch will have three positions: off, standby and on. In the 'off' position, no power is applied to the carriage stations. In the 'standby' position, power is applied to the station but functionality will be restricted to mission preparation activities such as mission data loading and alignment of the weapon's navigation system. Setting the MASS to 'on' enables full carriage station and weapon operation, including launch and where applicable, jettison. The switch is usually set to 'on' immediately prior to the aircraft taking off, as power to the carriage station equipment is essential to enable the rapid jettison of stores should an emergency arise during take-off. Delaying the setting of MASS to 'on' until the aircraft is at the end of the runway minimises the risks of hazards to ground crew, other aircraft and airfield infrastructure. Once enabled, the MASS is maintained in the 'on' state until after the aircraft lands. Note: There is no single description of a MASS which is applicable to all platforms. For example, some platforms utilize a switch which incorporates only Arm and Safe positions (i.e., on and off). The intention here is to display hardware functionality.

b. Late Arm/Master Arm: This is a switch that is enabled in flight a very short time before launching a weapon and is usually used to enable the SMS to provide electrical power to the store for use in safety or mission critical functions such as the firing of thermal batteries. A typical implementation of the Late Arm switch is a micro-switch operated by lifting the cover over the fire button on the pilot's control stick, such that the time interval between Late Arm 'on' and firing the weapon can be minimised.

c. Fire Button Press: This is the switch, usually operated by the pilot, which results in the SMS initiating the irreversible actions that result in weapon separation from the aircraft. The method of achieving separation can be either by the carriage system releasing or ejecting the weapon downwards, or by the weapon firing a motor that pushes it forwards along a rail.

3. In summary therefore, power may be applied to the weapon at any time prior to the MASS being set to 'on' for such mission critical actions as self-test, mission data loading and navigation system alignment. The MASS is set 'on' just before the aircraft takes off and will stay on until the end of the flight. Immediately before weapon launch, the pilot will switch Late Arm 'on', followed shortly after by pressing the Fire Button. The time interval between pressing the Fire Button and physical separation from the aircraft is system dependent and will range typically between 750 milliseconds and 4 seconds.

### 2.1.2 Safety Considerations of Weapon Operation on Manned Aircraft

1. In addition to the discrete crew-operated controls described above, system operation of complex weapons will be dependent upon the exchange of information, commands and signals between the aircraft and store, usually transferred by means of software-controlled data buses. Although software and data buses can be designed to provide extremely high integrity data transfers, the safety authorities usually require the system to have an element of crew control over safety critical actions such as weapon launch. To this end, it is normal for the SMS and weapon design to be such that any safety critical action commanded over a data bus cannot be carried out unless the aircrew has operated the requisite switches. The switches involved in weapon release are monitored by software and it is the system which controls the actual weapon release. The aircrew has executive authority.

2. Inherent in weapon system operation is a need for both the aircraft and weapon to be able independently to identify that the system is operating outside of design limits. An example of this would be that having signaled its readiness for launch, the weapon does not sense ejection from the aircraft within the specified time window and the aircraft also senses that the weapon remains on the aircraft. The aircraft is required to do what it can to render the weapon safe, such as removing power from both it and the launcher and if necessary, enable the crew to jettison the weapon. The store should render itself as safe as possible, by removing internal

power from subsystems and disabling any transmitters, actuators or pyrotechnic devices.

### 2.1.3 Weapons on Manned Aircraft

NIAG Subgroup 97 completed the Aircraft, Launcher and Weapon Interoperability-Common Interface (ALWI-CI) study in November 2006. This study is divided into four volumes and presents a path to achieving interoperability for weapons on manned aircraft. UAS were not a specific consideration during the conduct of the work but the project showed the way ahead for interoperability of weapons on manned aircraft. These premises provide a basis for planning for armed UAS. This section will review the principals as they affect the design for arming manned aircraft. Volume I of the study outlines the technical architecture while Volume II discusses the common services for aircraft, launcher, and weapons interoperability as well as interoperability with the NATO C3 systems. Volume II recommends a methodology based on the Object Management Group (OMG) Model Driven Architecture (MDA) philosophy. Volume III discusses interoperability using common interface control documents and configuration data files, which is the methodology followed by the U.S. Air Force with the Universal Armament Interface. Finally, Volume IV outlines how MDA based specifications can be implemented in air platform architectures. Figures 2-2 and 2-3 illustrate a potential inventory of weapon types and their respective aircraft interface standards. It should be noted that MIL-STD 1760 is an existing, widely used standard, MMSI (Miniature Mission Store Interface) has been issued by SAE as interface standard AS-5725 and IMM (Interface for Micro Munitions) has been issued as interface standard AS-5726.

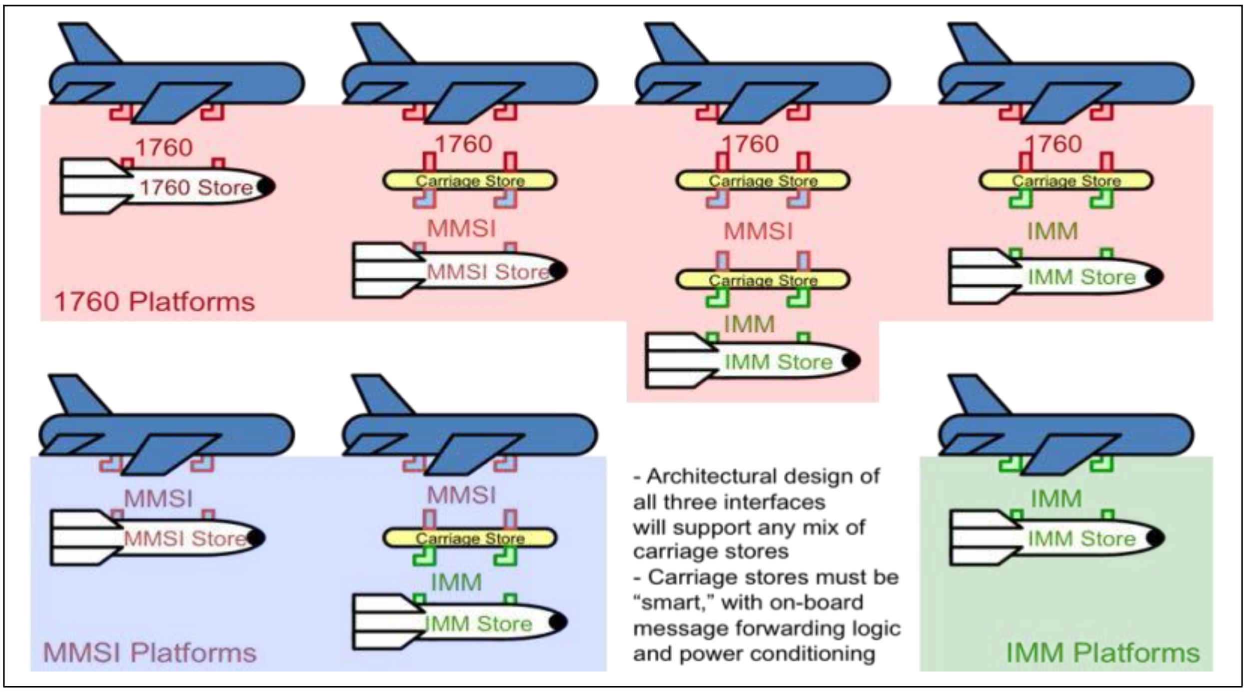


**Figure 2-2: Examples of Compatible Weapons**

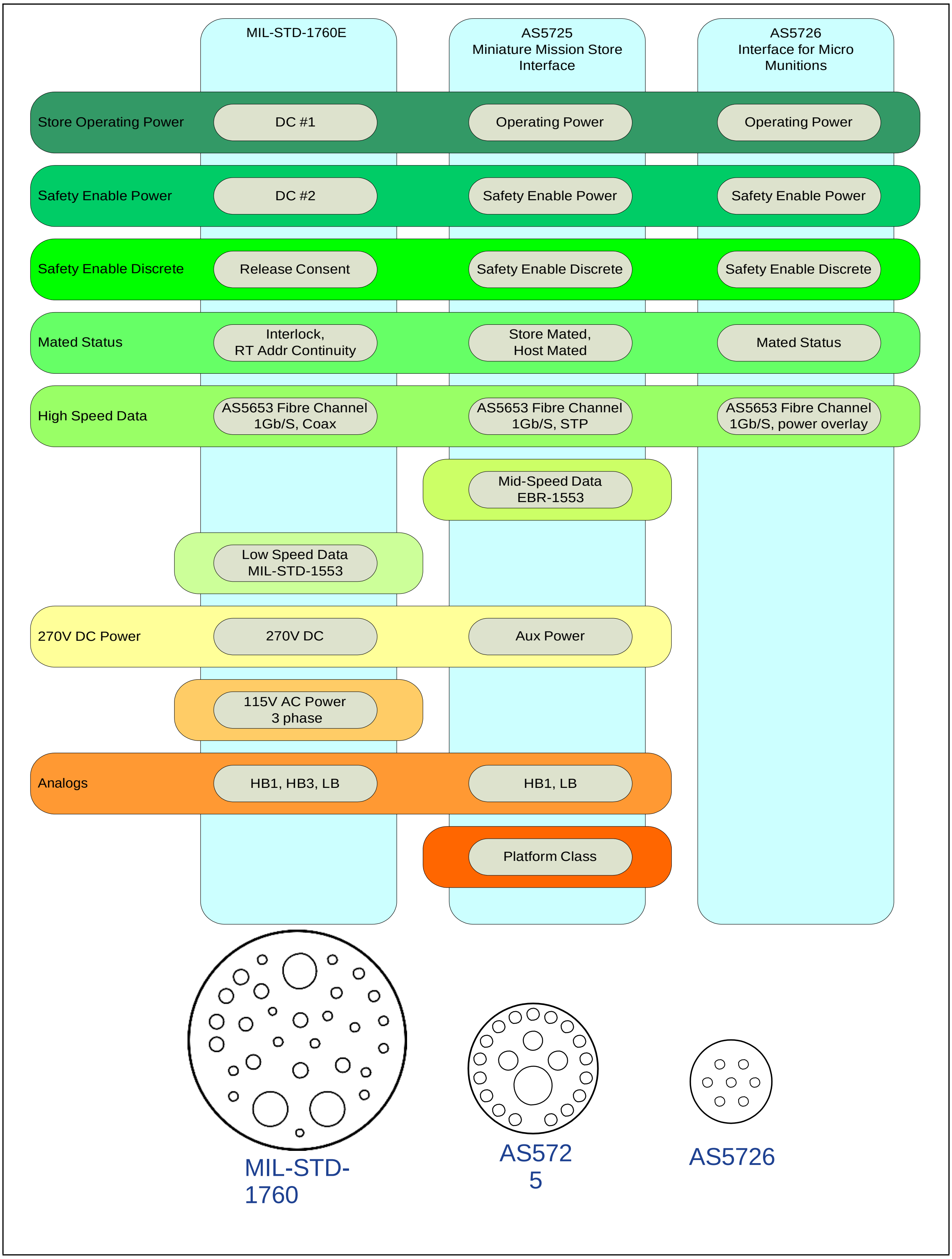


**Figure 2-3: Examples of Compatible Weapons**

## 2.2 JOINT CAMPAIGN/OPERATIONS STRUCTURE

Armed/Combat manned platforms support multiple missions in support of Joint Force Commander's (JFC) objectives. These missions are performed in accordance with established doctrine and specific Tactics, Techniques and Procedures (TTPs) and ROE established by the JFC. Annex 1 provides an overview of the current NATO doctrine as documented in Allied Joint Publications for Joint Air Operations.

## 2.3 JOINT TARGETING

1. Joint targeting is a function within the military decision-making process that supports joint operations planning and execution. Targeting must be focused on creating specific effects in order to achieve the Joint Commander's objectives or the subordinate component commander's supporting objectives. Joint targeting matches joint objectives, guidance and intent with inputs from each component and staff function to coordinate required forces and effects. The Joint Commander will, with the advice of Component Commanders, set priorities, provide targeting guidance and determine the weight of effort to be provided to various operations.

2. Annex 1 provides an overview of current NATO Joint Targeting as documented in AJP-3.9.2.

## 2.4 WEAPON SYSTEM DOCTRINE

1. This section outlines the employment of manned attack aircraft in the air-to-surface roles of tactical air support and indirect air support. Tactical air support refers to air operations carried out in coordination with surface forces and which directly assist land or maritime operations. Indirect air support refers to support given to land or sea forces by air action against objectives other than enemy forces engaged in tactical battle. It includes the gaining and maintaining of air superiority, interdiction, and harassing. The employment of tactical air support and indirect air support enables NATO forces to shape the close, deep, and rear battlespace in order to create opportunities for decisive action, restrict the enemy's freedom of action, disrupt the enemy's cohesion and operational tempo, and facilitate the achievement of our objectives. The successful employment of tactical and indirect air support normally requires effective targeting, target marking, and weaponeering.

2. Annex 1 provides an overview of manned attack aircraft in support of tactical and indirect air support missions.

## 2.5 ARCHITECTURE

### 2.5.1 Hardware/Electrical Standard Interfaces – Weapon-to-Platform

Weapon-to-Platform Hardware/Electrical interfaces have been defined in the following published standards: MIL-STD-1760, Miniature Mission Store Interface (SAE AS-5725), and Interface for Micro Munitions (SAE AS-5726). Summary descriptions of these interfaces are provided in Annex 1.

### 2.5.2 Messaging Standards – Weapon-to-Platform

1. All three physical interfaces above share a common core logical interface. All support MIL-STD-1760's command/response protocol, in which the store responds to the platform for every communication, whether it is receiving instructions from the platform, or being directed to supply information to the platform.

2. All interfaces include two basic data transfer formats; a common set of discrete messages consisting of up to 29 16-bit words, and the capability to transfer files, such as mission planning data.

3. Because of the point-to-point data connections in MMSI and IMM, intelligent processors are needed at an intermediate stage if IMM or MMSI are carried subordinate to a larger interface. These intermediate stages, most commonly carriage systems, must act as the subordinate to the higher-level interface, and then relay the messages or files, acting as the superior to the store at the lower-level interface. Figure 2-2 above shows the architectural flexibility of this capability.

4. MIL-STD-1760, including its reference to MIL-STD-1553, defines the basic format for discrete messages, over the 1553 bus that 1760 defines as its primary weapon control interface. 1760 also specifies a 1553-based protocol for "mass data transfer" of files using 1553 messages. 1760 references the Fibre Channel protocol for transferring files over the Fibre Channel interface. Finally, 1760 defines a purpose and content for six of the 32 separate messages that can be defined and 'reserves' four of the 32 words for specific uses outside the scope of normal tactical weapon employment, without defining their specific content.

5. Historically, each weapon defined the content and use of the other 22 messages. In most cases, to save money on aircraft integration, later weapons exploited the integration of earlier weapons and used all or part of their messages where convenient. As a result, for very common activities such as transfer alignment of a weapon's inertial navigation system or loading a GPS receiver's almanac and ephemeris information, virtually all weapons shared entire or nearly entire common messages.

6. It was in this environment that senior USAF leadership decided to bring integrators together from weapon and platform programs to develop a message-level weapon interface that could be universally applied across all new weapons that

shared functionality with existing weapons, calling the effort Universal Armament Interface.

7. Annex 1 provides an overview of logical message transfer protocols and data transfer across the weapon to platform interface.

## 2.6 MANNED AIRCRAFT WEAPONISATION SAFETY

In order to meet the agreed to national safety and weapon related requirements, NATO member nations agreed to develop weapons and their platforms in accordance with applicable standards called STANAGs. The applicable standards dealing with Weapons Safety are identified and discussed in Annex 1. This Annex includes NATO standards and standards from those nations who provided their national system safety and airworthiness documents.

| CHAPTER 3 | ARMED UAS CONSIDERATIONS |
|---|---|

## 3.0 OVERVIEW

1. As illustrated in Figure 3-1, the major elements (e.g., stores management system and the weapon, including their respective interface standards) are the same or similar to the manned platform, as illustrated previously in Figure 2-1. In an unmanned system however, the human operator is remotely located and his functions must be implemented in one of the UA subsystems (e.g., ground station, data link, and stores management systems).

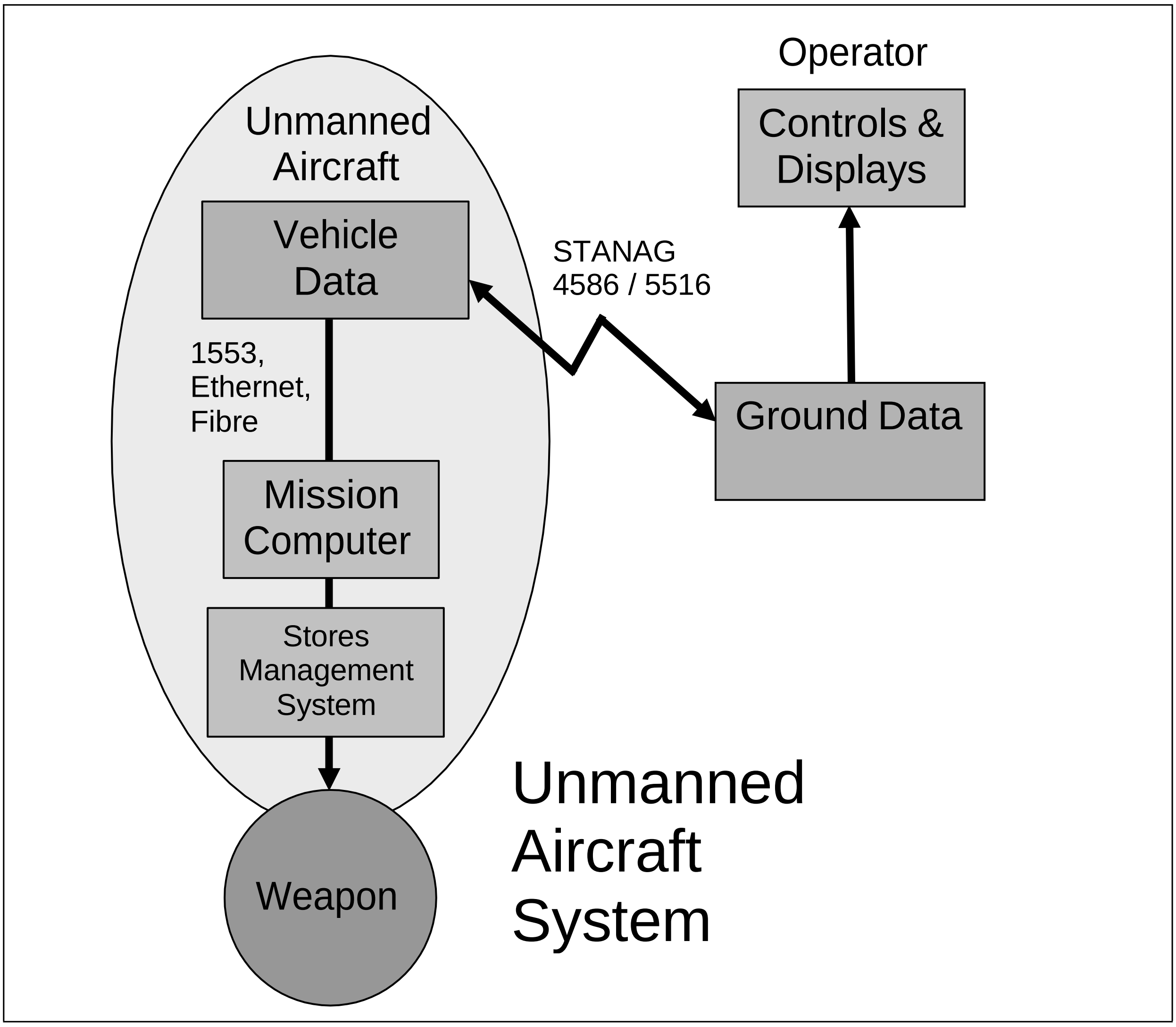


**Figure 3-1: Weaponised Unmanned Platform Architecture**

2. This section will describe the differences between the manned functions and data requirements as stated in Section 2, and unmanned functions and data requirements. Specifically, this section will discuss any of the UAS unique data element definition and processing requirements.

## 3.1. SYSTEM DESCRIPTION

Refer to AEP 82.

## 3.2 JOINT CAMPAIGN/OPERATIONS STRUCTURE

UAS operate under the same NATO command structure and doctrine as that for manned aircraft described in Section 2.2.

## 3.3 JOINT TARGETING

UAS operate using the same Joint Targeting strategies, processes and doctrine as that for manned aircraft described in Section 2.3.

## 3.4 WEAPON SYSTEM DOCTRINE

### 3.4.1 Concept of Employment

1. The concept of employment of the armed UAS will follow the established path of tactical reconnaissance and time-critical targeting execution. When required, the mission crew may coordinate directly with airborne C2 and strike aircraft, providing verbal “talk-ons”, laser target marking and designation as required for strike support. The crew may also provide immediate or revisited post-strike assessment. Combat assessment from on-board sensors may be simultaneously broadcast to all echelons of command for further exploitation. Armed UAS may be able to provide below-the-weather support for strike aircraft operating above or vice versa. Armed UAS will also be able to independently attack UAS detected targets of opportunity within their designated engagement area. The combination of sensor and shooter in a single platform, coupled with high-speed, machine-level data links and appropriate C2, will provide for rapid capability to engage TSTs.

2. Future employment growth options include missions throughout the full spectrum of conflict. In low intensity conflicts like Military Operations in Urban Terrain (MOUT), they will leverage their long endurance loiter and sensors that provide persistent presence and intelligence collection, with weapons adding quick reaction attack capabilities in support of theatre commander objectives. These aircraft could also be employed for limited precision strikes in support of national or theatre objectives when directed as a show of force or retaliation. Finally, armed UAS will employ sensors and weapons in support of missions across the range of roles during medium-to high-intensity operations; particularly where their greater survivability and lack of pilot will give them greater freedom to attack heavily defended targets. Roles may also include both offensive and defensive counter-air with flights of aircraft flying in mutual support. In politically constrained conflicts, the video dissemination

structure will permit timely decisions on the use of force by transmitting real time video and preliminary identification or validation of a target to appropriate levels of command with compatible signal reception equipment.

3. Regardless of the weapon type, special considerations may be given to developing procedures and mechanisms for the safe recovery of armed UAS; i.e. the automated or man-in-the-loop landing of UAS armed with live munitions.

#### 3.4.1.1 UAS Use Cases

In order to analyze the role of a UAS in performing missions, a set of Use Cases was developed. A Use Case is a methodology used in system analysis to identify, clarify, and organize system requirements. The Use Case is made up of a set of sequences of interactions between systems and users in a particular environment and related to a particular goal. A Use Case can be thought of as a collection of possible scenarios related to a particular goal, and in this case, the scenarios represent different methods to perform any of the above missions. The Use Cases shown below can be combined in different ways that will allow the performance of the stated missions. The Use Cases also show the minimum number of nodes necessary to achieve the information exchange.

##### 3.4.1.1.1 Pre-Planned Targeting

1. The Use Case presented in Figure 3-2 represents the most basic targeting scenario. A higher tasking authority, such as the CAOC, will prepare a complete mission plan for the UAS. It will include route information (i.e., waypoints, altitude, speed, timing); emergency divert information; target information (i.e., position, selected weapon); weapon information (i.e., fusing, internal parameters, codes); and data link information (i.e., channels, frequencies). If a UAS Control Station (UCS or Core UCS (CUCS)) has a mission planning capability, an ATO and ACO can be relayed by the CAOC and the local UCS will complete a mission plan.

2. The Control Station personnel will insure the plan contains all the information needed for execution and, if necessary, will update the plan with missing or local environmental parameters. The mission plan will then be loaded into the UAS. This plan could be loaded via a Radio Frequency (RF) link, hard wire, or a separate data media (e.g., “brick”, card, or disc). After start up on the ground, the UAS and weapon will periodically exchange messages throughout the mission. Platform/Weapon interface messages typically contain alignment, environmental, and moment arm information.

3. During ingress to the target, the UCS receives weapon status information as well as UAS position and state data. When the UAS/weapon, or the UCS, determines that it is within its Launch Acceptability Region (LAR) it will notify the operator that the release window is open. The man-in-the-loop (MITL) on the ground will initiate the launch sequence and release the weapon.

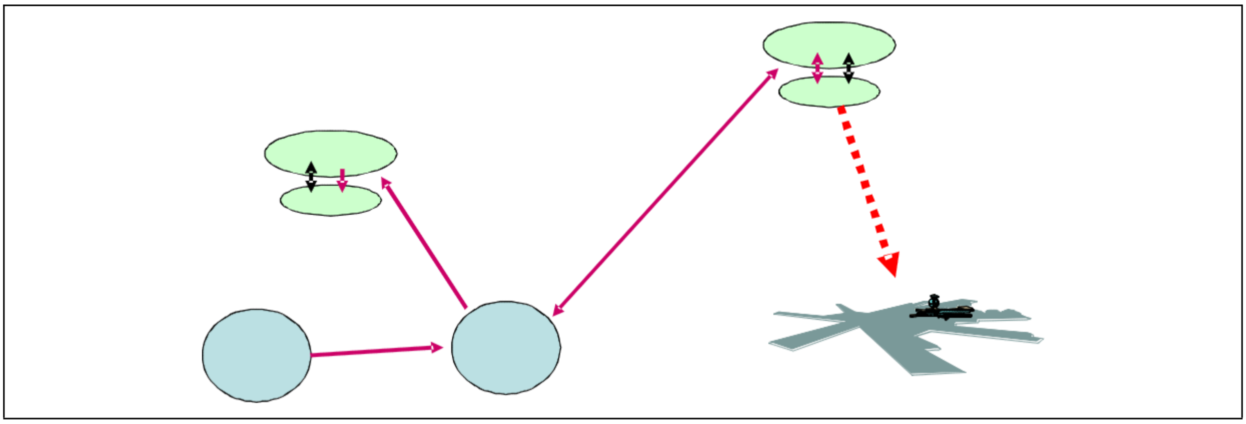

**Figure 3-2: Pre-Planned Targeting**

### 3.4.1.1.2 Re-Tasking During a Mission

1. A major variant to the situation presented in Figure 3-2, is the case where a new target is being assigned during a mission. In Figure 3-3, the initial mission plan is loaded into the UAS, which takes off for its original target. During ingress, a War-Fighter in the field identifies a high threat target and requests that the UAS be re-tasked to remove the threat.

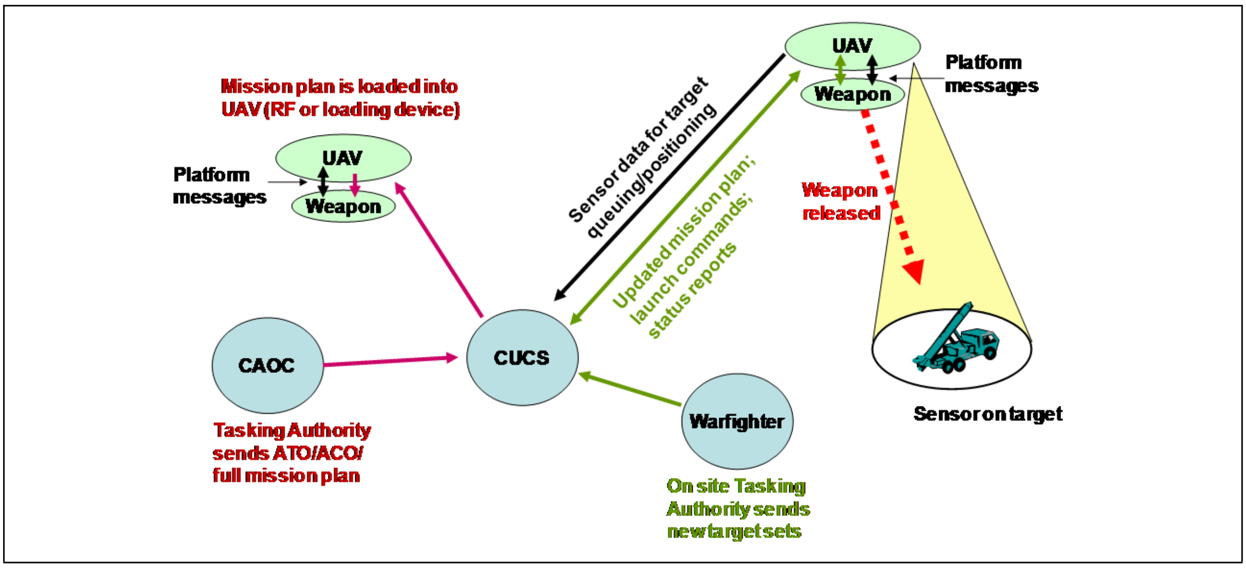


**Figure 3-3: Re-Tasking**

2. The personnel at the UCS update the mission plan with the new target coordinates and revised navigational routing. Updated target information is further corroborated and refined using on-board sensors. Updated segments of the mission plan are relayed to the UAS to update the weapon.

3. When the UAS/weapon or the UCS determines that it is within its LAR it will notify the operator that the release window is open. The MITL on the ground will initiate the launch sequence and release the weapon.

#### 3.4.1.1.3 Targets of Opportunity

It is expected that a great number of missions will involve some form of armed reconnaissance without pre-planning specific targets. Figure 3-4 is an example of this situation. A mission plan is still loaded in the UAS, probably without target locations. The UAS is launched on a reconnaissance mission. During that mission it discovers a potential target via its sensors. Personnel at the UCS will use the sensor data to create targeting data and to update the mission plan. Simultaneously, the personnel at the UCS will contact the local commander for permission to launch the weapon. With permissions granted, updated segments of the mission plan are relayed to the UAS to update the weapon. When the UAS/weapon or the UCS determines that it is within its LAR it will notify the operator that the release window is open. The MITL on the ground will initiate the launch sequence and release the weapon.

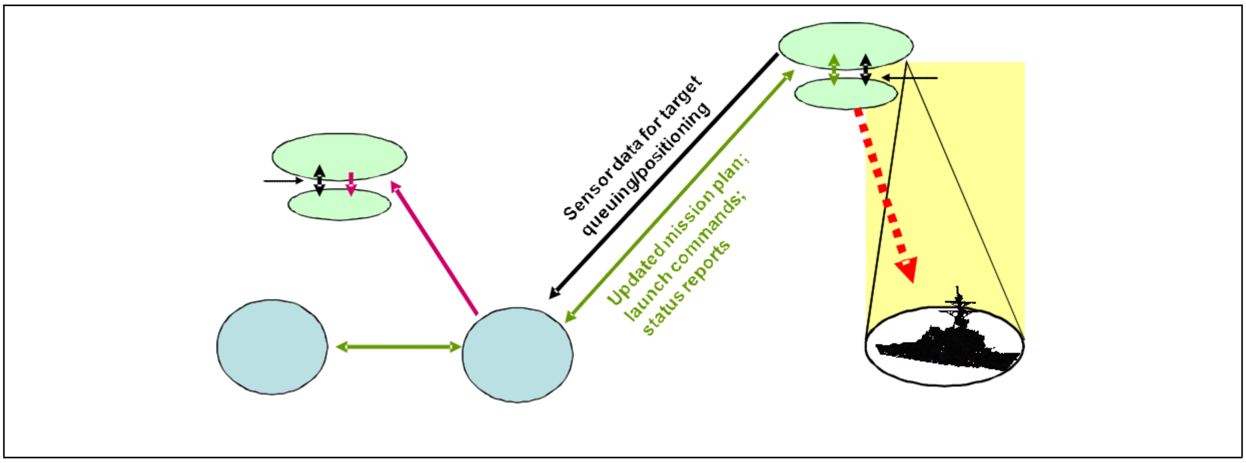


**Figure 3-4: Target of Opportunity**

#### 3.4.1.1.4 Net-Centric Targeting

A new class of Network Enabled Weapons (NEW) is under development. Under the scenario in Figure 3-5, an armed UAS is performing a routine reconnaissance mission with NEW stores. During one of its status reports its weapons capabilities were “discovered” by an entity operating as a NATO Network Enabled Capability node. At this point the Net-Centric entity negotiates with the UCS and takes over control of the UAS. The entity then re-tasks the UAS weapons and serves as the MITL for launching the weapon. It may be possible for some weapons to receive data directly from an external source. When it does, it must relay the relevant information to the controlling entity. Even after release, it is possible for the NNEC entity to still control the NEW store to impact.

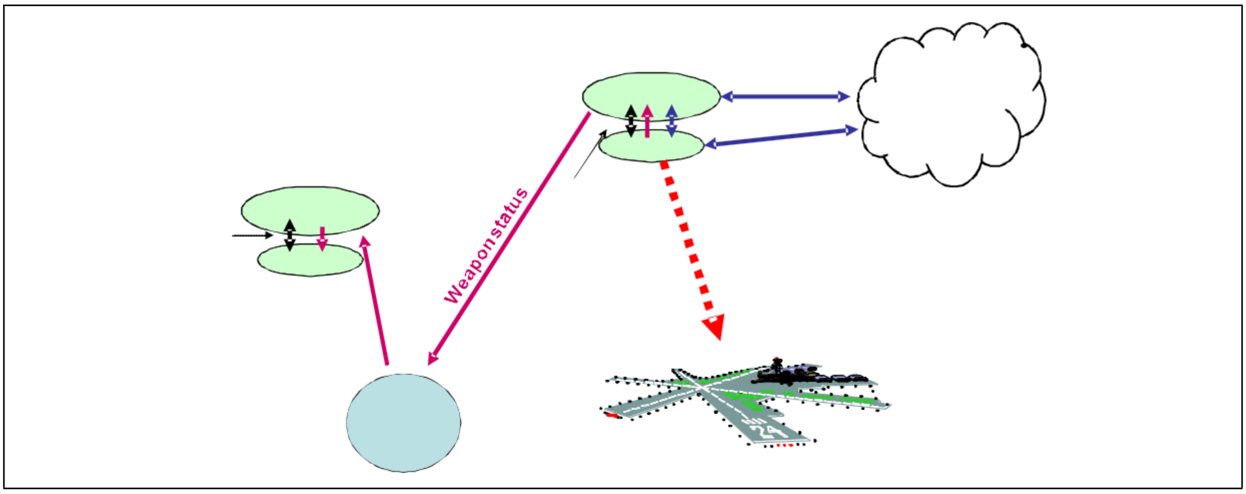


**Figure 3-5: Net-Centric Targeting**

### 3.4.2 Platform Weaponeering

In the air-to-surface role, armed UAS will likely employ guided bombs, precision guided bombs, and guided missiles vice unguided rockets or projectiles. For larger UAS, these may be the same munitions employed by manned aircraft such as the GBU-12 laser guided bomb or AGM-114 Hellfire missile. For smaller, tactical UAS these may be lightweight, low-collateral damage weapons (e.g., Viper Strike) specifically designed for use with UAS. UAS might also employ small, expendable, warhead-equipped UAS as guided missiles. Armed UAS munitions will likely employ similar warhead and fuse combinations as those employed by manned aircraft. The ability to select various fuse functions while airborne will maximize flexibility against an array of potential targets.

### 3.4.3 Mission Types

#### 3.4.3.1 Close Air Support

1. UAS can perform as a persistent forward air controller-airborne (FAC-A) or as weapons delivery platforms. UAS support ground force commanders through TTPs and with a combination of organic and off-board precision ordnance. Armed UAS possess the capability to provide rapid “on-call” precision weapons to accurately deliver supporting fires when needed, as well as coordinate supporting fires for ground force objectives. Armed UAS may directly support the ground manoeuvre unit, acting in a FAC-A role, as fire support assets to other FACs, or both. The requirement for integration of supporting fire for ground manoeuvre forces poses unique challenges. Comprehensive situational awareness of both friendly and enemy ground force tracking is essential. Aircrews may employ advanced sensors, laser target markers, laser target designators, advanced situational awareness displays showing friendly force disposition, and advanced machine-to-machine data links to coordinate supporting fires among assets in support of mission objectives.

Secure and robust communications are essential to exchange critical data among appropriate components, echelons, and assets.

2. It is feasible for armed UAS to perform Close Air Support (CAS) under all three types of control (as defined in Annex 1) though this will require considerable training for both UAS crews and terminal attack controllers. The UAS crew will have to maintain two-way communication with the terminal attack controller and this may require that the UA be equipped with an airborne communications relay if the UAS crew is unable to maintain communication with the terminal attack controller via other (e.g., ground) communication systems.

3. Under Type 1 Control, it may be difficult for the terminal attack controller to visually acquire the UAS, particularly during low visibility situations or if the UA is at medium altitudes or higher. If a low altitude approach is required because of this, an airborne communications/command & control relay would be required to maintain UAS C2 and communications between the UAS crew and the terminal attack controller. This airborne relay would most likely be another UAS or a manned aircraft. Communications and data link latency would have to be considered to ensure a timely weapons release

4. There are at least three variations of Type 2 Control that may be applicable to armed UAS. With the first variation, the terminal attack controller might have eyes-on the UAS but not the target during the attack. With the second variation, the terminal attack controller might have eyes on the target directly (i.e., sees the target with his eyes) but not the UAS during the attack. With the third variation, the terminal attack controller might have eyes on the target indirectly via remote video terminal or some other electronic device but not the UAS during the attack. The terminal attack controller's eyes-on perspective might be that of the attacking UAS itself (likely the preferred method) or that of another ground or airborne sensor.

5. Procedures for Type 3 Control will be rather similar to those for manned aircraft. Any means by which the terminal attack controller can monitor the armed UAS position and/or view its sensor output in real-time will enhance the process.

6. Although not in accordance with current manned aircraft doctrine, a further Type 4 CAS is possible for UAS, in which the weapon targeting and release control is geographically separated from the platform control. A Tactical Air Controller (TAC) local to the target acquires the target directly with a Remote Video Terminal (RVT) from a link to the overhead UAS, which being compliant to STANAG 4586 Level 3 interoperability, can take control of the armed UAS sensor and steer it onto the target. The TAC verifies that the target acquired by the armed UAS corresponds to the target acquired directly by the UAS overhead. When the flight path of the armed UAS meets the LAR for the weapon, the TAC can command weapon release according to the weapon characteristics; it may be necessary for the flight path of the UAS to be altered to achieve a firing solution. In such cases, the TAC provides a CAS brief to the UAS crew who will command the platform. Note that some weapon

system concepts may not require a specific attack profile and therefore this step is not needed.

7. In comparison with manned CAS, the call “Cleared Hot” is replaced with a direct launch command. This type of operation clearly implies a direct message (IER) between the TAC and the UAS stores management system. It should be noted that authorization for the TAC to launch the weapon must be obtained through the proper Chain of Command. In addition, the armed UAS crew may need to have executive authority to override the weapon launch. This is a different architecture from that implied by Type 1, 2, and 3 CAS.

#### 3.4.3.2 Air Interdiction

1. Armed UAS will exploit persistent loiter, sensor capabilities, and organic weapons to hunt and kill TSTs along lines of communication (LOC) or in areas of known or suspected enemy activity. Furthermore, pre-planned surface target sets may be tasked for armed UAS to provide additional weapons effectiveness. Imported data from wide-area search platforms fused to a common operational picture (COP) feed will provide situational awareness and augment initial target cueing. The UAS will be employed standalone or in concert with other assets, employing machine-to-machine data links, laser target designators and markers, and voice communications. Processor databases will permit the mission crew to modify search parameters, allowing the armed UAS to rapidly adapt to a dynamic tactical situation. Armed UAS may internally resolve unknown returns through sensor cross cue; Electro Optical (EO) and Infra-Red (IR) sensors will provide confirmation and correlation of radar-cued targets in clear weather; tailored modular sensors (e.g., radio frequency Electronic Intelligence (ELINT) sensors) will correlate radar “hits” when surface weather is inclement. Armed UAS may automatically compute a targeting solution based on fused sensor data for rapid weapons employment. Post attack, armed UAS will revisit the target, for Post Attack Reconnaissance (PAR) and possible re-attack.

2. Air Interdiction (AI), particularly against heavily defended targets, is an ideal mission for UAS because of their ability to collect immediate Battle Damage Assessment (BDA) with no pilots onboard. Employing armed UAS in the AI role may also help economize the force. During a typical manned AI mission, several “support” aircraft such as a refuelling element, an Electronic Warfare (EW) element, a Suppression of Enemy Air Defenses (SEAD) element, and fighter escort element are often required just to get the strike element safely to the target and back. An unmanned strike element may alleviate the requirement for such support aircraft. The employment of fewer aircraft may also thereby simplify command and control and reduce the chance of enemy detection.

#### 3.4.3.3 Armed Reconnaissance

1. Armed Reconnaissance (AR) (Hunter/Killer role) missions are flown with the primary purpose of locating and interdicting Targets of Opportunity (TOO) in

assigned general areas, or along assigned ground communications and not for the purpose of attacking specific briefed targets.

2. UAS are particularly suitable for the AR role because of their ability to persist over large areas for extended timeframes. UAS operations have already become synonymous with the “Persistent, Deep, Dull, Dirty and Dangerous” mission types. Covering a surface area with observation and fire, UAS equipped with EO/IR and/or Synthetic Aperture Radar (SAR)/Ground Moving Target Indicator (GMTI) sensors and armed with guided air-to-surface munitions, have the ability to strike a multitude of targets, with accurate, localised and lethal effect.

3. Armed Tactical UAS (TUAS) differ from the generic armed UAS because it is considered unlikely to be tasked to conduct offensive operations. Unlike the larger UAS which have the ability to carry significant ordnance, it is likely that the armed TUAS will be tasked to conduct its traditional ISTAR tasks but, in the event that a high priority TOO is identified, for example a TST, then it is on scene to engage that particular target if that course of action is deemed appropriate by the command and controlling authority.

#### 3.4.3.4 Strike Coordination and Reconnaissance

The role of Armed UAS in support of Strike Coordination and Reconnaissance (SCAR) missions is the same as for manned aircraft as defined in Annex 1.

#### 3.4.3.5 Suppression of Enemy Air Defense

1. Armed UAS may be employed against high value air defence nodes such as C2 facilities or radar sites to disrupt or destroy an adversary’s ability to perform air defence functions. Armed UAS will use advanced, modular, ELINT sensors to detect characteristic threat emitters at extended ranges with precision geo-location capabilities. The armed UAS presents a formidable capability when coupled with the inherent counter TST capability of the basic system and suitable weapons, and a SEAD sensor capability.

2. Armed UAS are perhaps ultimately suited for the suppression of enemy air defences because their employment does not risk the lives of human pilots. While this section focuses on destructive SEAD, UAS may also be ideal for conducting disruptive SEAD as well; particularly if the UAS is capable of spoofing the enemy air defence network into activating its radar(s) or other electronic emitters and revealing their positions for friendly attack aircraft to target.

3. UAS procedures for pre-planned SEAD will be similar to those of manned SEAD missions. An armed UAS suitability for performing immediate reactive SEAD will depend on the situation and the munitions carried. Deliberate and alert reactive SEAD procedures will also be similar to manned platforms, though the relative persistence of UAS compared to manned platforms may suit them ideally for airborne alert reactive SEAD missions

#### 3.4.3.6 Combat Search and Rescue Support

Armed UAS can be employed to augment Combat Search and Rescue (CSAR) missions to provide constant survivor status and geo-location data through its extended loiter ability. It will also support the CSAR mission by detecting and identifying potential threats to the recovery assets and survivor, and provides a mechanism to neutralize threats whenever they appear. The combination of persistent loiter, all-weather sensors, and weapons make it an ideal asset to fulfil on-scene commander responsibilities. Armed UAS will assist CSAR forces by utilizing fused multi-spectral sensors to geo-locate isolated personnel. It will exploit its endurance, sensors, and communications equipment to monitor survivor status, provide situational awareness updates to the survivor and rescue force, and provide a communications relay capability. The crew will locate, identify, and neutralize threats to the survivor through a combination of sensors, organic ordnance, and coordinated attacks with other assets. The mission crew will utilize advanced machine-to-machine data links to pass near real-time information (e.g., threats and survivor status) to CSAR package and C2 and will monitor and broadcast the recovery operation to appropriate parties.

## 3.5 ARCHITECTURE

Refer to AEP-82 Chapter 2 for UAS Weapons Architecture.

## 3.6 UAS WEAPONISATION SAFETY

Refer to AEP-82 Chapter 3 for UAS Weaponisation Safety Requirements and implementation.

| CHAPTER 4 | NIAG SG-125 STUDY |
|---|---|

The following is an extract of the Executive Summary from the NIAG Study Group 125 (SG-125) Report.

## 4.0 EXECUTIVE SUMMARY – OVERVIEW

1. In accordance with the recommendations of the ALWI-CI study, NIAG SG125 used the principles of the Object Management Group (OMG) Model Driven Architecture® (MDA) to satisfy the objectives of the study. This methodology is based on the Universal Modelling Language.

2. Central to MDA is a domain model. The domain model partitions the functionality and behaviour of the weaponised UAS based on different subject matters (domains), resulting in large, cohesive and loosely coupled ‘virtual’ components. The domains internal to the UAS weaponisation system are identified by NIAG SG125 as:

a. UAS Management;

b. Target Acquisition and Engagement (TA);

c. Fire Control (FC);

d. Stores Management (SM);

e. Station Control (SC);

f. Pre-Launch Store Control (PLSC);

g. Post-Launch Mission Store Control (PLMSC).

3. Information Exchange Requirements are initially expressed as interactions between these domains and between these domains and external domains and actors in the form of system use cases. The top level use cases are grouped into these UAS mission phases:

a. Pre-Mission – Includes Accept Mission Plan and Prepare UAS Mission and Pre-Flight;

b. Pre-Attack – Includes Launch UA, Initialize UAS Weapon System and Accept Mission Plan;

c. Attack – Includes Prepare and Target Weapon Package, Manoeuvre UAS to LAR Zone and Engage Target;

d. Post Attack – includes Safe and Secure System;

e. Post Mission – includes Recover UA and Generate Mission Report;

f. Jettison – includes Program UAS Jettison Package and Perform UAS Jettison;

g. Erase Sensitive Data – includes Erase Mission Data.

4. The weaponised UAS architecture is realised by allocating (or tagging) each internal domain to a system node. The system nodes are shown in Figure 4-1 and are based on STANAG 4586 definitions. The Payload Element and External C4I Systems are considered external to the UAS for the purposes of modelling.

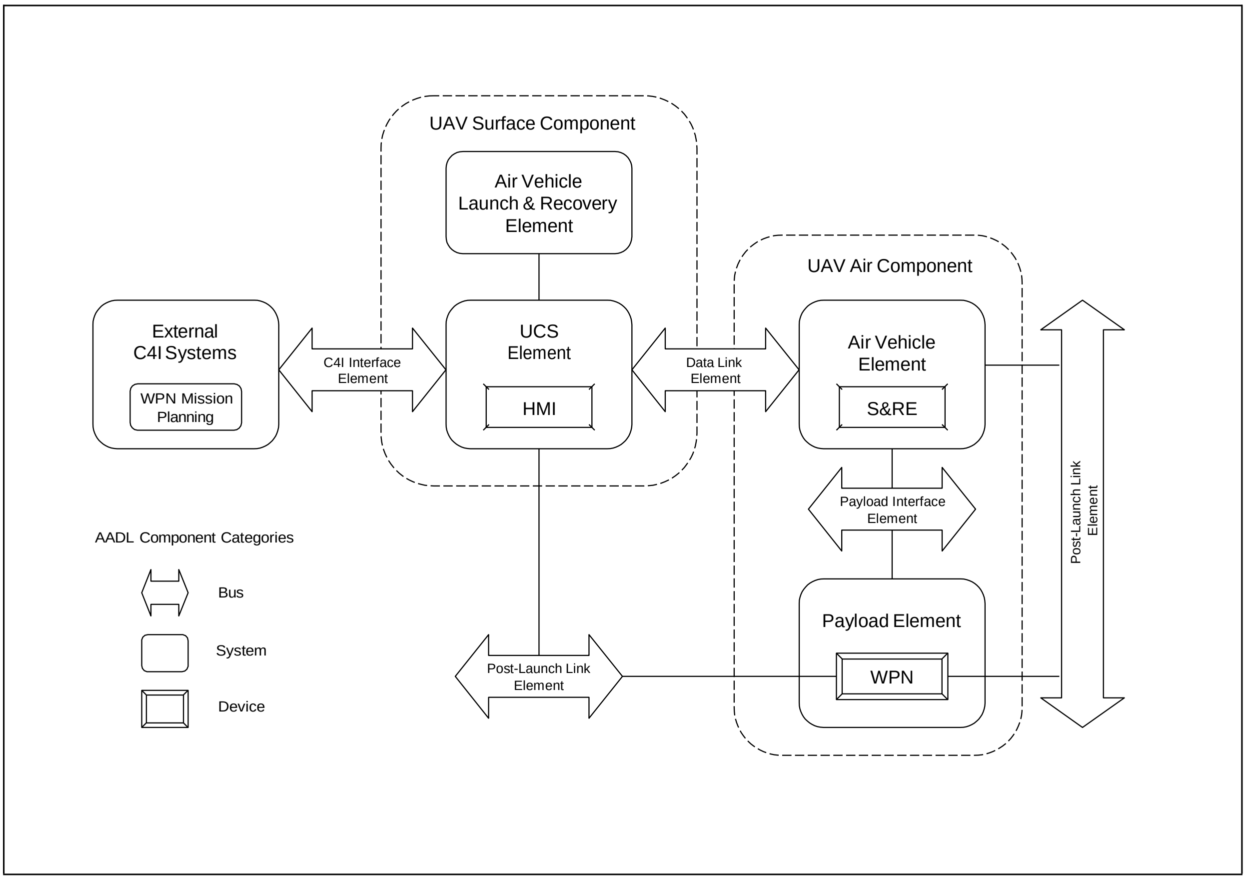


**Figure 4-1: UAS Interface Description (SV-1)**

5. Three architecture possibilities result from allocating the UAS weaponisation system domains to these nodes:

a. Level 1 Capability UA: The UA Element provides Station Control and Pre-Launch Store Control functionality. All other functionality is provided by the UCS Element;

b. Level 2 Capability UA: The same as Level 1 except the UA Element also provides Stores Management functionality instead of the UCS Element; and

c. Level 3 Capability UA: The same as Level 2 except the UA Element also provides Fire Control functionality instead of the UCS Element.

6. Based on these capability levels, different IERs can exist over the STANAG 4586 data link interface between the UCS and UA. However the IERs do not change between the UAS and external systems and actors, regardless of the UA capability level.

7. The study recommendations are provided below.

## 4.1 RECOMMENDATIONS

NIAG Subgroup 125 recommends these actions as a consequence of this study:

a. Formal engagement of the safety/airworthiness community is needed to validate the technical approach presented in this document. To that end, it is recommended that the JCGUAS WST meets with the JCGUAS Flight In Non-Segregated Airspace (FINAS) ST to present the study findings and solicit opinion. It is further recommended that the safety/airworthiness community is represented in the Weaponisation ST. It is expected that validation shall be undertaken by constructing a safety case for each capability level described in this document (see Section 8 of the NIAG 125 Study). For each capability level, a canonical system architecture should be developed with an associated hazard list in order to construct such safety cases.

b. To develop the IER further, it is recommended that message classes are defined together with a more complete definition of the data elements contained in each message class. Such an exercise should be applied to all interactions identified in the UAS weaponisation model. This activity may be performed by the Weaponisation ST with support from NIAG. (WST Chairman's Note: The IER class definitions and data elements have been defined to the appropriate level by the WST and are contained in Section 2.6.4 and Annex A in AEP-82).

c. It is recommended that a UAS weaponisation message set is developed in accordance with the complete definition of IER. This task may be undertaken by the JCGUAS STANAG 4586 ST in conjunction with NIAG. Weaponisation expertise and safety/airworthiness expertise will be essential to this activity.

d. It is recommended that the NATO nations consider the definition of service descriptions for the domains identified in the UAS weaponisation model. Such service descriptions may be implemented by technologies such as SOA and DDS.

e. It is additionally recommended that the nations consider the development of experimental systems to validate these key elements of the architecture:

(1) Messages;

(2) MDA based system generation;

(3) UAI/Data driven system integration;

(4) Time critical characteristics of the system;

(5) Hand-off mechanisms;

(6) Mission planning considerations;

(7) UCS architecture.

It is recommended that findings from these programmes are briefed to the Weaponisation ST.

f. Finally, it is recommended that the Weaponisation ST briefs the conclusion of this study to the NATO UAI ST (with appropriate support from NIAG SG125 members).

# CHAPTER 5 DEMONSTRATION RESULTS

To be promulgated when available from national/NATO exercises and demonstrations

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| CHAPTER 6 | WST RECOMMENDATIONS |
|---|---|

## 6.0 EXECUTIVE SUMMARY - OVERVIEW

1. Utilization of weapons on unmanned platforms impacts both technical and operational standards. The technical standards which will be impacted include but are not limited to the following:

   a. STANAG 4586

   b. STANAG 4670 (DUO)

   c. STANAG 4671 (USAR)

   d. Common Route Definition (CRD) and CRD extensions (e.g., UAS) Mission Planning (Platform and Weapon)

It is recommended that:

   a. The respective STANAG custodians review this report and update their standards as appropriate.

   b. For Operational Standards, the Strategic Commands/NSA should identify the appropriate impacts and scope of impact to their standards.

2. For weapons and mission planning systems that use the same Interface Control Document (ICD) to transfer data, it is strongly recommended that the UAS transfers that data to the weapon over the data link without modification.

3. Formal engagement of the safety/airworthiness community is needed to validate the technical approach presented in this document. To that end, it is recommended that the JCGUAS WST meets with the JCGUAS Flight In Non-Segregated Airspace (FINAS) ST to present the study findings and solicit opinion. It is further recommended that the safety/airworthiness community is represented in the Weaponisation ST.

4. It is recommended that a UAS weaponisation message set be developed by JCGUAS STANAG 4586 ST in conjunction with the WST in accordance with the requirements and IERs as presented in this document.

5. It is recommended that the JCGUAS initiate an effort to develop a Service Oriented Architecture (SOA) for an Armed UAS and definition/development of associated services which could be shared among NATO nations.

6. The results of the NIAG SG-125 study provided to the WST should provide the framework for the weaponisation portion of the SOA recommended in item 5 above.

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| ANNEX A | WEAPON SYSTEM CONCEPT AND ARCHITECTURE FOR MANNED AIRCRAFT |
|---|---|

## A1.0 JOINT CAMPAIGN/OPERATIONS STRUCTURE

### A1.1 Overview (AJP-3.3 c01 & 3.3.2)

Joint Air Operations and specifically, Anti Surface Force Air Operations (ASFAO) are conducted to deprive the enemy of the military power he needs to occupy territory or exploit sea space by neutralising, delaying or destroying his surface forces. In the maritime environment, ASFAO are carried out by land-based aircraft using Tactical Air Support for Maritime Operations (TASMO) procedures in support of the naval warfare areas (Anti-Surface Warfare (ASuW) and Anti-Submarine Warfare (ASW)). In the land environment, ASFAO are carried out by land and sea based aircraft in support of land or amphibious forces using procedures for Air Interdiction (AI) and Close Air Support (CAS). ASFAO must be closely coordinated with the supported commander. They must be integrated with the supporting commander's organic air operations to achieve unity of effort and avoid fratricide. ASFAO can either be accomplished in direct or indirect support of ground operations, or can be carried out with minimal or no friendly ground forces in the area. When friendly ground forces are present, ASFAO tends to be more effective at greater distances from the ground battle where fratricide is not an issue and the enemy may be more vulnerable. Air Operations that are used to perform ASFAO are AI and CAS.

a. Air Interdiction is an operation that destroys, disrupts, diverts, or delays an enemy's surface military potential before it can be used effectively against friendly forces, or otherwise achieve its objectives. Typical targets for AI are lines of communication, supply centres, command and control nodes, or fielded forces. AI is either performed as part of an overall Joint Operational Area (JOA)-wide interdiction effort, which typically aims to isolate all or part of the battlefield from its source of support and reinforcement, or as a more local effort in response to the needs of ground combat.

b. Close Air Support is an operation flown in direct support of own ground forces, in offensive and defensive operations, to destroy, disrupt, suppress, fix or delay enemy forces. CAS can be conducted at any place and time friendly forces are in close proximity to enemy forces. The term 'close' does not imply a specific distance; rather it is situational. The key factor to success is that detailed integration is required between each air mission and the fire and movement of surface forces to minimize the risk of fratricide. Control of CAS is performed by Tactical Air Control Parties (TACP) attached to units being supported.

## A1.2 Organizational Structure (AJP-3.3.2)

1. The Joint Force Commander (JFC) sets overall campaign/operation priorities, which guide component objectives and determine the level of support between components. The Air Component Commander (ACC) recommends JOA-wide targeting priorities and, in coordination with the other component commanders' interdiction priorities, forwards the air apportionment recommendation to the JFC. The JFC provides target priorities and air apportionment guidance to the ACC and other Component Commanders (CCs). The ACC, using priorities established in the JFC's air apportionment decision, then plans and executes the JOA-wide air interdiction effort. Other components may simultaneously conduct interdiction efforts with organic or assigned capabilities. The surface commander can determine specific targets for air interdiction or provide the air component mission-type instructions that allow tactical mission planning flexibility. In this way the ACC can best determine how to support the surface commander, without knowing in advance the exact location or timing of the priority targets. Ultimately, interdiction priorities within the surface Area of Operations (AOO) are considered along with the overall interdiction priorities that are established by the JFC and guide the overall targeting process. The supported commander should clearly articulate the concept of manoeuvre operations to the supporting commanders.

2. The air planning cycle is an interrelated series of actions that begins with the JFC's guidance for the cycle period. When operations begin, an air planning cycle is normally established to develop daily tactical tasking (Air Tasking Order (ATO)) based on the operational guidance provided by the Air Operations Directive (AOD) and other inputs. It provides for the efficient and effective employment of the air assets of one or more components. The ACC allocates resources based on the JFC's apportionment decision and the Air Operations Centre (AOC) publishes the ATO. The ATO, when combined with the Airspace Control Order (ACO) and Special Instructions (SPINS), provides operational and tactical direction for air operations. It is subsequently executed by the AOC.

### A1.2.1 ATO Format and Contents

1. The ATO format in NATO is standardized by Allied Data Publication 3 (ADatP-3). An ATO is organized into data sets; for each data set there are multiple data fields. General information about the ATO (its metadata) is contained in these data sets:

a. Name of operation or exercise

b. Message identifier and originator

c. Validity period of the ATO

d. Points of contact and acknowledgement procedures

e. Information of available assets and allotment

f. Summary information on cancelled missions, tasked nations and so on.

2. The specific information in the ATO is provided in the data sets and data fields identified in STANAG 5500 and summarized in Table A-1 below. Narrative and amplification data sets can be added to these general and specific data sets as necessary.

| DATA SET | DATA FIELDS |
|---|---|
| Air mission data | Mission number, primary/secondary mission type, alert status, departure/ arrival location |
| Aircraft data | Number and type of aircraft, call sign, primary/secondary configuration code (includes weapon load) |
| Air refuelling data (receiver) | Mission number, aircraft call sign, air refuelling point/area, air refuelling times, off-load, refuelling system, receiver aircraft type, frequencies, navigation aids |
| Air refuelling data (tanker) | Mission number, receiver call sign, number/type of receivers, refuelling system, off-load, fuel type, refuelling times |
| Routing information | Date/time, position (repeated as often as necessary) |
| Force package information | Package identification, mission number, mission type, number and type aircraft, aircraft call sign |
| Airborne alert data | Time window (start/end), location/area name, altitude, mission priority |
| Target location & description | Primary/secondary target designator, time window (NET/NLT), target type, desired mean point of impact (position/elevation), target priority |
| Reconnaissance data | Mission priority, time window (start/stop), reconnaissance type, image type/qualifier, target category, target identifier |
| Escort data | Number/type/call sign of escorted aircraft, frequencies |

**Table A-1: Mission Information in ATO**

### A1.3 Air-Land Integration (Reference AJP-3.3c01)

Fundamental to the Land Component Commander's (LCC's) scheme of manoeuvre within his AOO will be his exploitation of the capabilities of air power. Its reach, speed, flexibility and concentration of force give him opportunities to achieve surprise, shock, simultaneous actions and tempo. He may use air-delivered combat power, integrating his organic air capabilities with those of the ACC, to shape his battlespace in depth, by marginalizing or destroying adversary forces, or by seizing targets of opportunity or by providing direct support to ground manoeuvre with aerial fire power. The type of mission employed and degree of aircraft control used will be based on the proximity of hostile targets to friendly forces. Within a land AOO, the LCC will normally be the supported commander and will designate the target priorities, required effects and timing. The ACC, or other CCs, may need to conduct air operations within the LCC's AOO (e.g., to support counter-air or strategic objectives), but these must be coordinated with the LCC to ensure that the proposed attacks do not adversely affect his planned operations or scheme of manoeuvre. Joint planning and coordination utilising the liaison elements, such as the Air Operations Coordination Centre (Land) (AOCC(L)) and the Battlefield Coordination Detachment (BCD), is therefore an essential objective, but these must be coordinated with the LCC to ensure that the proposed attacks do not adversely affect his planned operations or scheme of manoeuvre.

### A1.3.1 AOCC (Land) (AJP-3.3c01)

The AOCC(L) integrates the liaison and coordination functions related to air operations. To avoid fratricide, all land organic air assets should appear on the ATO and their airspace requirements should be included in the ACO. Helicopter operations are listed in the ATO in as much detail as possible for de-confliction purposes. The responsibility for coordinating these aspects of army aviation and facilitating support requests to the AOC lies with the AOCC (L). The AOCC (L) is functionally subordinate to its AOC but is responsive to the LCC with which it is collocated.

### A1.3.2 Army Aviation/Airmobile (AJP-3.3c01)

Land forces view helicopters, not only Armed Helicopters (AH) but also those operating in support from another service, as an integral part of the LCC's scheme of manoeuvre and an irreplaceable element of the LCC's design for battle. Helicopters, when operating in the same battlespace as ground units, must be responsive to changing tactical environments and ground formation battle plans. Unlike fast-jet aircraft, AH stalk their targets, remaining on station for long periods while manoeuvering for advantage throughout the engagement. They can be given manoeuvre missions, and will execute these by moving tactically within the ground environment, employing fire and manoeuvre. Their operations appear on the ATO in as much detail as possible for de-confliction purposes. Nevertheless, they form a significant part of the air power spectrum and can make a major contribution to other CC's operations. Airmobile operations are conducted using forces deployed by helicopter under control of an appropriate land or amphibious force commander. They are similar to airborne operations and may include significant levels of fixed-wing support.

### A1.3.3 Joint Air Attack Teams (AJP-3.3c01)

The capabilities of fixed-wing aircraft and armed or AH are often complementary. AH can mark targets or suppress air defences, while fixed-wing aircraft can compound surprise and provide weight of firepower with a wide range of weaponry. Tremendous synergy can be achieved by combining both capabilities, if practicable with EW and artillery support, in Joint Air Attack Teams (JAAT) operations. JAAT operations are normally planned by the land component and supported by the air component. Conversely, Composite Air Operations (COMAOs) planned by the air component may benefit from the addition of AH support from the land component.

### A1.4 Naval Aviation (AJP 3.3.3)

In maritime air operations, land and sea-based aircraft work in close cooperation with maritime forces to ensure the most effective use of available air assets, with the aim of detecting, monitoring and/or neutralizing or destroying the adversary, achieving defence in depth and seizing and retaining the initiative. A primary aim of maritime air operations is to assist the Maritime Component Commander (MCC) in the compilation of the Recognized Maritime Picture (RMP), an element of the Common Operational Picture (COP).

#### A1.4.1 Employment of Ship-Based and Shore-Based Aircraft

Depending upon the area of operations, a choice may exist between employing ship-borne or land-based aircraft. The advantages and limitations of each should be evaluated before selecting the optimum force mix. The nature and location of the threat to maritime forces is likely to be the major influence in this decision. The threat may be beyond the range of the surface force organic sensors, requiring the MCC to initiate coordinated land-based air operations at some distance from the Maritime forces being threatened.

#### A1.4.2 Air Employment in the Maritime Environment

Maritime and land-based air assets may be tasked to provide support for forces at sea in three categories of operations:

a. **Area Operations (AO)**. Area Operations are conducted in a geographic area and are not directly related to the protection of a specific force. They are conducted in areas where adversary forces are known to be, through which adversary forces are likely to transit, in which friendly forces are planned to operate, or within which it is desirable to deny the adversary freedom of action.

b. **Direct Support (DS).** Aircraft in DS are related to the support and protection of a specific force at sea, during which Tactical Control (TACON) of the aircraft is delegated by the component commander retaining Operational Control (OPCON) (usually the MCC), to the maritime force's Officer In Tactical Command (OTC). Whilst on DS, aircraft will work mainly under control of a delegated Aircraft Control Unit (ACU) to which the OTC will have further delegated TACON.

c. **Associated Support (AS).** Aircraft tasked on associated support will operate independently of other forces at sea; however, their tasking is in support of a specific force. They may be tasked to support that force by providing contact information and to receive intelligence from the OTC who is being supported. The aircraft may be tasked to establish communications with the supported force to prevent mutual interference. The OTC of the supported force cannot take tactical control of the aircraft unless authorized by the aircraft tasking authority. The aircraft commander should be briefed on the degree of support that can be given to the OTC.

## A2.0 JOINT TARGETING

Targeting occurs at all levels of command within the joint force and is applied by component-level forces capable of attacking targets with both lethal and non-lethal means to achieve the desired effect. This linkage between component targeting is outlined in Figure A-1 below. All components should establish procedures and mechanisms to manage targeting functions. The Land Targeting Cycle fulfils that function at the operational and tactical level for land forces. Maritime, Air and Special forces will have complementary targeting methodologies and collaboration is a critical element of the execution of targeting at all levels of joint forces.

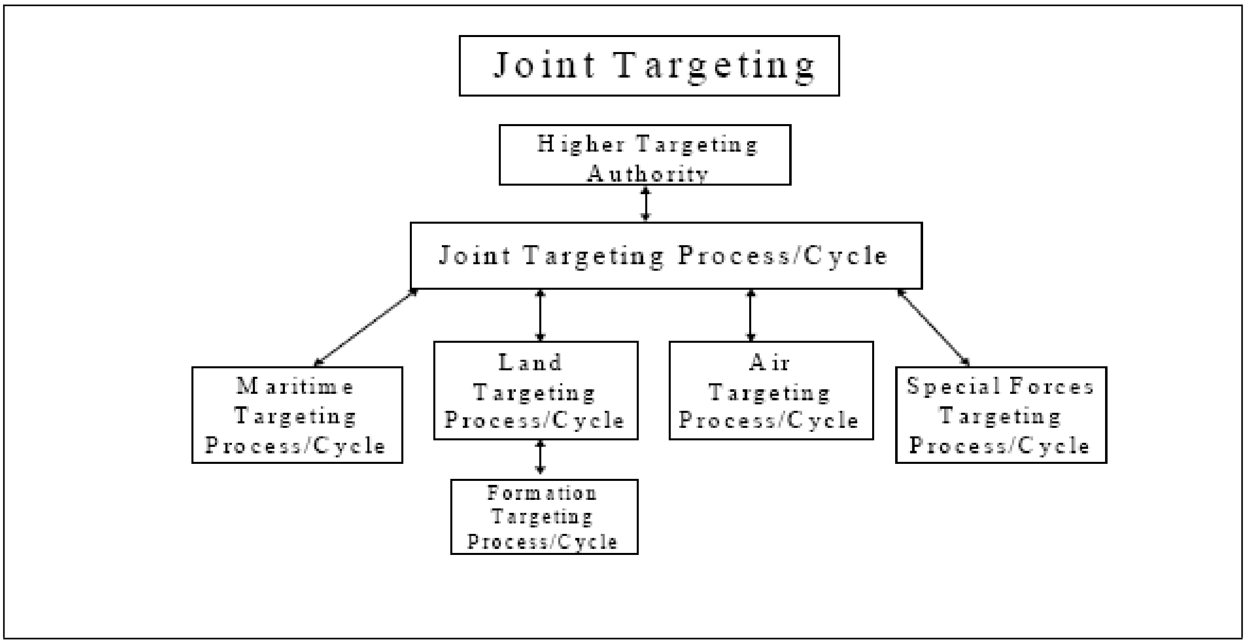


**Figure A-1: Joint Targeting**

### A2.1 Targeting and Targets

1. A target can be defined as an area, complex or installation, force, equipment, capability, function or behaviour identified for possible action to support the formation/manoeuvre commander's objectives, guidance and intent.

2. Military targets match the levels of warfare:

a. Strategic Targets. Targets that influence the overall war effort, or political objectives, are classified as strategic.

b. Operational Targets. Targets deemed critical to the enemy's capability to conduct successful campaigns are classified as operational. The distinction between the Operational level and the Tactical level has become less well defined as technology has advanced.

c. Tactical Targets. Targets that produce immediate (or near immediate) effects on the battlefield, or to the outcome of current operations, are classified as tactical.

### A2.2 Principles of Targeting

Principles of targeting will apply regardless of the component concerned or of the prevailing operational environment:

a. Focused. The process is focused on achieving the commander's objectives.

b. Effects-based. Targeting is concerned with producing specific effects. Targeting analysis will consider all possible means and the art of targeting is to achieve desired effects with the least risk and expenditure of resources.

c. Interdisciplinary. The targeting effort relies on the coordinated contribution of headquarters and staff functions.

d. Systematic. Targeting is a rational and iterative process that seeks to manage effects in a systematic manner.

### A2.3 Effects-based Targeting

1. Effective targeting is distinguished by the ability to identify targeting options, lethal and non-lethal, to achieve the desired effect. Targeting effects are designed to influence operational outcomes and are the cumulative results of operational actions taken. Targeting effects can be categorized in two forms:

a. Direct Effects. The immediate consequence of military action.

b. Indirect Effects. Delayed and/or displaced consequences of military action.

2. Effects terms will be used to describe the commander's targeting objectives. These higher level aims might include terms such as Capture, Degrade, Deceive, Limit, Disrupt, Delay, Divert, Exploit or Damage. These terms are not mutually exclusive and several terms may be applied to a given targeting objective.

3. The terms above should not be confused with terms used to determine the degree of damage or duration of effects on a specific target. Such terms may include the traditional artillery effects of destroy, neutralize, suppress and harass.

### A2.4 Legal Considerations

1. There must be due consideration of any collateral and/or additional effects as a result of the targeting process. Effects can spill over to create unintended consequences, usually in the form of damage unrelated to the military objective.

2. Planning should consider the risk of unintended consequences alongside the routine consideration of Laws of Armed Conflict (LOAC) and Rules of Engagement (ROE). Therefore a legal advisor should be included as early as possible in the planning process in order to ensure that all relevant issues are taken into account. Attention should be brought to that fact that actions taken at the tactical level may have effects at the operational and strategic level. The global impact of a single unintended event is likely to be out of proportion with the actual incident.

3. Targeting at all levels will always be governed by the parameters set by the LOAC and ROE. LOAC forms part of international law and are characterized as being either Hague or Geneva law. The former relates to the conduct of operations whilst the latter relates to the protection of persons and property. The basic concepts of LOAC are:

a. Military Necessity. This means that belligerents are justified in applying force to that extent which will ensure the submission of the enemy at the earliest possible moment, with the least possible cost and using methods and means of warfare that are not proscribed by international law in attacking a military objective.

b. Unnecessary Suffering. This relates to the means of warfare and methods of combat whose foreseeable harm would be clearly excessive in relation to the military advantage to be gained. In relation to a civilian population, it means whether the risk of incidental injury to the civilian population caused is so indiscriminate as to constitute a direct attack on the civilian population.

c. Proportionality. The formation/manoeuvre commander should have an expectation that a military action will make a relevant and proportional contribution to military objectives. In relation to civilians, this concept means that incidental civilian casualties and damage to civilian property cannot be excessive in relation to the military advantage to be gained.

d. Distinction. An emerging subsidiary concept means that there must be distinction between military and civilian objects as well as between civilians and combatants.

4. ROE, which will usually be restrictive in nature, will define when, where and how force may be applied. All formation/manoeuvre commanders must instruct their forces carefully on the ROE. It is essential that a targeting group knows the ROE and is able to apply them correctly to the operations in hand.

## A2.5 Joint Targeting Cycle

A joint targeting process might look like the cycle of activities in Figure A-2 below.

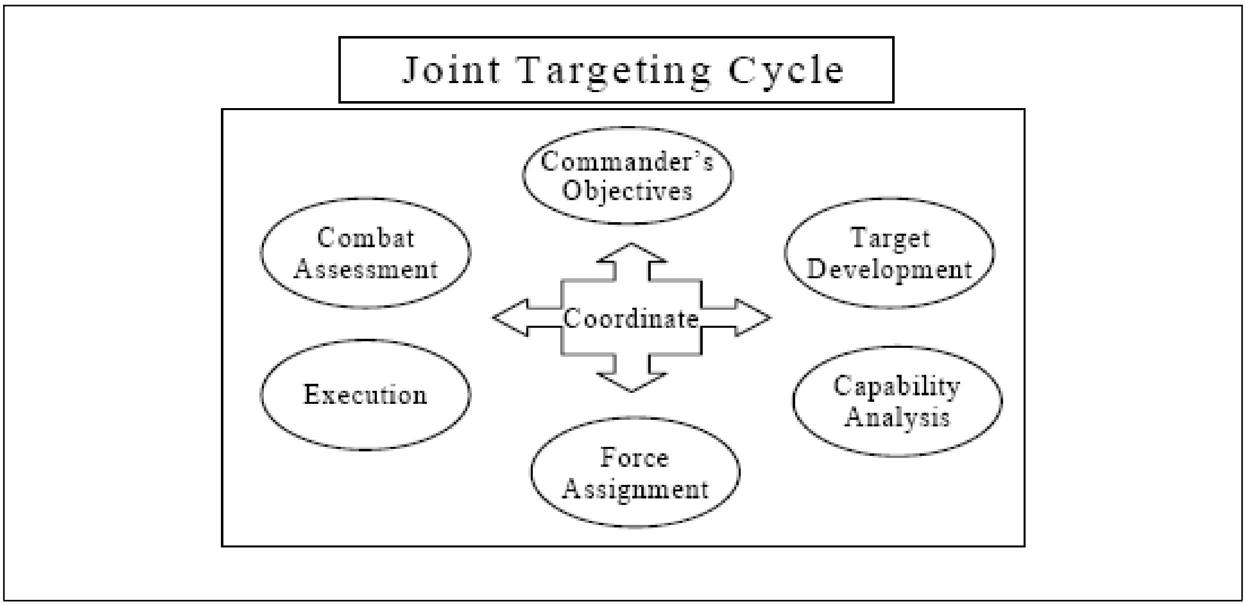


**Figure A-2: Joint Targeting Cycle**

## A2.6 Target Nominations

1. Various target lists may be developed by the joint targeting organization as a result of submissions from higher authorities or from component Target Nomination Lists (TNL). These can include:

a. Joint Target List (JTL) (No AAP-6 definition)

b. Joint Integrated Prioritized Target List (JIPTL) (No AAP-6 definition)

c. No-Strike List (NSL) (No AAP-6 definition)

d. Restricted Target List (RTL) (No AAP-6 definition)

2. An essential element of the joint targeting process is to take into account the needs of the full range of 'clients' and to manage resources in order to deliver the commander's requirements.

### A2.7 Coordination Elements

It will be important at the joint level that a common understanding of component commander's aspirations are developed and maintained. The deployment of coordination elements at appropriate levels of command will aid understanding and reduce organizational friction.

### A2.8 Land Targeting Methodology

1. The land formation/manoeuvre commander must determine which targets presented to him are of the most importance to the adversary and, of those, which he must effect to help him better achieve his own mission. The purpose of this section is to describe in detail the land targeting cycle methodology that has been developed to assist the formation/manoeuvre commander, and his staff, in making these decisions. The methodology has utility throughout the operational spectrum and can be used to manage lethal and non-lethal effects.

2. The Land Targeting Cycle is based on a cycle of functions; Decide, Detect/Track, Deliver and Assess. This methodology provides a systematic approach to enable the right target to be effected with the appropriate system at the right time and place. The process is shown diagrammatically at Figure A-3. The process provides an effective method for matching friendly capabilities against the most important targets in order to achieve the formation/manoeuvre commander's desired effects. It is a dynamic process that allows those involved in the targeting process to keep up with rapidly changing situations. The methodology, tools and products described in this chapter must be continually reviewed as the situation develops and updated on the basis of situation reports and combat assessments. The functions are not necessarily phased or sequenced and may frequently occur throughout operational planning and execution.

#### A.2.8.1. The Decide Function

1. The Decide function is the initial, most involved, part of the cycle and will take the most staff effort. The effectiveness of staff effort in the Decide phase will probably determine how effective the operational targeting effort will be. Targeting takes place at the same time and in parallel with, operations staff estimates and the intelligence collection effort. It may assist in setting priorities for intelligence collection and effects planning.

2. This function is divided into 6 elements:

   a. Identify Target Types. Target types and categories will depend on the nature of the operation and the range of effects available. Targets will be developed into target lists and further refined through intelligence collection and the need to manage the dynamic nature of the formation/manoeuvre commanders' operational requirements.

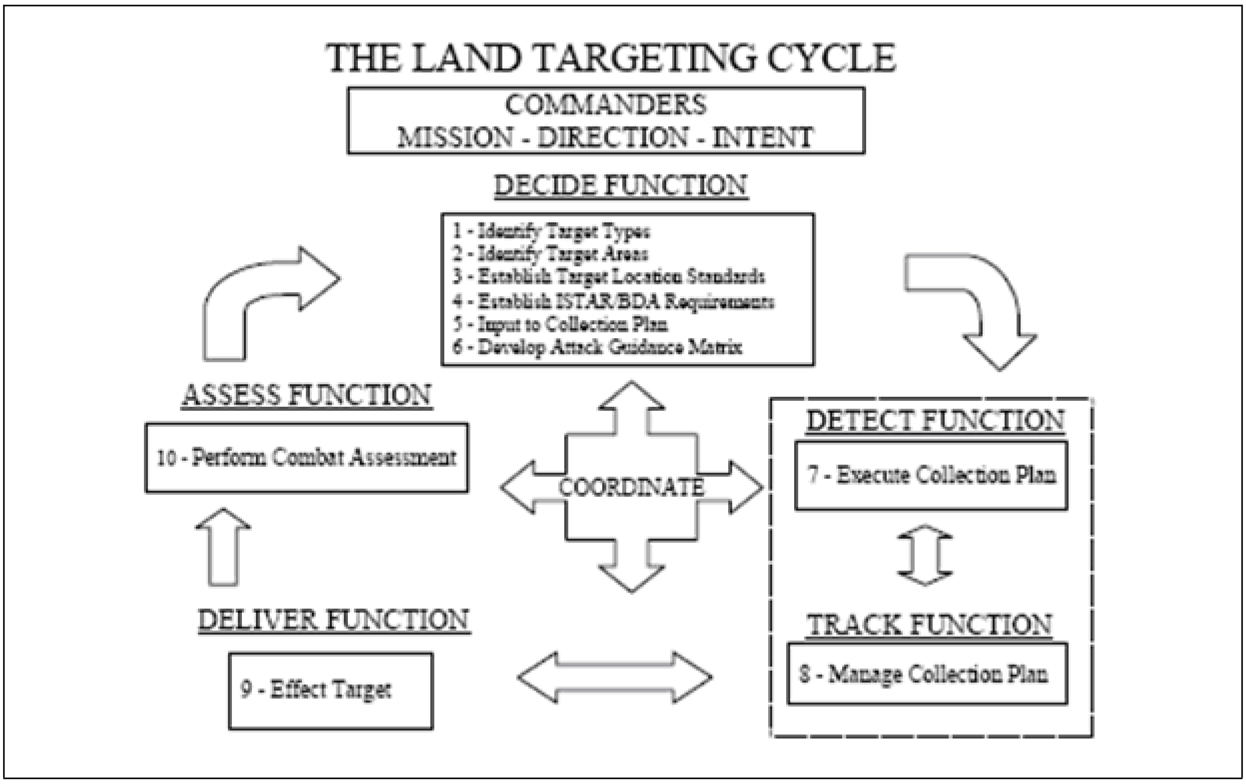


**Figure A-3: The Land Targeting Cycle**

b. Identify Target Areas. This stage will consider the Area of Operations and identify areas of targeting interest. All dimensions of the battlespace environment should be considered and limitations such as protected areas taken into account.

c. Establish Target Accuracy. The capabilities of available detection systems and effects systems will dictate technical and procedural limits that should be established. It is important to match appropriate ISTAR and effects systems in order to engage targets.

d. Input to Intelligence Collection Plan. Targeting input to the intelligence collection mechanism aims to provide a focus for the management of detection systems. Input will identify priority targets, how they might be detected and whether target tracking is required.

e. Establish Battle Damage Assessment (BDA) Criteria. Decisions must be made early in the process as to what can be defined as a successful (or unsuccessful) attack. There should also be decisions concerning the direction of systems to obtain BDA. Only effective BDA can assess that the effects desired by the formation/manoeuvre commander are being produced.

f. Develop Attack Guidance Matrix (AGM). The AGM provides a consolidated, tabulated support tool for operational targeting decisions and is the culmination of the Decide phase of the cycle. The matrix is intended to act, as far as practical, as an executive document allowing rapid engagement decisions to be made during current operations. AGM should be developed for each phase of an operation and for different operations.

#### A2.8.1.1 Target Nominations

1. Targets and missions beyond the capability of the formation are passed to the next higher formation HQ for action. The staff must know when the requests must be submitted for consideration within the target planning cycle of the higher formation. The synchronisation of these missions with current operations may be critical to the success of the mission. A key to co-ordination for both planning and execution is the exchange of trained liaison staff between HQ's.

2. Targets and missions may be included in orders or guidance from higher formations. The staff must include these targets in their own targeting decisions and assign the proper priority to them using the guidance provided by the commander. These targets may have a direct impact on detect, track and attack asset availability for the prosecution of their formation/manoeuvre commander's targets.

#### A2.8.1.2 Decide Function Products

1. The result of the Decide function should be a focused targeting effort and a series of supporting products. Some of the product possibilities are listed below:

a. High Value Target (HVT) List (HVTL).

b. High Payoff Target (HPT) List (HPTL).

c. Target Selection Standards (TSS).

d. Attack Guidance Matrix (AGM).

e. Battle Damage Assessment (BDA) requirements.

f. Combined HPT/TSS/AGM.

2. These products should be briefed to and approved by the formation/manoeuvre commander or, if time and circumstances do not permit, to the person nominated by the formation/manoeuvre commander to control and co-ordinate the targeting effort.

### A2.8.2 The Detect Function

The practical application of this function is the execution of the intelligence collection plan. Clear and concise information requirements must be given to the systems chosen to detect given targets. At the same time, there should be no gaps in the intelligence collection effort. In particular, HPT's must be detected in a timely, accurate manner.

### A2.8.3 The Track Function

Target tracking supplements the detect function but is distinct from it since target tracking requires specific asset management decisions. Many of these tracking decisions will have been agreed during the Decide phase and will be articulated in the AGM. Once detected, HPT's that cannot be immediately attacked, which are planned to be attacked during a later phase, or which require validation, must be tracked to ensure that they are not lost and to maintain a current target location.

#### A2.8.3.1 Target Reporting

As the intelligence collection effort is executed and target information is received, it is forwarded to the targeting function and, where appropriate, to target analysts for evaluation. It is important that full target reports are given.

### A2.8.4 The Deliver Function

1. The primary activity during the deliver phase of the targeting process is the application of the desired effect to targets in accordance with the AGM. This stage in the Cycle is intended to ensure the efficient delivery of the most appropriate effect.

2. Important targets may appear outside the decisions made during the Decide function. These opportunity targets are processed in the same manner as planned HPT's. Opportunity targets, not on the HPTL, are first evaluated to determine when, and if, they should be attacked. The decision to attack opportunity targets is based on a number of factors such as the activity of the target and the potential target pay-off compared to other targets being processed for attack.

3. The final tactical decision is to confirm the selection of appropriate effects system for each target in line with the AGM. For planned targets, this decision will have been made during the Decide function of the targeting process. Nevertheless, a check has to be made to ensure that the selected effects system is available and can conduct the attack as planned. If not, the targeting group must determine the best available system for the attack. In some cases more than one system, or type of system, may be used to attack the same target.

4. Once all tactical decisions have been made the appropriate staff issue orders for the designated system(s). The attack system formation/manoeuvre commander determines whether or not his system can meet the requirements and, if so, carries out the attack. If, for any reason, his system cannot meet the requirements he

should notify the staff so that further analysis and checks can be carried out and/or another system can be ordered to carry out the attack.

### A2.8.5 The Assess Function

1. Assessment is the concluding function of the targeting process and is the determination of the effectiveness of attacks on selected targets. Assessment will be a dynamic process and will be a constant feature of the staff effort.

2. One method of assessment, known as Combat Assessment comprises BDA, Munitions Effectiveness Analysis (MEA) and re-attack recommendations.

3. BDA is the timely and accurate assessment of damage resulting from the application of lethal or non-lethal effects against a target. The need for BDA for specific HPT's is determined during the decide function of the targeting process and the requirements for it are recorded on the AGM and in the intelligence collection process. The production of BDA is generally an Intelligence staff responsibility. BDA results are received and processed to determine whether or not the desired effects have been achieved for a given target and the results are disseminated to the targeting group.

4. Effective BDA accomplishes the following purposes:

   a. At the tactical level, BDA allows formation/manoeuvre commanders to get a series of snapshots of the effects current operations are having against the enemy. It provides formation/manouevre commanders with an estimate of the enemy's combat effectiveness and residual capabilities.

   b. As part of the targeting process, BDA helps to determine if further strikes on selected targets are necessary. Formation/manoeuvre commanders use this information to allocate, or redirect, attack systems to make best use of available combat power.

5. MEA is an assessment of the effectiveness of the selected strike system and is generally an operations staff function.

6. The combination of BDA and MEA will provide staff with the information required to make recommendations to the formation/manoeuvre commander. The effectiveness, or not, of a particular attack may require different attack options to be considered or for the formation/manoeuvre commander to alter aspects of the plan in order to meet the prevailing situation.

### A2.9 Sortie Mission Planning

1. There is no common mission planning system or mission planning process across NATO. However a typical mission planning path prior to flight operations is shown in Figure A-4.

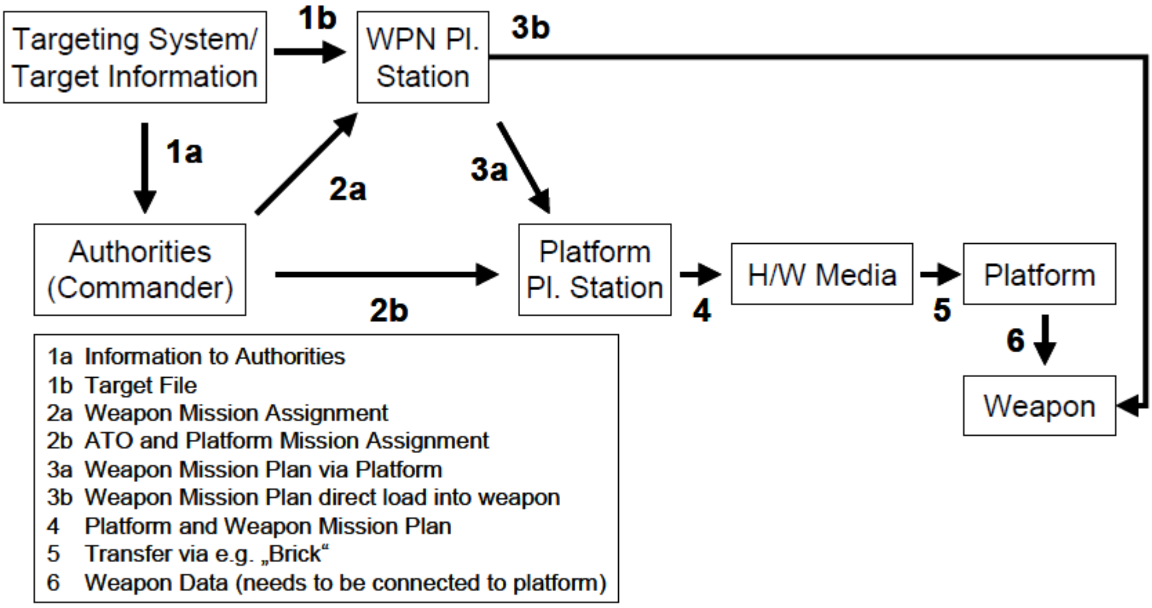


**Figure A-4: Typical Mission Planning Path Prior to Flight Operations**[1]

2. For deliberate targeting, many weapons require mission planning as part of the overall mission planning process. The mission data for the weapon can be included in the aircraft mission planning data for subsequent downloading into the weapon via the store station, or the weapon mission data can be directly downloaded into the weapon during ground operations. A recently defined US standard for mission data files is MIL-STD-3014, the Mission Data Exchange Format. NATO adoption of MIL-STD-3014 is being considered under the NAFAG ACG 2 led NATO Universal Armament Interface initiative.

3. Aircraft mission planning and weapon mission planning may be performed on separate tools, or in a common mission planning environment such as the US Joint Mission Planning System (JMPS). The final mission planning materials may be written to a combat mission folder and transferred to the aircraft via a portable data store device. To support dynamic targeting, new mission plans or mission plan changes can be transmitted via data links such as STANAG 5516 (Link 16) or STANAG 5522 (Link 22) to network-capable aircraft.

4. The following standards (Tables A-2 to A-5) are applicable to mission planning.

[1] NIAG Subgroup 72 – Aircraft, Launcher and Weapon Interoperability Study (ALWI), Second Study.

| Reference | Title |
|---|---|
| STANAG 3809 | Digital Terrain Elevation Data (DTED) Exchange Format |
| STANAG 4575 | NATO Advanced Data Storage Interface (NADSI) |
| STANAG 4559 | NATO Standard ISR Library Interface (NSILI) |
| STANAG 7074 | Digital Geographic Information Exchange Standards (DIGEST) |

**Table A-2: Database Related Standards**

| Reference | Title |
|---|---|
| STANAG 4607 | NATO Ground Moving Target Indicator Format (GMTIF) |
| STANAG 4609 | NATO Digital Motion Imagery Format |
| STANAG 4545 | NATO Secondary Imagery Format (NSIF) |
| STANAG 7023 | NATO Primary Image Format (NPIF) |
| STANAG 7085 | Interoperable Data Links for Imaging Systems |

**Table A-3: C4ISR Related Standards**

| Reference | Title |
|---|---|
| STANAG 5516 | Tactical Data Exchange - LINK 16 |
| STANAG 5522 | NATO Improved LINK Eleven (NILE) - LINK 22 |
| ADatP-03 | NATO Message Text Formatting System (FORMETS) - Concept of FORMETS (CONFORMETS) |

**Table A-4: C2 Related Standards**

| Reference | Title |
|---|---|
| STANAG 7044 | Functional Aspects of Mission Planning Station Interface Design |
| MIL-STD-3014 | Department of Defense Interface Standard for Mission Data Exchange Formal |

**Table A-5: Mission Planning Related Standards**

## A3.0 WEAPON SYSTEM DOCTRINE

### A3.1 Weaponeering

1. Weaponeering is the process of determining the strike package composition (including aircraft types and their respective load outs) that is required to achieve the desired effect upon potential target(s). Target type, Target Location Error (TLE), weapon characteristics, and aircraft capabilities are all considered during weaponeering.

2. Weapons characteristics vary widely but overall, most aerial delivered munitions can be classified as a bomb, guided missile, unguided rocket, or projectile. A bomb is a non-self-propelled munitions that reaches its target by virtue of kinetic energy and aerodynamic forces acting upon it. Bombs may be conventional (i.e., a single non-nuclear, biological, or chemical warhead) or dispersive if filled with sub munitions such as with a cluster bomb unit. Bombs may also be guided or unguided, precision or non-precision. The trajectory or course of a guided bomb may be altered by internal or external mechanisms during flight whereas an unguided bomb relies purely on physics to reach its target. Precision bombs use a seeker to detect electromagnetic energy reflected from a target or reference point and, through processing, provide guidance commands to a control system that guides the weapon to the target. A guided missile is self-propelled munitions whose trajectory or course can be controlled in-flight. Guided missiles may be controlled by wires, data-links, or internal homing mechanisms such as an infrared or electromagnetic radiation seeker. An unguided rocket is a self-propelled munition whose trajectory or course cannot be controlled in-flight and reaches its target by virtue of kinetic energy and the aerodynamic and gravitational forces acting upon it. A projectile is a munition propelled by an external force (normally from a gun or cannon) that reaches its target by virtue of kinetic energy and the aerodynamic and gravitational forces acting upon it.

3. Weapons effects are essentially a function of warhead and fuse type versus the target’s vulnerabilities. The warhead is that part of the munition intended to inflict damage. Conventional warheads may include high-explosive types, thermobaric types, fragmentation types, shaped-charge/explosively formed projectile types, or combinations of these. The fuse is the device used to detonate, or to set forces into action to detonate the warhead under specified conditions. Fuse types may include point/impact detonation, time delay detonation, proximity detonation, and altitude detonation.

4. Weaponeering seeks to apply specific combinations of warhead and fuse types against the target’s vulnerabilities to achieve one of several specific effects: Missions conducted to destroy will damage the structure, function, or condition of a target so that it can neither perform as intended nor be restored to a usable condition, rendering it ineffective or useless. Missions conducted to disrupt will upset an enemy’s formation or tempo, interrupt his timetable, or cause his forces to commit prematurely or attack in piecemeal fashion. Missions conducted to suppress will

degrade a target's performance below the level needed to fulfill its mission objectives at a specific time and for a specified duration. Missions conducted to fix will prevent the enemy from moving any part of his force from a specific location for a specific period of time. Missions conducted to harass will disturb enemy troops, curtail enemy movement, and lower the enemy's morale. Missions conducted to neutralize will render a target temporarily ineffective or unusable. Missions conducted to delay will slow the enemy's momentum and inflict maximum damage on the enemy.

5. Generally, munitions delivery parameters are a function of altitude tactics and delivery technique. High altitude tactics are flown above 25,000 feet MSL and are normally employed to keep the attacking aircraft above the enemy's low and medium altitude surface-to-air weapons. High altitude tactics may also reduce fuel consumption, facilitate command and control, and enable weapons delivery from greater ranges. However, high altitude tactics also may enable enemy acquisition radar to detect the force earlier or make target recognition/acquisition more difficult. Additionally, unguided munitions may not be as accurate from higher altitudes. Medium altitude tactics are flown between 10,000 to 25,000 feet MSL and have most of the same advantages and disadvantages as high altitude tactics. However, visual acquisition of some targets may be enhanced and weapons accuracy of unguided munitions may improve. Low altitude tactics are flown below 10,000 feet AGL and are normally employed to keep the attacking aircraft below enemy radar coverage. Marginal weather or attacks against smaller targets may also drive the decision to employ low altitude tactics. Low altitude tactics may also be employed for terrain masking or to reduce exposure to radar-guided weapon systems. Conversely, low altitude tactics may enable the enemy's visual or acoustic detection of attacking aircraft and expose the attacking aircraft to small arms fire, anti-aircraft artillery, and man-portable surface-to-air missiles. Command and control is typically more difficult at lower altitudes.

6. Delivery techniques may include level, dive, pop-up, or loft delivery. For level deliveries, the attacking aircraft releases the munition during a wings-level pass approaching or over the target. For dive deliveries, the attacking aircraft releases the munition during a dive toward the target at the prescribed dive-angle for that munition. For pop-up deliveries, the attacking aircraft proceeds toward the target at low altitude until reaching a calculated point at which it "pops-up" to the desired altitude and executes a dive delivery (this technique is normally employed to achieve surprise). For loft deliveries, the attacking aircraft proceeds toward the target until reaching a calculated point at which it performs a loft maneuver pull-up and releases the munition. The munition then continues in an upward trajectory until reaching its apex and then follows a ballistic trajectory until impact. Like the pop-up delivery technique, loft deliveries are typically performed at low altitude and are useful to maximize standoff from the target or threats in the vicinity of the target.

7. Target marking employs visual or electronic means to aid in the proper identification and location of targets. Visual means may include pyrotechnics such as smoke and flares, tracer ammunition fired by nearby friendly forces, or laser

markers/illuminators. Electronic means may include laser designators or electromagnetic beacons.

## A3.2 Mission Types

### A.3.2.1 Close Air Support

1. AAP-6 (2007) defines close air support (CAS) as air action against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces.

2. CAS missions are performed in order to destroy, disrupt, suppress, fix, harass, neutralize, or delay enemy forces. They can be performed during day or night and in all weather conditions. CAS missions may be preplanned or immediate, but in either case normally require a qualified terminal attack controller such as a Joint Terminal Attack Controller (JTAC) or Forward Air Controller (FAC) to direct the actions of the aircraft during the attack. Terminal attack controllers employ three different types of air control to choreograph CAS attacks: Type 1, Type 2 and Type 3.

3. Under Type 1 Control, the terminal attack controller must visually acquire both the attacking aircraft and the target under attack. By visually tracking the attacking aircraft’s position and geometry in relation to the target under attack (as well as friendly forces), the terminal attack controller helps ensure first pass success and reduces the risk of fratricide. The following procedures describe a typical CAS mission performed under Type 1 Control:

a. Terminal attack controller visually acquires the target.

b. Terminal attack controller transmits a CAS Brief (9-Line or Theater Standard Brief) to the CAS aircraft.

c. CAS aircraft verifies that target coordinates correlate to the expected target area using all appropriate means such as map plot, head-up display symbology, or on-board sensors.

d. CAS aircraft confirms target elevation and location and any restrictions imposed by the terminal attack controller.

e. CAS aircraft reports inbound from the prescribed initial point.

f. Terminal attack controller marks or designates the target if practicable.

g. CAS aircraft transmits an “in” call to report maneuvering for weapons firing solution.

h. CAS aircraft visually acquires the target or mark.

i. Terminal attack controller visually acquires the CAS aircraft.

j. Terminal attack controller analyzes the CAS aircraft's position and geometry relative to friendly forces and the target under attack in order to ensure the attack will not adversely affect friendly forces and that the weapon(s) will impact the target.

k. Terminal attack controller transmits a "Cleared Hot" or "Abort" call to the CAS aircraft based on the above criteria. The "Cleared Hot" call grants weapons release clearance against that specific target while the "Abort" call directs the CAS aircraft to not release weapons.

l. CAS aircraft attacks the target or aborts.

m. Terminal attack controller evaluates the effectiveness of the attack, collects battle damage assessment (BDA), and determines if a re-attack is required.

n. Terminal attack controller reports BDA to the CAS aircraft and appropriate command and control nodes.

4. Type 2 Control is employed when the terminal attack controller desires to control individual attacks but assesses that either visual acquisition of the attacking aircraft or target at weapons release is not possible or when attacking aircraft are not in a position to acquire the mark/target prior to weapons release. Examples are night, adverse weather, high threat tactics, and high altitude and standoff weapons employment. Successful CAS attacks under these conditions depend on timely and accurate targeting data. Digital or data link systems capable of displaying aircraft track and sensor point of interest significantly enhance situational awareness that better enables the terminal attack controller to authorize weapons release when he is unable to visually acquire the attacking aircraft. The following procedures describe a typical CAS mission performed under Type 2 Control:

a. Terminal attack controller or other observer with real-time targeting information (such as an UA) "sees" the target.

b. Terminal attack controller transmits a CAS Brief (9-Line or Theater Standard Brief) to the CAS aircraft.

c. CAS aircraft verifies that target coordinates correlate to the expected target area using all appropriate means such as map plot, head-up display symbology, or on-board sensors.

d. CAS aircraft confirms target elevation and location and any restrictions imposed by the terminal attack controller.

e. When delivering GPS/INS guided weapons, CAS aircraft confirms that the selected munition has accepted the briefed target elevation and location. When using aircraft system targeting, the CAS aircraft confirms the coordinates loaded into the waypoint, offset, or target points. CAS aircraft verifies correct data is selected prior to transmitting the “in” call.

f. CAS aircraft reports inbound from the prescribed initial point.

g. CAS aircraft transmits an “in” call to report maneuvering for weapons firing solution.

h. Terminal attack controller transmits a “Cleared Hot” or “Abort” call to the CAS aircraft.

i. CAS aircraft attacks the target or aborts.

j. Terminal attack controller evaluates the effectiveness of the attack, collects BDA, and determines if a re-attack is required.

k. Terminal attack controller reports BDA to the CAS aircraft and appropriate command and control nodes.

5. Type 3 Control may be employed when the risk assessment indicates that CAS attacks impose a low risk of fratricide. Under Type 3 Control, the terminal attack controller grants a “blanket” weapons release clearance for the CAS aircraft to engage a target (or targets) that meets his prescribed restrictions. The terminal attack controller will monitor radio transmissions and other available digital information to maintain control of the attacks and he maintains abort authority throughout the attack. The following procedures describe a typical CAS mission performed under Type 3 Control:

a. Terminal attack controller transmits a CAS Brief to the attacking aircraft. The CAS Brief will include the area for attacks, restrictions/limitations, and attack time window.

b. CAS aircraft verifies that target coordinates correlate to the expected target area using all appropriate means such as map plot, head-up display symbology, or on-board sensors.

c. CAS aircraft confirms target elevation and location and any restrictions imposed by the terminal attack controller.

d. Once satisfied that the CAS aircraft has situational awareness of the target area, the terminal attack controller transmits a “cleared to engage” call to the attacking aircraft.

e. CAS aircraft attacks the target within the restrictions/limitations imposed by the terminal attack controller.

f. Terminal attack controller monitors the engagement by all means available and maintains abort authority throughout the engagement.

g. Upon completion, CAS aircraft transmits an “attack complete” call to the terminal attack controller.

h. Terminal attack controller evaluates the effectiveness of the attack, collects BDA, and determines if a re-attack is required.

i. Terminal attack controller reports BDA to the CAS aircraft (or vice-versa) and appropriate command and control nodes.

### A3.2.2 Air Interdiction

1. AAP-6 (2007) defines Air Interdiction (AI) as air operations conducted to destroy, neutralize, or delay the enemy's military potential before it can be brought to bear effectively against friendly forces at such distance from friendly forces that detailed integration of each air mission with the fire and movement of friendly forces is not required.

2. AI missions are performed in order to shape the battlespace and influence future operations by creating windows of opportunity for decisive action, restricting the enemy’s freedom of action, and disrupting the cohesion and tempo of his operations. AI missions may also deny sanctuary to the enemy and cause him to divert resources and offensive potential to defensive reactions. AI missions are pre-planned and require accurately located targets prior to execution. An AI package typically involves multiple elements of multiple fixed and/or rotary-wing aircraft armed with precision and/or non-precision weapons. Because AI targets are preplanned, AI aircraft are armed with weapons best suited to achieve the desired effects on the target. The AI package will always include a strike element but may also include a suppression of enemy air defenses (SEAD) element, a fighter/escort element, a refueling element, and/or an electronic warfare (EW) element. In many cases, the EW element is the SEAD element. The AI package is organized for either force concentration or defense in depth. Force concentration employs relatively tight formations when the air-to-air threat is low while defense in depth disperses the airborne assets for greater protection when the air-to-air threat is credible. Because of their complexity, AI missions are often rehearsed ahead of time when the situation permits. AI missions may be performed day or night, in all weather conditions, and at high, medium, or low altitude.

3. The following procedures describe a typical AI mission:

a. Mission commander conducts a mission briefing that details the mission, weather, roles of each element, friendly situation, enemy situation, command/control/communications plan, navigation plan, go/no-go criteria, abort criteria, critical information flow, and return to force procedures.

b. AI package minimizes communications and other electronic emissions during launch, rendezvous, and ingress.

c. If a flight rendezvous (including re-fueling) is required, AI aircraft join-up outside of the enemy's early warning capability. If this is not practicable, AI aircraft join-up outside of the enemy's surface-to-air weapons system envelope.

d. During ingress, AI package flies formations that provide maximum lookout, mutual support, and allows individual aircraft room to maneuver against enemy threat systems if required. AI package may also vary altitude and heading to avoid predictability.

e. During ingress, the mission commander evaluates specific go/no-go criteria based on weather, environment, threat, aircraft, and weapons status required to successfully accomplish the mission. If abort criteria have been met, the mission commander executes a timely abort in order to reduce the AI package's exposure to enemy threats.

f. EW element (when present) suppresses or neutralizes enemy early warning, communications, and/or other command and control functionality as required during ingress, at the target area, and during egress.

g. SEAD element (when present) suppresses enemy air defenses as required during ingress, at the target area, and during egress.

h. Once the target is acquired, the strike element employs level, loft, pop-up, dive, or combinations of these delivery techniques to attack the target. When laser-guided munitions are employed, one or more of the strike aircraft may "lase" the target for the other strike aircraft.

i. Whenever practicable, the AI package collects BDA to evaluate the mission's effectiveness and determine if re-attack is required.

j. AI package egresses the target area, normally via different routes than those used during ingress and in compliance with pre-briefed return-to-force procedures.

k. Whenever practicable during egress, AI package passes BDA and or other in-flight reports as required to inform the commander's decision-making and situational awareness.

l. Mission commander conducts a mission debrief

### A3.2.3 Armed Reconnaissance

1. JP 1-02 defines Armed Reconnaissance (AR) as a mission with the primary purpose of locating and attacking targets of opportunity in assigned general areas or along assigned ground communications routes, and not for the purpose of attacking specific briefed targets.

2. AR missions are performed in order to identify previously un-located enemy forces and destroy them before they can threaten friendly forces or to search for and destroy high-payoff, high-value, and/or time-critical targets. AR missions are also suitable for reconnoitering and defending large areas not suited to friendly surface forces. An AR package typically involves an element of two-to-four fixed or rotary-wing aircraft armed with ordnance that is optimized against a variety of potential or expected targets. AR aircraft employ formations that maximize target detection capability while managing threat mitigation for their assigned area. AR mission altitudes vary based on the target size and threat. When AR aircraft fly in section, the primary search area is normally between the aircraft, which allows for overlapping search sectors and facilitates mutual support. If four aircraft are employed, a box formation is often used with the trail element elevated. Each aircraft is assigned specific search responsibilities based on system capabilities.

3. Unlike air interdiction missions, AR missions often require searching for targets without accurate targeting information ahead of time. To facilitate such conditions, three basic search methods are employed: area, route, and specific. Area searches are limited to a specific area and are normally used to find targets that may be dug-in or to attack targets not previously located before aircraft launch. Route searches are employed to search a specific line of communications (LOC) and attack enemy activity along critical avenues of approach or targeted areas of interest. Specific searches are utilized to locate particular targets (such as high-value, high-payoff, or time-critical) or to search specific areas or targeted areas of interest.

4. Once a target is located and identified, the AR aircraft has three basic options for the attack: direct, transition, or delayed. With the direct attack, the target can be engaged directly from the search profile. With the transition attack, the identified target is too close to attack directly from the search profile and the AR aircraft must transition to a more suitable position/geometry from which to attack. Finally, the delayed attack is employed when the surface-to-air threat prohibits a direct or transition attack and the AR aircraft must egress the target area and return using tactics that limit exposure to the threat.

5. Two important factors for effective AR are reliable communications and timely information flow between AR aircraft and the appropriate command and control nodes. This enables the AR aircraft to report their observations to decision-makers and update the enemy situation, satisfy critical information requirements, or influence the friendly scheme of maneuver. It also enables command and control nodes to provide updates or intelligence derived from other sources to the AR aircraft, which may aid their target search.

6. The following procedures describe a typical AR mission employing two aircraft (for AR missions employing four aircraft, assume a section for each individual aircraft described below.):

a. AR aircraft establish and maintain communications and timely information flow with appropriate command and control nodes throughout the mission.

b. AR aircraft commence search in their assigned area or along their assigned route.

c. AR aircraft fly formations that maximize target detection capability, provide maximum lookout, mutual support, and allow individual aircraft room to maneuver against enemy threat systems if required.

d. AR aircraft detect a target.

e. One of the AR aircraft prepares to attack the target while the other provides cover/overwatch.

f. The attacking AR aircraft performs a direct, transition, or delayed attack as appropriate.

g. One or both AR aircraft assess the effectiveness of the attack and collect bomb hit assessment or BDA if able.

h. If required, one of the AR aircraft performs a re-attack while the other provides cover/overwatch.

i. AR aircraft report the results of the engagement to the appropriate command and control node as soon as practicable.

### A3.2.4 Strike Coordination and Reconnaissance

1. MCRP 5-12A defines Strike Coordination and Reconnaissance (SCAR) as a mission flown for the purpose of acquiring and reporting deep air support targets and coordinating armed reconnaissance or air interdiction missions upon those targets.

2. SCAR aircraft acquire, report, and coordinate attacks against targets in an assigned area. This area may be defined by a box or grid where worthwhile potential targets are known or suspected to exist, or where mobile enemy surface units have relocated because of surface fighting. SCAR aircraft typically discover enemy targets and then provide a target mark and/or talk-on for other attack aircraft. SCAR aircraft perform a similar function for AI missions that the forward air controller (airborne) (FAC(A)) provides for CAS missions, though the SCAR function should not be confused with FAC(A) function as it does not require the detailed integration with surface forces for the delivery of munitions. SCAR missions are similar to AR missions in most respects; the key difference is that the SCAR aircraft is normally equipped with the ability to mark targets or provide a talk-on for other attack aircraft.

3. The following procedures describe a typical SCAR mission:

a. SCAR aircraft establish and maintain communications and timely information flow with appropriate command and control nodes throughout the mission.

b. SCAR aircraft commence search in their assigned area or along their assigned route.

c. SCAR aircraft fly formations that maximize target detection capability, provide maximum lookout, mutual support, and allow individual aircraft room to maneuver against enemy threat systems if required.

d. SCAR aircraft detect a target.

e. SCAR aircraft report the target's location, elevation, description, activity, and any other relevant information to the appropriate command and control node (or directly to attack aircraft if able).

f. Appropriate command and control node directs attack aircraft to establish communications with the SCAR aircraft.

g. Attack aircraft establish communications with the SCAR aircraft.

h. SCAR aircraft provides an update of the enemy situation and directs attacking aircraft to position(s) that facilitate the appropriate attack heading, weapons employment geometry, and/or threat mitigation.

i. SCAR aircraft marks the target and/or provides a verbal "talk-on" to the attacking aircraft.

j. Attack aircraft engage the target.

k. SCAR aircraft evaluates the effectiveness of the attack, collects BDA, and coordinates re-attacks as required.

l. SCAR aircraft report the results of the engagement to the appropriate command and control node as soon as practicable.

### A3.2.5 Suppression of Enemy Air Defense

1. AAP-6 (2007) defines Suppression of Enemy Air Defense (SEAD) as that activity which neutralizes, temporarily degrades or destroys enemy air defenses by a destructive and/or disruptive means.

2. Effective SEAD enables friendly aircraft to operate in airspace defended by enemy air defences. SEAD is either pre-planned or reactive and may be performed simultaneously or sequentially with other air missions such as CAS or AI, or as a stand-alone offensive counter-air (OCA) mission. Pre-planned SEAD is allocated or apportioned through the normal air tasking order (ATO) cycle as an OCA mission and

targets fixed enemy air defense assets that have been accurately located ahead of time. Reactive SEAD (RSEAD) suppresses or destroys “pop-up” surface-to-air threats that are too urgent to wait for the next ATO cycle. RSEAD is further subdivided into three types: Immediate, Deliberate, and Alert.

a. Immediate RSEAD occurs when a friendly aircraft locates an enemy air defense asset and targets it during the conduct of another mission. This affords the timeliest response to “pop-up” enemy air defense assets.

b. Deliberate RSEAD is a coordinated response to “pop-up” enemy air defenses with assets diverted from other missions with enough time to organize such a response. This allows for a coordinated, combined arms attack. Disadvantages include the possible employment of less than optimum ordnance and the potential requirement for attackers to enter threat engagement envelopes. Deliberate RSEAD is often the response when an immediate RSEAD strike is neither feasible nor sufficient.

c. Alert RSEAD responds to threats requiring dedicated planning. Planners may use alert RSEAD against a particular surface-to-air system, when requiring a multi-axis attack, or after having discovered multiple previously un-prosecuted air defense assets. Alert RSEAD may employ airborne alert or strip alert assets. Advantages include: dedicated planning, proper weaponeering, and using dedicated platforms or weapon systems (i.e., no assets diverted from other missions). Disadvantages include the lack of a timely response, timely threat locations, and dedication of assets to SEAD which may have been employed otherwise.

3. SEAD is also categorized as either destructive or disruptive. Destructive SEAD suppresses enemy air defenses by destroying the targeted system. Disruptive SEAD employs electronic attack assets to temporarily deny, degrade, deceive, delay or neutralize the targeted system.

4. Destructive, pre-planned SEAD missions are rather similar to an AI mission, though the target in this case is specifically an enemy surface-to-air threat. The following procedures describe a typical destructive, pre-planned SEAD mission: Mission commander conducts a mission briefing that details the mission, weather, roles, friendly situation, enemy situation, command/control/communications plan, navigation plan, go/no-go criteria, abort criteria, critical information flow, and return to force procedures.

a. SEAD package minimizes communications and other electronic emissions during launch, rendezvous, and ingress.

b. If a flight rendezvous (including re-fuelling) is required, SEAD aircraft join-up outside of the enemy's early warning capability. If this is not practicable, SEAD aircraft join-up outside of the enemy's surface-to-air weapons system envelope.

c. During ingress, SEAD package flies formations that provide maximum lookout, mutual support, and allows individual aircraft room to manoeuvre against enemy threat systems if required. SEAD package may also vary altitude and heading to avoid predictability.

d. EW element (when present) suppresses or neutralizes enemy early warning, communications, and/or other command and control functionality as required during ingress, at the target area, and during egress.

e. Once the target is acquired, the SEAD package employs level, loft, pop-up, dive, or combinations of these delivery techniques to attack the target.

f. When laser-guided munitions are employed, one or more of the SEAD aircraft may "lase" the target for the other aircraft.

g. The SEAD package may also employ anti-radiation missiles to attack radar systems that provide surface-to-air missile targeting data.

h. Whenever practicable, the SEAD package collects BDA to evaluate the mission's effectiveness and determine if re-attack is required.

i. SEAD package egresses the target area, normally via different routes than those used during ingress and in compliance with pre-briefed return-to-force procedures.

j. Whenever practicable during egress, SEAD package passes BDA and or other in-flight reports as required to inform the commander's decision-making and situational awareness.

k. Mission commander conducts a mission debrief

5. The following procedures describe a typical destructive, immediate RSEAD mission:

a. During the course of another mission, the friendly aircraft detects an enemy surface-to-air threat that can be targeted immediately.

b. The friendly aircraft performs a direct, transition, or delayed attack as appropriate.

c. The friendly aircraft assess the effectiveness of the attack and collects BDA if able.

d. If required/able, the friendly aircraft performs a re-attack.

e. The friendly aircraft reports the results of the engagement to the appropriate command and control node as soon as practicable.

6. The procedures for a typical destructive, deliberate RSEAD mission are similar to those of an immediate RSEAD mission, though the attacking aircraft are diverted from other missions.

7. The procedures for a typical destructive, alert RSEAD mission are similar to those of a pre-planned SEAD mission, though executed once a previously un-located surface-to-air threat has been detected.

### A3.2.6 Joint Personnel Recovery

Royal Air Force Air Publication AP3002 defines Joint Personnel Recovery (JPR) as the aggregation of military, civil and political efforts to obtain the release or recovery of personnel from uncertain or hostile environments and denied areas whether they are captured missing or isolated. It is comprised of Search and Rescue (SAR) and Combat Recovery (CR) operations. Figure A-5 depicts the different types of possible operations as they relate to location and threat. Since the threat environment may range from a low risk environment through to a situation where an opposing force is attempting to prevent the recovery, JPR operations vary widely:

a. Search and Rescue Operations recover personnel in distress where no threat is posed by hostile interference.

b. Combat Recovery is the recovery of isolated personnel in distress and/or equipment, from an environment in which a threat is posed by hostile interference, who are not trained and/or equipped to receive Combat Search and Rescue (CSAR).

c. Combat Search and Rescue is the recovery of isolated personnel in distress, from an environment in which a threat is posed by hostile interference, who are trained and equipped for CSAR. CSAR is amongst the most time-sensitive of operations. After 4 hours on the ground the chance of recovering a survivor in combat is historically less than 20%.

d. Special Forces (SF) Operations. SF may conduct unconventional assisted recovery tasks within their own planning and execution criteria.

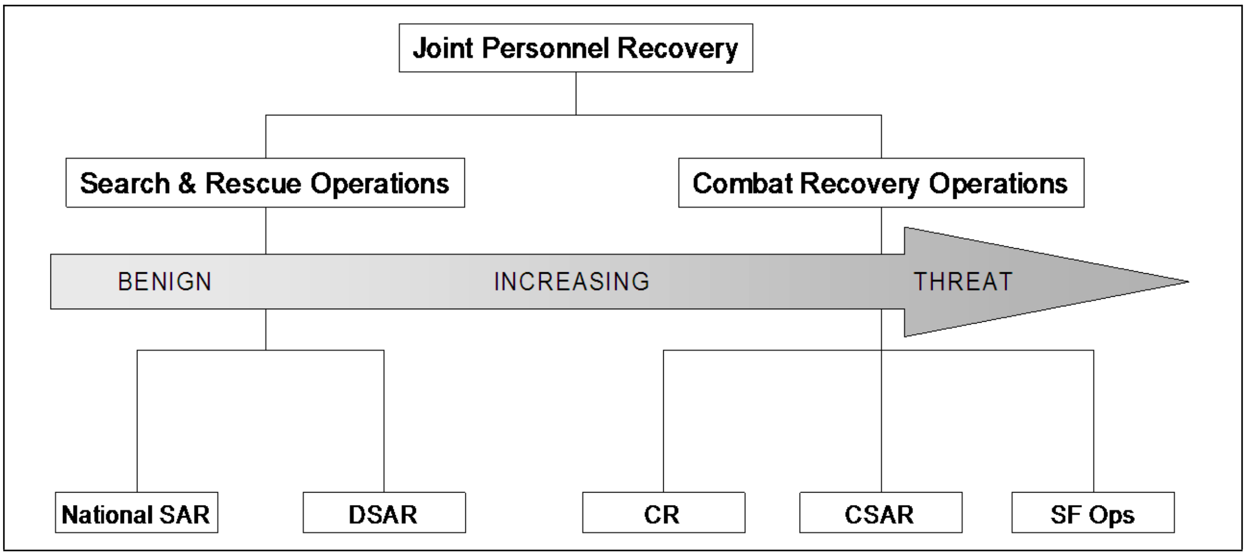


**Figure A-5: Joint Personnel Recovery Operations**

### A3.2.6.1 Combat Recovery Planning and Execution Considerations

1. Threat Considerations. The threat environment defines the enemy's ability to detect and engage rescue forces which influences the appropriate recovery techniques or methods used.

   a. Nominal Threat Risk. Threats have either been destroyed, suppressed, negated or are widely scattered or even non-existent and recovery can usually take place with a minimum of support assets.

   b. Increased Threat Risk. Significant threats are active requiring extensive mission planning for threat avoidance or degradation by suitable support assets such as Rescue Escort (RESCORT), SEAD, Rescue Combat Air Patrol (RESCAP) and other strike assets.

2. Mission Planning. Threat avoidance requires thorough mission planning interfaced with real time threat information and precise C2 coordination. Specific information requirements will include, threat, weather, terrain, objectives, codes and authentication, safe passage corridors and refuelling points. Moreover, considerations must be given to the Host Nation and other component and multinational force capabilities, during all phases of planning.

3. Mission Execution. Once the mission is assessed as feasible, participating units will generally be tasked from ground or airborne alert. Some rescue forces may be forward located to decrease flight time and refuelling stops enroute to anticipated recovery areas. Key elements of a recovery force may include the following:

   a. Rescue Mission Commander (RMC). The RMC establishes communications, locates, authenticates and protects isolated personnel until recovery forces arrive. He controls all assets involved in the recovery including RESCAP, SEAD, additional strike assets and Air-Air Refuelling (AAR).

b. RESCORT. RESCORT aircraft provide navigational assistance, route sanitization and armed escort for recovery vehicles. Ideally, they should be tactical aircraft capable of operating in the same environment as recovery vehicles and be proficient in rendezvous procedures, escort tactics at medium and low levels, and defence of recovery assets during mission execution. RESCORT may be provided by specialist aircraft such as the A-10, or other CR qualified fixed and rotary wing aircraft.

c. Airborne Mission Coordinator (AMC). An AMC coordinates the flying mission and acts as an airborne communications and data relay platform between the Joint Air Operations Center (JAOC) and rescue forces. AMC is usually performed by an AWACS or JSTARS.

d. On-Scene Commander (OSC). The OSC initiates rescue efforts in an objective area until rescue forces arrive. His initial actions include attempting to establish communication, locating and authenticating isolated personnel, and passing essential elements of information to the AMC. The OSC role transfers to the RMC or lead recovery vehicle on arrival.

e. FAC(A). The FAC(A) controls air strikes in close proximity to the isolated personnel and may be able to provide current and accurate assessment of enemy activity as well as functioning as the OSC.

f. ISR Support. Surface, air and space based ISR assets offer the capability for detecting and locating isolated personnel, as well as monitoring threat systems in the objective area.

g. SEAD. SEAD forces can minimize the surface-to-air threat; however, interoperable communications between SEAD forces, rescue forces and ISR assets are critical.

4. Locating Isolated Personnel. Several methods exist to determine location such as area electronic surveillance, reconnaissance, C2 aircraft, global satellites, wingman reports and battlefield radar control posts and centres. Recovery vehicles, aircraft and RESCORT aircraft equipped with personnel locator systems can also pinpoint the isolated personnel's position when isolated personnel are equipped with specialized communications devices. The concept of actual search associated with CR should be considered extremely limited in scope. In most cases, the search will be primarily electronic as the vulnerability of rescue resources in a threat environment will preclude extended aerial search operations in all but a permissive

environment. As such most CR rescue efforts will be primarily dedicated to recovering isolated personnel from previously identified geographic positions.

## A4.0 ARCHITECTURE

### A4.1 Hardware/Electrical Standard Interfaces – Weapon-to-Platform

#### A4.1.1 MIL-STD 1760

1. MIL-STD-1760 was the original standard interface for Precision Guided Munitions (PGMs). It was developed in the late 1970s and 1980s for initial deployment with a variety of weapons, most notably the Joint Direct Attack Munitions (JDAM). This interface was designed from the beginning to be a standard, with capability that was beyond the combined needs of all weapons then anticipated for its use. It was designed for rugged use on tactical weapons, and for the widest possible environmental envelope. Its signal set provided a lot of power in several different formats, a complete set of discrete signal lines, analogue signals ranging from acoustic through L-band RF frequencies, and digital data through a then-fast MIL-STD-1553 serial data bus. All of these capabilities had a price in terms of the size of the connector, whose signal carrying “insert” measured over 35mm in diameter, but at the time, precision weapons were large, mostly in the 1000 kg class. The 1760 interface has proven suitable for weapons down into the 220 kg class, most notably the GBU-38 500 lb JDAM. Its design is robust enough that it has been used by all PGMs in that size class, and all platforms carrying them, to date.

2. A characteristic of 1760’s development timeline is that its primary data path is a one-megahertz dual-redundant MIL-STD-1553 data bus, which is shared by up to 32 individually-addressed weapons on the bus. For all platforms but large bombers, there is typically only one bus on the aircraft.

#### A4.1.2 Miniature Mission Store Interface

1. In the 1990’s, improvements in the performance of Global Positioning System (GPS) and targeting systems led to significant decreases in total miss distances for GPS-guided weapons. At the same time, aircraft unit prices soared while defense budgets were dropping with the conclusion of the Cold War, leading to a strong desire for the ability of fighter/bombers to prosecute more aim points per mission. Finally, improvements in electronics and computing technology were allowing affordable sophisticated guidance systems to be integrated into smaller and smaller weapons. The Small Diameter Bomb (SDB) is an example of an emerging class of weapons that combine the full sophistication of previous precision guided munitions into much smaller weapons. SDB allows aircraft to carry four weapons per store station, with approximately the same total weight and drag as a 500 kg JDAM or a Joint Standoff Weapon (JSOW). While the warhead of SDB is much smaller than those of JDAM or JSOW, great improvements in delivery accuracy render it effective against a large fraction of tactical targets.

2. SDB included the development of both the weapon itself and a carriage system which would carry four SDBs on a single aircraft store station. Because SDB is in the 100 kg weight class, it is considered too small to support a MIL-STD-1760 connection. Development of a new interface was begun during SDB's risk reduction phase of development. This interface would be between the weapon and the carriage system. Since the carriage system was to be mounted on aircraft store stations that were equipped with MIL-STD-1760 connectors, it was clear that the design of the new interface would have to support a role as a subordinate interface to MIL-STD-1760. That meant in general that power, data and discrete signals would be constrained by what was available in MIL-STD-1760.

3. The USAF coordinated with the Society of Automotive Engineers (SAE) International to develop a new connector and interface that would support the SDB. SAE agreed to undertake the development with the understanding that it would develop a general-purpose interface that would be adaptable to future uses, as was MIL-STD-1760. While the competitive development of SDB dictated that the interface for that specific program was selected by the winning contractor, and was purpose-designed to meet program-specific requirements and stringent cost goals, the SAE effort eventually led to the Miniature Mission Store Interface (MMSI), a connector generally suited to weapons in the 50-100 kg class.

4. The MMSI interface has been designed with signals that can be directly mapped to the MIL-STD-1760 interface. Certain reductions in signal set were driven by the requirement for a smaller connector in the same rugged design class, which required fewer contacts:

a. 1760's dual-redundant MIL-STD-1553 data buses were reduced to a single point-to-point connection.

b. 1760's reserved contact locations for fiber optic connections, which have never been implemented, were eliminated.

c. 1760's low-bandwidth and two high-bandwidth analog signal pairs were reduced to a single signal pair.

d. The names of 1760's "Interlock" and "release consent" were changed to "store mated" and "safety enable" respectively, which were believed to be more accurate descriptions of the (unchanged) functions of the signals.

e. 1760's interlock return signal was eliminated; the safety enable power return was selected as the reference for the safety enable discrete.

f. The address lines in the 1760 interface allow the weapon to determine which messages on the 1553 digital buses apply to that weapon. Since the MMSI interface uses individual point-to-point serial data lines, address identification is unnecessary; all incoming messages are intended for the MMSI weapon receiving them. However, the 1760 address lines also allow the weapon to determine the presence of the carriage system, in that one of the address lines, or the address parity line, will be at low impedance relative to the address return. This function is replaced in the MMSI by the replacement of the entire seven-pin address interface with a single “carriage mated” discrete, referenced to the operating power return.

g. 1760’s “28V DC Power 1” and “28VDC Power 2” are renamed “Operating Power” and Safety Enable Power” respectively, in alignment with their purposes, and require less current to be provided from the host/carriage system than does 1760.

h. 1760’s high-power 115V 3-phase AC and 270VDC power supplies have been eliminated in MMSI as redundant and not essential for the smaller weapons.

5. The impact of the design of MMSI was to go from a Shell Size 25 to a Shell Size 15, with an “insert” (rigid insulating component that carries the contacts) diameter reduction of 40% and an insert area reduction of 65%, and a contact count of 21; a reduction of 30% with respect to 1760.

6. From a functional architecture standpoint, the only real change was to the analogue and digital data. Instead of multiple analogue and multiple digital signal paths, the MMSI supports one high-speed analogue/digital data path, and one primary digital data path that is based on the Fibre Channel protocol, and operates at ten megahertz, supporting a single weapon. The increase in effective bandwidth is on the order of 20 or better, dependent upon the mix of messages and weapons on the platform. The MMSI was formally published as SAEs AS-5725.

**A4.1.3 Interface for Micro Munitions**

1. In the 2005 time frame, many defense laboratories and contractors were taking all of the targeting precision and electronic/computing advances to the next level, and developing munitions as small as 5 kg and 50 mm diameter that had equivalent sophistication (and need for a launch platform interface) as the earlier JDAM/JSOW class weapons. On request from the USN, SAE took up the challenge to develop a new interface that would support these weapons, and looking to the future, to weapons as small as 2.5 kg and 40 mm diameter. This interface was, like MMSI, to be designed to be architecturally subordinate to 1760 or MMSI interfaces. The Interface for Micro Munitions (IMM) interface was formally published as SAE's AS-5726.

2. The requirement to support very small weapons drove a premium on dramatically decreasing both the size and the total number of signals/contacts in the interface. This led to several basic design approaches:

a. Ruthless elimination of redundant capability.

b. Multiplexing functions on signal paths.

c. Increasing the nominal voltage, and tightening the minimum voltage, of operating power.

d. The decision to separate the “mating” interface, by which the weapon is connected to the launch platform, from the “de-mate” interface, which separates when the weapon is launched or released. Because it is isolated from the mating interface, the “de-mate” interface can be as simple as the solder contact patch at the end of a narrow flex cable, which rips off of the weapon at launch. This allows great flexibility of design, in both weapons and carriage/launch approaches, because the connector defined by the standard does not have to separate, one half staying with the weapon, at launch.

3. The aggressive approach allows IMM to maintain full equivalent functionality with MMSI and 1760, with only seven signals/contacts, size 22 or smaller. The initial interface connector being considered for the IMM is MIL-STD-81511, shell size 10, which is roughly equivalent of a shell size 9 in the connector series used by 1760 and MMSI. As a comparison, this connector’s “insert” is roughly a third the diameter and a tenth of the area of 1760, and half the diameter and a third of the area of MMSI. The decrease in available power is appropriate for these much smaller weapons, but is less than would be expected because the well-regulated voltage, with a significantly higher minimum voltage, allows the weapon much more usable design power for the contact size. IMM also has the ability for the weapon to request doubled power voltage, called “Class 2 Power”, from launch aircraft carriage systems.

### A4.2 Messaging Standards – Weapon-to-Platform

#### A4.2.1 Weapon Complementary Identification and Recognition

All general-purpose weapon interfaces that can support more than one kind of weapon, and all weapons whose interface supports multiple platforms, require the exchange of some early identification of the correspondent to whom they are talking. This is necessary because the behaviour of both the weapon and the platform tend to differ depending on which entity is on the other side of the interface. In the MIL-STD-1760 stores, this mutual self-identification is normally achieved by the exchange of user-defined digital messages, in which the platform tells the weapon who it is, and asks the weapon to confirm its identity in return. These messages, known as “Aircraft Description” (1R) and “Weapon Description” (1T), allow each entity to configure its interface to properly support the other. Therefore, these messages are typically among the very first exchanged when a weapon is powered up.

#### A4.2.2 Data File Transfer

1. Data file transfer is increasingly required as a part of weapon employment, for two reasons. First, the weapon will require mission-specific information that may

include its own current condition (e.g., coordinates and velocity vector, air pressure and temperature, launch platform, etc.), the target they are attacking (e.g., coordinates, velocity vector, description, etc.) and other mission parameters (e.g., flight route, payload settings, GPS constellation updates, post-paunch data link parameters, terminal attack profile, etc.). Second, since weapons are often “wooden rounds” (sealed inside storage canisters until immediately before launch), they may require updates to their operating software. If updates cannot be installed by other means, they may have to be installed by the launch platform.

2. Typically, this sort of data is provided in structured files that are defined in the weapon’s mission planning process, and downloaded to the weapon over its interface. Some files are generic enough to be built once and downloaded to many weapons, such as software updates, data link network load files, and GPS almanac and ephemeris data. Other files are specific to the weapon type and each particular mission.

### A4.2.2.1 File Transfer Protocols

1. Early versions of the original standard interface, MIL-STD-1760, used the MIL-STD-1553 serial data bus. This standard allows only for the transfer of messages consisting of up to 29 16-bit data words, wrapped in three or more 16-bit bus control words. Users of MIL-STD-1760, needing to transfer files, developed a file transfer protocol based on a sequenced exchange of MIL-STD-1553 data messages managed by MIL-STD-1553 control messages. This protocol is known as “mass data transfer”. The protocol uses 1553 messages to set up, monitor, correct errors and close out transfers, collectively defined as “Transfer Control” (14R) and “Transfer Monitor” (14T) messages. In MIL-STD-1760E, the file transfer process using this mass data transfer protocol is defined in Appendix C.

2. The other, more recently developed interfaces exclusively use the same Fibre Channel protocol that was adopted as a supplemental digital interface for MIL-STD-1760 in its revision E. Unlike MIL-STD-1553, the Fibre Channel has its own native file transfer protocol.

3. The controller of any interface, on its launch platform side, controls the transfer of files to the weapon.

#### A4.2.2.1.1 Use of MIL-STD-3014

1. While 1760 mass data transfer and Fibre Channel file transfer protocol define how to transfer files, MIL-STD-3014 “Department of Defense Interface Standard for Mission Data Exchange Format,” known colloquially as “MiDEF” (pronounced “my’-deaf”) standardizes the structure of weapon mission data files, so that file developers need only understand which data content each weapon needs, without having to define standard formats for each weapon’s files. MiDEF is a publicly-released standard, fully available to all NATO countries and contractors.

2. MiDEF was developed within the US DoD because legacy weapon-to-aircraft interfaces defined not only the content but the detailed format of mission data files for the weapons. As a result, the aircraft software was coded as a function of the detailed mission data of each weapon, even though the content and structure of that weapon data was, for the most part, irrelevant to the aircraft. The weapon was dependent upon knowing the specific mission data file, block and record number of each specific transfer; position in the file was used by the weapon to identify specific data content. The challenge arose when updates to the weapon software required changes to the mission data they received. Even minor updates to the weapon mission data files, which were functionally transparent to the launch aircraft, were tied to aircraft software development cycles. The idea behind MiDEF was that, regardless of the content of the file, all MiDEF files can be treated by platforms simply as variable-length files of unknown content. As a result, the weapon's interpretation of data content in a MiDEF file is based on very simple parsing of the file header and its table of contents. As a result, a platform can treat all MiDEF files, for all weapons that accept them, exactly the same. One set of platform software code supports the transfer of mission files for all weapons that use MiDEF. Further, changes to a weapon's mission file content or organization is transparent to the platform, and can be driven solely based on weapon program cost and schedule.

3. MiDEF is designed for compactness and ease of use by the file user, the weapon. While architecturally similar to file standards like Extensible Mark-up Language (XML), which are designed for a peer-to-peer environment and balance workload between file creator and consumer, MiDEF places more burden on the file creator (typically a weapon's mission planning software) to make processing easier for the file's consumer (typically a weapon).

4. Similarities between MiDEF and XML are:

  a. Fully "nestable" design, where the basic file unit can carry subordinate units of the same structure, and can be carried within superior units of the same construction, without inherent limit.

  b. Use of labelled data entities, including both strongly-encouraged standard entities defined by a controlled, published registry, and the freedom of user-defined data entities under controlled conditions.

5. Differences between MiDEF and XML are:

  a. While XML is defined by ASCII alphanumeric characters, all critical MiDEF data entities are byte-aligned native binary entities, which result in files that are significantly more compact than XML files, even after XML files are compressed.

  b. While the basic unit of XML is defined by a "start tag" and "end tag," MiDEF's basic unit (a "module") starts with a compact header that defines the module's size, and lists the "table of contents" of the module by each registered entity's 16-bit "Class Code". This architectural design allows the file's consumer to ingest files and each data entity with foreknowledge of their size and purpose. This makes for much simpler parsing in the weapon, although it does require file creators to edit the headers of all superior modules every time it edits any individual module.

#### A4.2.2.2 Formats of Files to be Transferred

1. Historical convention has led to a de facto common format for GPS almanac and ephemeris files. That common format has been codified in the UAI interface and is being considered for the NATO UAI standard. Other mission data files for weapons in the UAI interface are defined simply as MiDEF-compliant files. Platform mission planning module interfaces are responsible for coordinating target and mission data with weapon mission planning modules, and requesting either the data, in Joint Mission Planning System (JMPS) standard XML data entities, or requesting completed MiDEF files from the weapon modules. UAI has a core service module that converts JMPS XML files to MiDEF files, which can be used by both weapon and platform modules.

2. Positive control of formats for MiDEF files fully addresses file header format, but for the data content carried below the header, MiDEF requires only that there be a direct correlation between the header's Entity List (the "table of contents" of the data) and the data entities themselves. Therefore, normally the order of the data is not critical, and optional data can be simply not sent, which allows the file to be dramatically smaller than fixed-size legacy files, whose data are defined by their position in the fixed-size file.

3. In MiDEF, each data entity is defined by a Class Code, which allows file consumers to know the size and definition of those data elements. Data entities can be one of three basic types. Primitive data elements have a fixed size in bytes, a specific definition for interpretation of their bit patterns, and represent a single item of data, for example a target latitude. Concatenated data elements are also a fixed size in bytes, and are defined as ordered sequences of primitive data elements. As an example, a Target 3D Coordinate Concatenated data type is defined as a Target Latitude followed by a Target Longitude, followed by a Target Height Above Ellipse. Concatenated data types reduce the size of the element list and the complexity of processing for groups of primitive data elements that are commonly associated, without tying each such group to other, non-associated data.

4. The final data type in MiDEF is the module. A module consists of a header followed by data. All files are constructed as modules. Any file may contain subordinate modules as data entities, and any subordinate module may contain its own subordinate modules. Each module may contain up to 4 million subordinate data entities, in any mix of primitive, concatenated and module types. Data can be added or subtracted as required, simply by adding them or removing them from the file, and adding or removing their respective class code from the Entity List.

5. This flexible, real-time interpretable structure allows mission files to be only as large as each individual mission requires, and allows their data content to be easily adjusted as weapon software evolves.

#### A4.2.2.2.1 Target and Mission-Specific Scalar Data

1. Mission data varies with each weapon type, and in many cases, with the needs of each specific mission.

2. Target-specific data may include such entities as:

   a. Target WGS-84 coordinates (latitude, longitude, and height above ellipsoid).

   b. Target composition, wall thickness, layer counts, etc.

   c. Target environment (temperature, nearby objects, etc.).

3. Mission-specific data may include such entities as:

   a. Route waypoints and route leg behaviour.

   b. Atmospheric data (winds, temperature, pressure, cloud layers, etc.).

   c. No-fly and no-impact zone definitions.

   d. Attack profile (impact heading, impact dive angle, impact speed).

   e. Payload/fuse settings.

   f. Data link parameters (network, channel, controller ID, EMCON timing, etc.).

   g. Laser designator coding and countermeasure rejection parameters

   h. Seeker parameters (polarity, zoom setting, scan pattern, turn-on time, etc.).

#### A4.2.2.2.2 Target Reference Data for Seeker (e.g., Image)

1. Target reference data is very dependent upon the type of terminal seeker in the weapon, and also upon the type of targeting sensor providing the data. Depending on the target recognition algorithm, the weapon seeker and targeting sensor need not necessarily be of the same type.

2. Target reference data may include scalar data:

   a. Target class or type (such as Challenger tank or Ticonderoga Cruiser).

b. Target dimensions.

c. Target emission characteristics (frequency, pulse width and repetition frequency, etc.).

3. Target reference data may be vector data:

a. Image: pixel, brightness/color, line length, lines per field, interlace profile.

b. Image point/axis of view and/or relationship to WGS-84 coordinates.

c. Edge map: line segment start & stop coordinates, polarity strength/direction.

**A4.2.2.2.3 GPS Almanac, Ephemeris, Crypto and Satellite Status Data**

As was mentioned before, there are several types of data needed to initialize a GPS receiver. These data are of significant size in the aggregate, and come from several sources. Typically, they are loaded to the weapon as a series of files:

a. GPS Almanac - A basic definition of the currently active satellites; their specific identifications and accurate orbits. This data is required for each of the transmitting satellites, at least 24 in all. This data is relatively stable, and can be downloaded from secure and non-secure websites. By itself, almanac data would serve to provide GPS system performance on the order of the old LORAN system.

b. GPS Ephemeris - This data identifies the subtle departure of each satellite from the orbit defined in the almanac. Improvements in the quality and timeliness of this data define the real performance of the GPS constellation. This data is like bakery bread. Useful as much as a day old, but best fresh out of the oven. It is typically loaded as part of mission planning just before launch platform departure, and where possible, it is updated by the reception data embedded in real-time GPS satellite broadcast signals immediately prior to weapon release.

c. GPS Cryptological Data - The highest performance aspects of the GPS system depend upon signals that are encrypted. GPS receivers need decryption algorithms, and periodically updated crypto key data, in order to receive and use that data. GPS Crypto Data is generally managed by national security organizations, and delivered to users through well established, secure processes. It is presumed that weapons will take advantage of the GPS crypto delivery processes of the systems that employ them, since the overwhelming majority of GPS-capable weapons will be delivered by GPS-capable platforms.

#### A4.2.2.2.4 Weapon Data Terminal Initialization

1. For those weapons requiring post launch data communication, the respective data terminals must be initialized. Weapon data terminal initialization details are highly dependent upon the radio frequency encoding protocols (sometimes termed “waveforms”) that they employ and the communication protocol and message format they employ. Two of the more common message formats are LINK-16, defined by STANAG 5516, and the Variable Message Format (VMF,) defined by MIL-STD-6017, carried over the UHF waveform defined by MIL-STD-188-220 using the header format defined by MIL-STD-2045-47001.

2. In each data link protocol, the weapon needs to know its own identification on the link, and the identification of its controller and any other link participants with whom it is authorized to communicate. The weapon also needs to know the parameters (i.e., frequencies, channels, codes, waveform format options, protocol options, etc.) under which it will operate on the link. Finally, most links are encrypted in some form, and the weapon must receive the encryption and decryption key data its algorithms will use to participate in the link during the time period in question.

### A4.2.3 Platform-to-Weapon Control & Status (Operator-Independent)

During the pre-launch phase some weapon to platform interfaces do not involve the operator. Following a decision to power up and initialize the weapon, processing for these operations and the interface activity that supports it is automatic. The following paragraphs provide a summary overview of the weapon pre-launch interface.

#### A4.2.3.1 Initialization & Alignment of GPS, INS and Bus Clocks

1. Most weapon-to-platform interfaces have critical timing parameters; to communicate on the interface the weapon listens to incoming messages, and aligns its interface clock to the received messages, typically to a leading or falling edge of a specific digital word on a serial interface.

2. The GPS receiver uses precise time as the basis for navigation; it is dependent upon the fact that GPS radio signals travel roughly 1/3 meter per nanosecond. The quality of the current global time that can be passed to the weapon over its interface can determine the “search space” over which the GPS receiver must look when acquiring its first signals, and precise time, leading to a small search space, speeds the acquisition of that signal, especially in a noisy or hostile radio frequency environment. Weapon interfaces generally have a means to digitally pass the current “GPS time” accurate to some fraction of a second. In additions, the interfaces may have a means of providing a precise “time hack,” based on the leading or falling edge of a pulse on a discrete signal line, or through a known, standardized relationship between a particular rise or fall in a particular digital word and the digitally transmitted fine-resolution time.

3. Some data links, such as LINK-16, are synchronous, and require precision time data similar to those of GPS, for similar purposes. Weapon interfaces supplement the processes they use for GPS time initialization, to

provide the data link time references to their data link receivers.

#### A4.2.3.2 Air and Environmental Data

Weapon navigation and autopilot systems perform better if they know the precise air conditions at launch and their ability to predict an accurate flight path can be enhanced if they get accurate air data to describe their entire flight path.

#### A4.2.3.3 Weapon Health & Status Reporting

1. Launch platforms need current health and status data from their weapons, especially since, for many weapons, significant timelines are required from initial power-on to weapon ready. Also the interactive exchange of commands and responses during the launch process is dependent on weapon processes that can take anywhere from significant fractions of a second to many seconds (which can seem like hours to a pilot in combat).

2. This health and status reporting allows the weapon to inform the platform of an unexpected change in status such as a subsystem failure or an incipient overheat condition. In the event of weapon failure or degradation during the "weapon ready" process or the launch process, the operator needs timely notification so that appropriate corrective actions may be taken.

3. Three forms of health status are often implemented in weapon systems. Power up Built-In-Test (P-BIT) is executed at weapon power up. It typically checks items such as RAM which can only be performed prior to completion of weapon initialization. Initiated BIT (I-BIT) is commanded during weapon operation by the system operator. This BIT typically corrupts on-going weapon readiness, and the weapon initialization process must be restarted to restore the weapon to operational status. I-BIT is usually employed to help isolate a problem/degradation with the weapon and to determine if the weapon can be made ready for utilization. Continuous BIT (C-BIT) typically runs in background with other operations of the weapon software. This BIT does not degrade nor interfere with normal weapon operation but of necessity is less comprehensive than I-BIT. Usually I-BIT is only executed following a failure report from C-BIT to determine if re-initialization of the weapon can restore it to fully operational status.

#### A4.2.3.4 INS and GPS Transfer Alignment

1. The GPS receiver system senses the weapon's current position in four dimensions (i.e., latitude, longitude, height above ellipsoid, and time) by comparing the time of arrival of signals from multiple satellites. Ease of acquiring initial signals from these satellites, especially encrypted military-precision signals, is a function of the accuracy with which the weapon's GPS receiver knows its current position and the current time. While time was discussed above, the weapon also needs to know its current position. The platform sends on a periodic basis, as often as several times a second, precision data on the platform's current position and velocity, defined in WGS-84 coordinates. It also periodically sends platform angular rate data and moment arm, distance and angle (in Body Axis coordinates) between the platform's inertial navigation centroid and a reference point on the store

station. This frequently-updated and precise position data, together with accurate time data, allows the weapon's GPS receiver to quickly acquire a GPS signal, before launch where that is possible, or immediately after launch when the weapon's GPS antenna is shielded by the launch platform before launch.

2. In a similar manner, a weapon's inertial navigation system uses the transfer alignment messages (i.e., position/velocity updates with associated moment arm) to determine its alignment with respect to WGS-84 coordinate space. Comparison of changes in velocity reported by the platform and those reported by the weapon are used to align the weapon system to the platform. Un-modeled relative motions of the weapon and platform will degrade the alignment process. Thus real-time moment arm and angular rate data enable the weapon to account for these relative motions and provide an accurate weapon alignment.

### A4.2.4 Operator-to-Weapon Command & Status

The bulk of a weapon interface is typically devoted to command and status messages sent to the weapon as initiated by the operator via the automated systems aboard the platform. This section addresses the elements of a weapon-to-platform interface that typically involve the operator.

#### A4.2.4.1 Mission / Target Update & Selection

Following the download of multiple pre-planned missions into the weapon, the operator may designate one of those missions. The operator may also over-write any pre-planned mission with real-time mission data, in response to an unplanned tactical situation, or as the standard practice with some weapons and platforms.

#### A4.2.4.2 Weapon Seeker Control

Prior to weapon launch, depending on a weapon's capability, an operator may turn a seeker on or off, change its polarity, contrast or zoom, configure other seeker-specific settings, slew it up, down, left or right, slave it to a bore sighted platform sensor, slew a cursor overlaid on the seeker image, and lock that cursor on a designated aim point.

#### A4.2.4.3 Weapon Data Link Communications Control

Prior to launch, depending on weapon capability, an operator may enable the weapon in a receive mode, enable its transmission at low power, enable its transmission at full power, authorize the weapon to perform specific data link activities, change the weapon's data link parameters, or change the authorization status of a weapon's relationship with off-board data link participants.

#### A4.2.4.4 Weapon Launch Acceptability Region Data

Prior to launch, depending on weapon capability, an operator may query a weapon for its current estimate of its kinematic footprint capability, or its capability to reach a specific set of coordinates. In the latter case, the operator may ask whether it is possible for the weapon to reach the coordinates in full compliance with terminal profile requirements, or simply to reach the coordinates with no constraints on terminal profile. For less sophisticated weapons, the Launch Acceptability Region (LAR) is computed by the host platform rather than the weapon. In this situation, the data needed to perform the LAR computations must be loaded with the other mission data files.

## A4.3 Weapon Power-Up & Initialization

### A4.3.1 Power-Up Initiation

1. Precision Munitions, as with any computer-controlled devices, need time at power-up to initialize their processors, load internal programming, and perform self-diagnostics. For weapons, this can take longer than for other systems; in part because their on-board sensors need time to thermally stabilize, and in part because their normal service life, years of storage without maintenance, harsh environments, and one-time use, maximize the extent of justified self-testing.

2. The power-up sequence is normally initiated by the operator. Because of the lethality of these weapons, keeping them unpowered until required by the operational timeline, and powering them up only on human command, are two of the many layered weapon safety practices employed. However, the human command is normally a simple, one-button operation that initiates a complex sequence of interactive, carefully timed events and processes that bring the weapon from a cold start to full launch readiness. That sequence is normally managed by the automated platform systems, with minimal decision inputs from the operator.

3. The power supplied by the platform to weapons is most often segregated. Non safety critical power is supplied to support communication over the interface, initialize electronic systems, thermal conditioning, and powers up non-hazardous weapon subsystems such as guidance and navigation, seekers, and data links. A separate power signal, usually supplied separately and immediately prior to launch, activates the weapon subsystems that generate potential hazards such as rocket motors and warhead fuses, and for irreversible functions such as control surface deployments and thermal battery initiators. In this construct, the generic terminology refers to these two signals as “operating power” and “safety enable power.” Typically, operating power may be applied at any time, subject only to overheat conditions in some weapons under some circumstances. Application of safety enable power to the weapon, on the other hand, is typically a key component of weapon system safety design, and is subject to significant constraints and requirements.

### A4.3.2 Safety-Critical Power Management

A key aspect of weapon launch system safety, mentioned earlier, is that certain systems that change the weapon's physical state to greater readiness to depart the launch platform or detonate its warhead are operated by a separate power supply (safety enable power) provided by the launch aircraft. In order to reduce the probability that failures in any of the weapon's systems would harm the launch platform, this "safety enable power" is withheld until launch is imminent For many manned platforms "safety enable power" is not provided to the weapon until the pilot switches on master arm, selects a specific weapon station, and depresses the weapon fire/release button. Only then is power supplied to the weapon that permits the commanded initiation of weapon control surface activation or deployment, thermal battery firing, rocket motor firing, and initiating the release and arming processes of fuses. For other weapon systems, safety enable power is provided shortly prior to weapon fire/release, and the fire/release is only executed when the weapon reports it has successfully initiated its safety related functionality.

### A4.3.3 Weapon Arm, Fire and Launch Sequence

1. The weapon arm, fire or launch sequence is driven by the specifics of the individual weapon capability, and by the requirements of the weapon system safety organization(s) that must approve the integration. For the simplest weapons, the logical interface is equally simple. For simple bombs, the platform commands its store station hooks, which holds the bomb until launch, to release the bomb. For unguided rockets, the platform sends a fire commend, which ignites the rocket motor, whose exhaust pushes against a paddle that releases a retaining pin.

2. For precision guided munitions in the MIL-STD-1760 family, the launch sequence is more involved. The launch sequence will generally not start until the weapon has been powered up, passed built-in test, and successfully downloaded its mission data files. Then, the nominal launch sequence is:

a. Platform supplies safety enable power to the weapon

b. Platform asks the weapon to prepare for imminent launch

c. Platform begins periodic status checks of weapon

d. Weapon initiates irreversible launch events, most often including firing of thermal batteries

e. Weapon reports readiness for launch

f. (MIL-STD-1760 and MMSI only) Platform enables a safety discrete signal that validates digital launch messages that follow

g. Platform sends a "launch is imminent" command

h. Platform releases “hooks” and allows weapon to drop away

i. Weapon detects separation of its umbilical and its electrical interface with the platform

j. Weapon declares itself to be in free flight and executes its immediate post-launch manoeuvres

**A4.3.4 Boresighting of Weapon Seekers.**

1. Some weapons have a capability known as “Lock-on Before Launch” (LOBL.) Use of these weapons requires pointing the weapon’s seeker at the target, designating the aimpoint within the seeker’s field of view, and starting the weapon’s target tracking processes before it is launched. Pointing the seeker at the target often involves cueing the weapon seeker from the launch platform, either by pointing the launch platform itself to point the weapon as a whole at the target, or by pointing the weapon in the same direction as another platform sensor. This cueing process requires good understanding of the orientation differences between the weapon’s seeker and the platform itself, and if the launch platform’s sensors are involved, between the weapon seeker and those sensors. This process is known as boresighting.

2. The physical orientation of the weapon relative to the airframe of the platform can vary first by inherent mechanical tolerances of the various parts involved, and second due to the fact that some launcher systems orient multiple weapons differently, such as triple racks that orient one weapon vertically aligned with the platform, a second weapon at 45 or 90 degrees clockwise, and the third weapon 45 to 90 degrees anti-clockwise. Platform intent to point the weapon seeker down relative to the platform must be translated either by or for each weapon. For affordability, weapon seekers often have very limited fields of view, much like a high-powered pair of binoculars. Simply getting the target and its recognizable surroundings into the seeker field of view may require quite precise boresighting that accounts for both the predictable store station orientation and the mechanical tolerances as well. In such cases, at some point following mounting of the weapon on its operational store station and power-up, boresighting of each weapon must take place.

3. Originally this function was performed by the operator at early power-up, before aircraft take-off, by manually slewing both the seeker and a platform sensor toward a known distant object, and determining in the pitch and yaw offsets of the weapon seeker pointing (relative to its own airframe) as opposed to the pitch and yaw values of the platform seeker relative to the platform itself. If roll is an issue, slewing both seeker and sensor to point at another object several degrees away from the first can calibrate the roll offset as well.

4. The scene must have adequate contrast content in both images, and the scale of the contrast must be visible in both seeker and sensor, to allow correlation of the

two images. The contrast need not have the same polarity; with appropriate selection of correlation algorithms, any mix of images using visible light, near-infrared, and long-wave infrared can be used for bore sighting. Nor must the images have the same scale, so long as scene content is of a scale that is recognizable in both images. Finally, the images must be of generally the same dimensionality. Visible and infrared images, for example, have generally the same viewpoint; “up” and “left” will mean the same thing, after bore sighting. An infrared seeker cannot be easily boresighted, however, to a radar sensor; “left” means generally the same thing, but the seeker’s “up” does not translate well to the radar’s “downrange.”

5. With the current increases in computer processing, if both seeker and sensor can produce a video raster image, automated image processing can perform the same functions against any random scene.

6. Images from both seeker and sensor, plus the ability to slew at least one of them relative to the other (and/or to designate a common pixel in each) are required for the boresighting operation, whether performed by a human or an automated system.

## A5.0 MANNED AIRCRAFT SAFETY STANDARDS

1. There is no agreed system safety standard across NATO, and currently each nation must use its own. In order to arrive at a common lexicon and set of safety objectives for this document, MIL-STD-882D was selected as the top level standard for system safety, which was chosen because of its wide familiarity.

2. Compliance with specific national safety requirements and the resultant certification process is performed in accordance with each nation’s policies and procedures.

3. The responsible committee in NATO for establishing a common baseline for the safety and suitability for service of munitions and explosives is AC/310. The glossary of specialized terms and definitions concerning the safety and suitability for service of munitions, explosives and related products is Allied Ordnance Publication (AOP) 38.

4. NATO safety standards for air-launched weapons and fuses are listed below (Tables A-6 to A-8). Additional more specialized standards apply to environmental safety requirements, and to the composition, transportation and exchange of energetic materials.

| STANAG Number | Title | Dated | Notes/Summary of content |
|---|---|---|---|
| 3786 Ed4 | Safety Design Requirements for Airborne Dispenser Weapons | 18/12/96 | States the areas that must be taken into account in the design of Airborne Dispenser Weapons and associated sub-munitions excluding chaff and flare dispenser systems. |
| 4297 Ed2<br>And<br>AOP15 Ed2 | Guidance on the Assessment of the Safety and Suitability for Service of Munitions for NATO Armed Forces | 16/2/01 and 1/11/98 | Provides a uniform guide to achieving a positive assessment that munitions are safe and suitable for use by NATO forces. Recommends system safety design and development criteria. Provides a methodology for assessing and documenting munitions safety. |
| 4325 Ed1 | Environmental and Safety Tests for the Appraisal of air Launched Munitions | 18/5/92 | Identifies what tests need to be carried out to provide evidence that air launched munitions are safe and suitable for service. The procedures and sequences for conducting the tests are given and test criteria are summarized. |
| 4432 Ed1 | Air Launched Guided Munitions, Principles for Safe Design | 24/1/00 | States the areas that must be taken into account in the design of air launched munitions including the explosives, propulsion systems using energetic substances, compatibility of materials fuses and safe jettison arrangements. |
| 4439 Ed1<br>and<br>AOP39 Ed1 | Policy for Introduction, Assessment and Testing for Insensitive Munitions.<br>Insensitive Munitions (MURAT) Requirements for Assessment Testing and Evaluation | 18/11/98 and 18/11/98 | States the NATO agreement for the introduction of Insensitive Munitions (IM) and lists the IM requirements, goals and tests.<br>Provides guidance and direction to enable the policy and requirements specified in STANAG 4439 for the development, assessment and testing of Insensitive Munitions to be implemented. |

| STANAG Number | Title | Dated | Notes/Summary of content |
|---|---|---|---|
| 4518 Ed1 | Safe Disposal of Munitions, Design Principles and Requirements, and Safety Assessment. | 8/10/01 | Specifies the policies and principles to be adopted for the demilitarization and disposal of munitions in a safe, cost effective, practicable and environmentally responsible manner. |
| 4519 Ed1 | Gas Generators, Design Safety Requirements and Safety and Suitability for Service Evaluation | 1/3/00 | Identifies the essential safety characteristics to be included in the design of gas generators and specifies test requires to establish safety and suitability for service. |

**Table A-6: General Policies for Assessment of Safety & Suitability of Service**

| STANAG Number | Title | Dated |
|---|---|---|
| 4157 Ed 1 | Development of Safety Test Methods and Procedures for Fuzes for Unguided Tube Launched Projectiles | Aug 1991 |
| 4187 Ed 1 with AOP16 Ed 3 | Fuzing Systems - Safety Design Requirements Fuzing Systems<br>Design Guidelines for STANAG 4187 | Oct 1996<br>Oct 1999 |
| 4368 Ed 1 | Electric and Laser Ignition System for Rockets and Guided Missile Motors: Safety Design requirements | Feb 1998 |

**Table A-7: Fusing Systems and Other Initiating Systems**

## A5.1 Europe

1. The European Aviation Safety Agency (EASA) has prepared the paper E.Y01301, Policy Statement Airworthiness Certification of UAS. However, this paper is a recommendation, not a standard.

2. EASA Part 21, Principles and Regulations for Design, Production, Maintenance and Operation of Aeronautical Products, is intended for commercial aircraft but might be applied. This documentation is supplemented by Certification Specifications for different types of aircraft and equipment.

### A5.1.1 Germany

The principal document in Germany is ZDV 19/1, Das Prüf-und Zulassungswesen für Luftfahrzeuge und Luftfahrtgerät der Bundeswehr, which describes the organization of the national authorities and the clearance process. Under ZDV 19/1 established standards are used include MIL-STD-882, DO-178 and so on.

#### A5.1.2 Italy

The Italian airworthiness requirements for UAS under STANAG 4671 is AER.P-2 Emendamento 1, dated 6 February 2008.

#### A5.1.3 United Kingdom

1. System Safety in the United Kingdom is governed by Def-Stan 00/56. This standard is mandated across all new defense contracts and, wherever possible, legacy systems are encouraged to move towards compliance with the requirements of the standard when upgrades are embodied.

2. Def-Stan 00/56 outlines the requirements of the system safety program plan and aims to ensure that safety is a fundamental consideration throughout the lifecycle of a system. The safety program plan requires a robust process to be followed to assure system safety.

3. The safety activities require evidence that each hazard is mitigated to a level which is deemed ‘As Low As Reasonably Practicable’ (ALARP). Theoretically, the hazard analysis should precede and drive any architecture design, providing acceptable probabilities against each feared event, which then have to be mitigated by the design and then validated by analysis.

4. In relation to armament control systems, additional requirements and best-practice guidance that influence the design for safety is provided by parts of Def-Stan 00/970. This standard also covers some high-level requirements for UA. The main standard that governs the design of guided weapons is provided by Def-Stan 07/85.

5. The different design drivers and the evolution of how safety is assessed for manned platforms and guided weapons have resulted in different approaches to how safety is considered. Current practices dictate that the platform manufacturer has to certify against probability requirements per flying hour, whereas the weapon has been certified against requirements per launch.

6. Overall certification of the platform / weapon combination that ensures a safe system is released to service is governed by the requirements of Def-Stan 05/123.

### A5.2 Canada

1. The Canadian Department of National Defence airworthiness program does not address the design and qualification of aircraft stores but instead ensures that store carriage, release and jettison is accomplished to an acceptable level of safety.

2. Standards used by the Canadian Forces in the clearance of weapons on manned aircraft are detailed below (Table A-8). These standards are used as guidance and other standards may be used and considered especially if the end result is reduced mishap risk.

| Standard Number | Title |
|---|---|
| AIR-STD 20/21C | Airborne Stores Ground Fit and Compatibility Criteria |
| AIR-STD 20/22 | Aircraft Store Electrical Interconnection System |
| AIR-STD-20/9G | Design Safety Principles for Aircraft Stores Fuzing |
| DEF-STAN-0055 | Requirements for Safety Related Software in Defence Equipment |
| DEF-STAN-00-970 | Design and Airworthiness Requirements for Service Aircraft (Vol. 1) |
| DEF-STAN-05/123 | Technical Procedure for the Procurement of Aircraft, Weapons and Electronic Systems |
| DEF-STAN-07/85 | Design Requirements for Weapons and Associated Systems |
| MIL-A-8591 | General design Criteria for Airborne Stores, Suspension Equipment and Aircraft Store Interface |
| MIL-E-7016 | Electric Load and Power Source Capacity, Aircraft, Analysis Of |
| MIL-E-704 | Aircraft Electric Power Characteristics |
| MIL-HDBK-1763 | Aircraft/Stores Compatibility |
| MIL-STD-1760 | Aircraft/Store Electrical Interconnection System |
| MIL-STD-461 | Requirement for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment |
| MIL-STD-464 | Electromagnetic Environmental Effects, Requirements for Systems |
| MIL-STD-498 | Software Development and Documentation |
| MIL-STD-810E | Environmental Test Methods and Engineering Guidelines |
| MIL-STD-882D | Department of Defense Standard Practice for System Safety |
| MIL-W-5088 | Military Specification Wiring Aerospace Vehicle |
| STANAG 4297 | Guidance on the Assessment of the Safety and Suitability for Service of Non-Nuclear Munitions for NATO Armed Forces |
| STANAG 4325 | Air-Launched Munitions Safety and Suitability for Service Evaluation |

**Table A-8: Airworthiness and System Safety Standards – Canada**

3. The process to obtain a flight permit includes both operational and technical clearances which are reviewed by the Airworthiness Review Board, as summarized below:

a. Technical Airworthiness Clearance:

(1) Type Certificates, Design Changes, and Type Records such as the Basis of Certification;

(2) Flight Authority, Technical Records, Type Design, and Configuration status;

(3) In-Service Support: engineering, logistics, maintenance aspects;

(4) Ballistics review;

(5) Stores clearance, including flight test;

(6) Risk Assessment.

b. Operational Airworthiness Clearance:

(1) Safety of Flight & Safety and Suitability for Service (S3) are used to ensure the store is safe for air operations (also includes explosive safety);

(2) Laser Safety (as applicable);

(3) Range Safety, Certification , and ‘Templating’;

(4) Risk Assessment;

(5) Flight Safety;

(6) Standard Assessment of Safety and Suitability for Service of Ammunition and Explosives.

c. Ammunition Safety and Suitability Board (ASSB): The ASSB provides impartial appraisal of the safety and suitability of ammunition and explosives design for service use. The appraisal is based upon design review, evidence obtained during development, selected tests on the ammunition or explosive, the proposed production version and the system environment. The assessment process is carried out prior to acquisition commitment.

### A5.3 United States

In the United States, precedence is given to Department of Defense documents and to ratified NATO documents. The individual Services provide additional requires as noted below:

a. Department of Defense

(1) AT&L Memorandum – Defense Acquisition System Safety, 23 September 2004;

(2) DODI 5000.02 – Operation of the Defense Acquisition System, 8 December 2008;

(3) MIL-STD-882D – DoD Standard Practice for System Safety, 10 February 2000;

(4) Unmanned Systems Safety Guide for DoD Acquisition, 27 June 2007;

(5) MIL-HDBK-516 – Airworthiness Certification Criteria, 1 October 2002.

b. US Navy

(1) OPNAVINST 5100.24B – Navy System Safety Program Policy, 6 February 2007;

(2) OPNAVINST 3750.6R – Naval Aviation Safety Program, 31 December 2007.

c. US Army

(1) AR 385-10 – The Army Safety Program, 23 August 2007;

(2) AR 70-62 – Airworthiness Qualification of Aircraft Systems, 21 May 2007;

(3) AMCOM Regulation 385-17 – AMCOM Software System Safety Policy, 15 March 2008.

d. US Air Force

(1) AFPD 63-12 – Assurance of Operational Safety, Suitability and Effectiveness, 1 February 2000;

(2) Air Force System Safety Handbook (Air Force Safety Agency), revised July 2000;

(3) AFPD 62-6 – USAF Aircraft Airworthiness Certification, 1 October 2000.

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## ANNEX B MAPPING OF PAYLOAD USE CASES TO UAI PLATFORM/STORE ICD

Table B-1 provides cross-references to the applicable sections of the UAI Platform Store ICD, where additional definition of the UAI IERs may be obtained. Additional IERs will be required for the operation of stores that are not UAI-compliant. The cross-references define the interactions between the Pre-Launch Store Control Domain and the External Payload Domain.

| PAYLOAD USE CASE (L3) | UAI ICD REFERENCE PARAGRAPH(S) | UAI REFERENCED MESSAGES |
|---|---|---|
| Power Up Store | 3.5.1, 3.5.2, 3.5.3, 3.5.4, 3.8.2, | |
| Identify Store | 3.5.1.1, 3.5.1.2, 3.8.2, | 01R/T, 10R/T |
| Perform BIT | 3.5.5, 3.8.3 | 11R/T, 22R/T |
| Report Store Status | 3.5.12.7, 3.8.2 | 10T, 11T, 14T, 16T, 17T-0001, 17T-0002, 21T, 22T, 24T |
| Initialise GPS | 3.5.6.2, 3.5.12.5 | 03R, 12R, 13R-0005, 13R-0007, 13R-0010, 13R-0011, 13R-0015, 18R |
| Initialise Transfer Alignment | 3.5.6.1, 3.5.12.6 | 09R, MC-17R |
| Perform Transfer Alignment | 3.5.9, 3.5.17.1 | 02R, MC-17R |
| Load / Modify Mission Data | 3.5.8, 3.5.12.2, 3.5.17.1, 3.5.21, 3.5.22 | 14R/T, 13R-0020, 13R-0021, 13R-0022, 13R-0023, 16R, 17R-0001, 17R-0002, 21R, 22R |
| Transfer Environmental Data | 3.5.7, 3.5.12.6 | 15R |
| Designate Target | 3.5.12 | |
| Manage Seeker / Sensor | 3.5.17.1, 3.5.20 | 24R/T |
| Transfer Fuzing Data | 3.5.12.3, 3.5.19 | 11R/T |
| Request LAR | 3.5.10 | 05T, 06R/T |
| Release Weapon | 3.5.12.4, 3.5.12.7, 3.5.12.8, 3.5.13, 3.5.14, 3.5.17.2, 3.5.17.3, 3.8.6 | 11R/T |
| Erase Mission Data | 3.5.11 | 11R/T |

**Table B-1: Mapping of Payload Use Cases to UAI Platform/Store ICD Revision 2**

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## ANNEX C ACRONYMS

| | |
|---|---|
| AAI | Attack-Attack Interface |
| AAP | Air Armaments Panel |
| AAR | Air-Air-Refuelling |
| ACC | Air Component Commander |
| ACCS | Aircraft Command & Control System |
| ACG | Air/Aerospace Capability Group |
| ACM | Airspace Control Measures |
| ACO | Airspace Control Order |
| ACT | Allied Command Transformation |
| ACU | Aircraft Control Unit |
| ADatP | Allied Data Publication |
| AEIS | Aircraft Store Electrical Interconnection Set |
| AGM | Attack Guidance Munitions |
| AH | Armed/Attack Helicopter |
| AI | Air Interdiction |
| AJ | All Jettison |
| AJP | Allied Joint Publication |
| ALARP | As Low As Reasonably Practicable |
| ALWI-CI | Aircraft, Launcher & Weapon Interoperability Common Interface |
| ALWI-TA | Aircraft, Launcher & Weapon Interoperability Technical Architecture |
| AMC | Airborne Mission Coordinator |
| AO | Area Operations |
| AOC | Air Operations Centre |
| AOCC | Air Operations Coordination Centre |
| AOCC(L) | Air Operations Coordination Centre (Land) |
| AOD | Air Operations Directive |
| AOO | Area Of Operations |

| | |
|---|---|
| AOP | Allied Ordnance Publication |
| AOR | Area Of Responsibility |
| AR | Armed Reconnaissance |
| AS | Associated Support |
| ASCII | American Standard Code for Information Interchange |
| ASFAO | Anti-Surface Force Air Operations |
| ASuW | Anti-Surface Warfare |
| ASW | Anti-Submarine Warfare |
| ATO | Air Tasking Order |
| AWACS | Airborne Warning & Control System |
| BCD | Battlefield Coordination Detachment |
| BDA | Battle Damage Assessment |
| C2 | Command & Control |
| C3 | Command, Control & Communications |
| C4I | Command, Control, Communications, Computers & Intelligence |
| CA | Combat Assessment |
| CAOC | Combined Air Operations Centre |
| CAS | Close Air Support |
| C-BIT | Continuous Built In Test |
| CC | Component Commander |
| CDA | Common Domain Architecture |
| CDT | Control Data Terminal |
| COMAO | Composite Air Operations |
| COP | Common Operational Picture |
| CR | Combat Recovery |
| CRD | Common Route Definition |
| CSAR | Combat Search & Rescue |
| Def-Stan | Defence Standard |
| DLI | Data Link Interface |
| DMPI | Desired Mean Point of Impact |
| DoD | Department of Defense |

| | |
|---|---|
| DoDAF | Department of Defense Architectural Framework |
| DS | Direct Support |
| EASA | European Aviation Safety Agency |
| EJ | Emergency Jettison |
| ELINT | Electronic Intelligence |
| EO | Electro Optical |
| ESM | Electronic Support Measures |
| EW | Electronic Warfare |
| FAA | Federal Aviation Agency |
| FAC | Forward Air Controller |
| FAC-A | Forward Air Controller (Airborne) |
| GASIF | Generic Aircraft Store Interface Framework |
| GAT | Guidance, Apportionment & Targeting |
| GCS | Ground Control Station |
| GI&S | Geospatial Information & Services |
| GMTI | Ground Moving Target Indicator |
| GPS | Global Positioning System |
| HALE | High Altitude Long Endurance |
| HCI | Human-Computer Interface |
| HPT | High Payoff Target |
| HPTL | High Payoff Target List |
| HUMINT | Human Intelligence |
| HVT | High Value Target |
| HVTL | High Value Target List |
| IA | Information Assurance |
| I-BIT | Initiated Built In Test |
| ICD | Interface Control Document |
| IER | Information Exchange Requirements |
| IMINT | Image Intelligence |
| IMM | Interface for Micro-Munitions |
| INS | Inertial Navigation System |

| | |
|---|---|
| IR | Infra Red |
| ISR | Intelligence, Surveillance & Reconnaissance |
| ISRT | Intelligence, Surveillance, Reconnaissance & Targeting |
| ISTAR | Intelligence, Surveillance, Target Acquisition & Reconnaissance |
| IT | Information Technology |
| JAAT | Joint Air Attack Team |
| JAOC | Joint Air Operations Centre |
| JAPCC | Joint Air Power Competency Centre |
| JCGUAS | Joint Capability Group Unmanned Aircraft Systems |
| JDAM | Joint Direct Attack Munition |
| JFACC | Joint Forces Air Component Commander |
| JFC | Joint Force Commander |
| JFHQ | Joint Force Headquarters |
| JIPTL | Joint Integrated Prioritised Target List |
| JMPS | Joint Mission Planning System |
| JOA | Joint Operational Area |
| JPR | Joint Personnel Recovery |
| JSF | Joint Strike Fighter |
| JSOW | Joint Stand-Off Weapon |
| JSTARS | Joint Surveillance & Target Acquisition Radar System |
| JTAC | Joint Terminal Attack Controller |
| JTCB | Joint Targeting Coordination Board |
| JTFHQ | Joint Theatre Forces Headquarters |
| JTL | Joint Target List |
| JUASP | Joint Unmanned Aircraft System Panel |
| LAR | Launch Acceptability Region |
| LCC | Land Component Commander |
| LOAC | Law Of Armed Conflict |
| LOBL | Lock-On Before Launch |
| LOC | Lines Of Communication |
| LORAN | LOng RAnge Navigation |

| | |
|---|---|
| MAAP | Master Air Attack Plan |
| MALE | Medium Altitude Long Endurance |
| MASS | Master Arm Safety Switch |
| MCC | Maritime Component Commander |
| MDA | Model Driven Architecture |
| MEA | Munitions Effectiveness Analysis |
| MiDEF | Mission Data Exchange Format |
| MITL | Man-In-The-Loop |
| MMSI | Miniature Munitions Standard Interface |
| MOUT | Military Operations in Urban Terrain |
| NAF | NATO C3 Architectural Framework |
| NAFAG | NATO Air Force Armaments Group |
| NATO | North Atlantic Treaty Organization |
| NC3 | NATO Command, Control & Communication |
| NC3A | NATO Command, Control & Communications Agency |
| NC3TA | NATO C3 Technical Architecture |
| NCSP | NATO Common Standards Profile |
| NEW | Networked Enabled Weapon |
| NIAG | NATO Industrial Advisory Group |
| NNAG | NATO Naval Armaments Group |
| NNEC | NATO Networked Enabled Capability |
| NNWESB | Non-Nuclear Weapons & Explosives Safety Board |
| NRC | Nuclear Regulatory Commission |
| NSL | No-Strike List |
| NSO | NATO Standardisation Office |
| NSR | NATO Staff Requirement |
| NTRM | NATO Technical Reference Model |
| NUAI | NATO Universal Armament Interface |
| OCA | Offensive Counter Air |
| OMG | Object Management Group |
| OPCON | Operational Control |

| | |
|---|---|
| OSC | On-Scene Commander |
| OTC | Officer in Tactical Control |
| PAR | Post Attack Reconnaissance |
| P-BIT | Power up Built In Test |
| PGM | Precision Guided Munition |
| PLSC | Pre-Launch Store Control |
| RAI | Recce Attack Interface |
| RAM | Random Access Memory |
| RF | Radio Frequency |
| RMC | Rescue Mission Commander |
| RMP | Recognized Maritime Picture |
| ROE | Rules of Engagement |
| RR | Re-attack Recommendations |
| RSEAD | Reactive Suppression of Enemy Air Defenses |
| RSTA | Reconnaissance, Surveillance & Target Acquisition |
| RTL | Restricted Target List |
| RTO | Research & Technology Organisation |
| RVT | Remote Video Terminal |
| S&RE | Suspension & Release Equipment |
| S/G | Study Group |
| SAE | Society of Automotive Engineers |
| SAL | Semi-Active Laser |
| SAR | Synthetic Aperture Radar |
| SC | Station Control |
| SCAR | Strike Coordination & Reconnaissance |
| SDB | Small Diameter Bomb |
| SEAD | Suppressions of Enemy Air Defenses |
| SIGINT | Signals Intelligence |
| SM | Stores Management |
| SMS | Stores Management System |
| SOA | Service Oriented Architecture |

| | |
|---|---|
| SPINS | Special Instructions |
| STANAG | Standardisation Agreement |
| TAC | Tactical Air Controller |
| TACON | Tactical Control |
| TACP | Tactical Air Control Party |
| TASMO | Tactical Air Support for Maritime Operations |
| TLE | Target Location Error |
| TNL | Target Nomination List |
| TOO | Target Of Opportunity |
| TSS | Target Selection Standards |
| TST | Time Sensitive Targeting |
| TTP | Tactics, Techniques & Procedures |
| TUAS | Tactical UAS |
| UA | Unmanned Aircraft |
| UAI | Universal Armament Interface |
| UAS | Unmanned Aircraft System |
| UCS | UAS Control System |
| UHF | Ultra High Frequency |
| UML | Universal Modelling Language |
| USN | United States Navy |
| VDT | Vehicle Data Terminal |
| VMF | Variable Message Format |
| WEA | Weapons Effects Analysis |
| WF | Warfighter |
| WGS 84 | World Geodetic System 84 |
| WST | Weaponisation Specialist Team |
| XML | Extensible Mark-up Language |