Linking tactical aviation battle task standards to automated performance measures for simulation

Final Report Document

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LINKING TACTICAL AVIATION BATTLE TASK STANDARDS TO AUTOMATED PERFORMANCE MEASURES FOR SIMULATION

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1 Introduction

This document presents an Evaluation Report for Defence Research and Development Canada-Toronto (DRDC-T) under contract W7719-165298/001/KIN Task Authorization 6 - LINKING TACTICAL AVIATION BATTLE TASK STANDARDS TO AUTOMATED PERFORMANCE MEASURES FOR SIMULATION. The intent of this report is to present the findings of the assessment conducted to assist DRDC-T in determining the feasibility of utilizing a tool such as the Coalition Performance Evaluation Tracking System (C-PETS) to assess tactical aviation battle task standards in simulation by monitoring Distributed Interactive Simulation (DIS) network packets. An assessment of battle task standards descriptions to data availability is presented, and conclusions and recommendations are provided.

1.1 Background

Performance objectives or standards are statements detailing what a trainee must be able to do in a situation, under given conditions. They are sometimes expressed as a minimum level of performance. For example, the Tactical Aviation Battle Task Standard (TA-BTS) for tactical aviators comprehends all fighting and combat support tasks, and lists success criteria. These criteria can be used as measures of success for trainee competence, or to determine the efficacy of training exercises or simulations.

The rapid pace and complexity of a distributed simulation environment dictates that training personnel cannot attend to all warfighters, situations and details in an exercise. Equally in some instances, strong collective performance will permit completion of mission objectives even though individual player performance may have been below standard.

Automated performance measure software enables capture, playback and archiving of warfighter performance in real-time providing training officers with concrete metrics that can be used to debrief trainee deviation from optimal mission completion. For example, the Coalition Performance Evaluation Tracking System (C-PETS), developed by the United States Air Force Research Laboratory (AFRL) monitors Distributed Interactive Simulation (DIS) network traffic for instances when virtual or constructive entities approach or exceed user-defined values. These values are derived from entity-generated Protocol Data Units (PDUs), packets of information detailing the status of an entity on the network at any given point in time. Depending on the entity, information in a PDU might include velocity, Cartesian coordinates, damage or health status, orientation, and munitions or weapons use, and can be used to derive proximity of entities or munitions use relative to friendly or enemy entities, assets or territory, as well as timings and durations of tasks and events within a mission. In addition to an existing library of measures for various weapons platform entities, custom measures can be developed in a C++ Application Programming Interface (API).

Development of appropriate custom performance measures requires identification of candidate standards and criteria, enumeration of network entities implicated in the measure, as well as threshold values required to trigger an event in the measurement software.

1.2 Objectives

The objectives of this report are to provide information to assist DRDC-T in assessing the feasibility of applying automated performance measurement software, such as the AFRL C-PETS, to the evaluation of tactical aviation battle task standards (BTS).

1.3 Document Outline

This report is divided into the following sections:

- Section 1– Introduction. This section provides an overview of the purpose and organization of the document.
- Section 2 – Categorization of B-GA-446-002/PT-001 Battle Task Standards. This section provides a brief overview of the BTS as well as a description of the hierarchical nature of the standards and categorizes them as such.
- Section 3 – Assessment. This section presents the findings of the assessment conducted to evaluate the feasibility of using DIS network packets to evaluate BTS within a simulated environment.
- Section 4 – Conclusions and Recommendations. This section offers conclusions and recommendations based upon the assessment findings presented in Section 3.

1.4 References

The following documents form part of this Interim Feasibility Report to the extent specified herein:

A. National Defence. (2012). CH146 Griffon Standard Manoeuvre Manual. (B-GA-002-146/FP-001). Ottawa, Canada.

B. National Defence. (2013). Tactical Aviation Battle Task Standards. (B-GA-446-002/PT-001). Ottawa, Canada.

C. Standards Committee on Interactive Simulation (SCIS) of the IEEE Computer Society (1995) IEEE Standard for Distributed Interactive Simulation (DIS) Application Protocols

D. B-GA-440-000/AF-000, Tactical Helicopter Operations

E. B-GA-441-001/FP-001, Tactical Level Aviation Doctrine

G. B-GA-442-001/FP-001, Tactical Aviation Tactics, Techniques and Procedures

G. B-GA-443-001/FP-001, 1 Wing Standing Operating Procedures

H. B-GA-444-001/FP-001, 1 Wing Tactical Aide-Memoire

I. B-GL-383-002/FP-002, Battle Task Standards

J. B-GL-300-008/FP-001, Training for Land Operations

1.5 Acronyms

AAR	After Action Review
AFRL	Air Force Research Laboratory
API	Application Programming Interface
CAF	Canadian Armed Forces
C-PETS	Coalition Performance Evaluation Tracking System

DIS	Distributed Interactive Simulation
DND	Department of National Defence
DRDC	Defence Research & Development Canada
GFE	Government Furnished Equipment
GSM	Government Supplied Materials
PDU	Protocol Data Unit
PI	Principal Investigator
S&T	Science & Technology
SME	Subject Matter Expert
SRCL	Security Requirements Checklist
TA-BTS	Tactical Aviation Battle Task Standard
TCPS	Tri-Council Policy Statement
TTPs	Tactics Techniques and Procedures

2 Categorization of B-GA-446-002/PT-001 Battle Task Standards

2.1 Introduction

The role of tactical aviation is to provide the Army with mobility, firepower and reconnaissance. Tactical aviation doctrine describes all the fundamental missions and tasks that tactical aviation conducts. In the Tactical Aviation Battle Task Standards (BTS), B-GA-446-002/PT-001, issued under the authority of the Commander 1 Wing, all tactical tasks are described. These BTS cover all recognized fighting echelon and combat support echelon (logistic and maintenance) tasks.

The development of these BTS was based on approved doctrine and is part of the tactical aviation training strategy to implement a system approach to collective training. BTS are not a substitute for doctrine or tactics, techniques and procedures. Each battle task outlined in the B-GA-446-002/PT-001 provides commanders with common standards against which performance can be measured. BTS can be used to assist commanders at all levels in providing direction and guidance in the planning and conduct of collective training.

Each BTS as listed in the B-GA-446-002/PT-001consists at a high level of a statement of the Task Standard as well as preemptory conditions and a list of necessary criteria to be evaluated.

2.2 Evaluation

As stated within the B-GA-446, BTS are only sufficiently detailed to enable the description and rating of the task and to provide assistance in the development of training events. While they are authoritative, they, nevertheless, still require judgement in application as training must be performance-oriented and performance must be judged on task accomplishment, not just process. Evaluation of BTS should use the following rating.

- **Effective**. An ‘Effective’ rating indicates task performance met the standards in all respects;
- **Needs Practice**. A ‘Needs Practice’ rating indicates only minor shortcomings in task performance which are expected to be corrected in subsequent evaluation iterations with little or no further training required; and
- **Ineffective**. An ‘Ineffective’ rating indicates significant shortcomings in task performance requiring further training before re-evaluation.

The Tactical Aviation Battle Task Standards (B-GA-446-002/PT-001) itself states that,

“*BTS are only sufficiently detailed to enable the description and rating of the task and to provide assistance in the development of training events. While they are authoritative, they, nevertheless, still require judgement in application as training must be performance-oriented and performance must be judged on task accomplishment, not just process.”*

The BTS are inherently poorly suited to quantifiable data evaluation at the higher level, however thorough decomposition of the tasks and subtasks does allow identification of lower level functionality that can be quantifiably assessed.

2.3 Hierarchy Levels

Upon first review of the B-GA-446 it was readily evident that the BTS are hierarchical in nature. Many of the BTS are built upon other BTS and lower level tasks that are covered in the supplementary supporting documentation. As such the first effort in assessing BTS was to structure them in a dependency hierarchy which revealed two depth levels. This allowed the initial categorization of base level tasks and composite tasks which are built upon one or multiple base level tasks.

2.4 Categorization

The second review of the B-GA-446 sought to rank the composite tasks into an order of how well they might be assessed using DIS traffic as previously outlined. The first outcome of the second review was the identification of BTS which fundamentally did not lend themselves to an assessment from network traffic analysis. This group of BTS consisted primarily of all the combat support tasks. The primary discriminator for this non-suitable category was the lack of flight operations. The tasks in this category concerned themselves with non-flying support activities and as such could not be assessed from the operation of a flight simulator.

The next step in categorization was to further assess the remaining tasks specifically looking at task hierarchy. The first sub-classification of these BTS was the identification of base tasks. A base task was defined to be measurable, did not reference other BTS but was itself referenced by other BTS. These base, or atomic tasks often referenced supporting documentation and specifically B-GA-442-001/FP-001, Tactical Aviation Tactics, Techniques and Procedures which provided more quantifiable items applicable to DIS packet analysis. Additionally, there were several base tasks that although not defined as BTS, were repeatedly referenced by BTS as offering some measurable criteria for task completion. An example of such a non-BTS is effective use of communications.

After identification of base tasks, the remaining BTS were found to consist of combinations of base level tasks. As such these BTS were categorized as composite tasks. With three distinct categories of BTS identified, a category lexicon was applied for easy identification. The following lexicon has been applied:

- UNFIT: The BTS was found to be not suitable for evaluation through DIS packet monitoring. The single factor for an UNFIT rating is that none of the BTS criteria involve flying. These UNFIT tasks are either mission planning related or non-flying ground tasks.

- BASE: The BTS is considered an atomic or foundation level task that has no lower level tasks and is present in higher level tasks. Base tasks have criteria that can be evaluated from DIS network traffic and may contain other base tasks.

- COMPOSITE: The BTS solely consists of one or more base tasks and does not present any clearly definable uniqueness. Composite tasks represent missions or vignettes that call into exercise base tasks against a set of conditions.

Table 1 – Categorization of Battle Task Standards

IDENTIFIER	TITLE	LEVEL	CAT
H02304030E	EXECUTE DOWNED AIRCREW EVASION PLAN OF ACTION	2	UNFIT
H02303300E H03403300E	ENGAGE TARGETS WITH INTEGRAL WEAPON SYSTEMS	2-3	BASE
H02605130E H03605130E	EXECUTE AIR CASEVAC TASK	2-3	UNFIT
H02304040E H03404040E	FLY TACTICALLY	2-4	BASE
H02303020E H03403020E H04603020E	OCCUPY A HOLDING AREA	2-4	UNFIT
H02604010E H03404010E	REACT TO DIRECT SURFACE-TO-AIR FIRE	2-3	COMP
H02304012E H03404012E	REACT TO IR OR RF MISSILE ENGAGEMENT	2-3	COMP
H02304011E H03404011E	REACT TO RADAR OR LASER ILLUMINATION	2-3	COMP
H02304023E H03404023E	REACT TO AIR-TO-AIR FIGHTER ATTACK	2-4	COMP
H02304004E H03403300E	REACT TO AIR-TO-AIR HELICOPTER ATTACK	2-4	COMP
H03401000E H04601000E H05601000E	CONDUCT TACTICAL AVIATION BATTLE PROCEDURE	3-5	UNFIT
H02303110E H03403110E H04603110E	EXECUTE AN INSERTION	2-5	COMP
H02303120E H03403120E H04603110E	EXECUTE AN EXTRACTION	2-5	COMP
H02303103E	EXECUTE TACTICAL RESUPPLY AND TACTICAL MOVEMENT	2-4	COMP

H03403103E H04603103E	OF EQUIPMENT		
H02303102E H03403102E H04603102E	EXECUTE LOGISTICAL AIRLIFT	2-4	COMP
H02303101E H03403101E H04603101E	CONDUCT TACTICAL TROOP AIRLIFT	2-4	COMP
H04603100E H05603100E H06703100E	EXECUTE AIRMOBILE/AIR ASSAULT OPERATIONS	4-6	COMP
H06701003E	REACT TO DOWNED AIRCRAFT	4-6	COMP
H06705002E	EXECUTE COMBAT RECOVERY OF AIRCRAFT	6	UNFIT
H13402230E H14602230E	EXECUTE AN AVIATION SCREEN	3-4	COMP
H13402210E H14604320E	EXECUTE A ROUTE RECONNAISSANCE	3-4	COMP
H13402220E H14602220E	EXECUTE A ZONE/AREA RECONNAISSANCE	3-4	COMP
H13402200E H14602200E	EXECUTE RECONNAISSANCE TASK	3-4	COMP
H13403310E	EXECUTE A CLOSE COMBAT ATTACK	3	COMP
H13403311E	EXECUTE AN INTERDICTION ATTACK	3	COMP
H13404340E H14604340E	EXECUTE AIRBORNE CONVOY ESCORT	3-4	COMP
H13404330E H14604330E	EXECUTE AN AVIATION GUARD	3-4	COMP
H13403360E	CONDUCT DIRECTION AND CONTROL OF FIRE	3	BASE
H13404350E	CONDUCT AERIAL ESCORT	3-4	COMP
H13404320E H14604320E	CONDUCT AREA SECURITY OPERATIONS	3-4	COMP
H92602210E	PROVIDE AVIATION METEOROLOGICAL SERVICES	2	UNFIT
H92601200E	PROVIDE INTELLIGENCE SUPPORT TO TACTICAL AVIATION	2-3	UNFIT
H92405420E	EXECUTE MOBILE REPAIR PARTY TASK	2-3	UNFIT

H93605410E			
H93605400E	CONDUCT FARP OPERATION	2-4	UNFIT
H93405420E H94605420E	CONDUCT FIRST AND SECOND LEVEL MAINTENANCE	3-4	UNFIT
H03405440E	ESTABLISH AND OPERATE A HELICOPTER LANDING SITE	4-6	UNFIT

3 Assessment

A general review of the BTS and supporting documentation gave the impression that assessment of evaluation criteria in a purely automated manner would be very difficult. This assessment was due to the highly subjective nature of both the evaluation criteria themselves and the situational dependencies of any given scenario. Quantitative analysis in this case lends itself much better to identification of violations as opposed to a rated evaluation of success. As such, the approach taken in evaluating BTS was to identify what could be reasonably assessed quantitatively and what could not, vice suggesting an evaluation standard or score rating approach.

3.1 Assumptions

Based on the previously mentioned overall task assessment, the evaluation assumes some degree of human-in-the-loop involvement in the actual assessment and interpretation of captured results. As well the following factors and considerations should be noted prior to reviewing the main body of work, that being the breakdown of BTS into measurable data points.

3.1.1 Human-in-the-Loop

The BTS itself does not breakdown or define the tasks by quantifiably measurable units. Instead the BTS breaks down tasks into much higher-level actions as it is intended as both an assessment guide for squadron standards officers and as tactical doctrine for pilots and aircrew. The absence of assessed criteria does not imply that supporting quantifiable measures cannot be extracted, however it does highlight the necessity for human-in-the-loop involvement in the interpretation of measured data.

3.1.2 Triggers & Timings

There are a great many tasks and subtasks that involve the using timing as part of the measures of effectiveness. Although timing represents an easily quantifiable data source, the mechanism to trigger the timing process can be very subjective in nature. Timer triggers could include items such as entry into a physically described zone, crossing of a boundary, or event based items such as the triggering of warning system or firing/detonation of a weapon system. The evaluation of aircrew reaction time will require carefully thought out criteria for the start of the vignette.

As an example, if we were to consider assessing the reaction time of aircrew to incoming hostile fire the timing activation event could be very situationally dependent. Detection of hostile fire could take the form of impacts on the assessed helicopter, visual identification, audio identification or a radio alert from another member of an element. In addition, visual and audio detection will be affected by lighting and time of day as well as flight profile. It may be possible for careful scenario planning to help minimize these discrepancies however due to this ambiguity the breakdown of timing related tasks in the evaluation are set against a generic “trigger event” to be determined upon implementation.

3.2 Situational Dependency

The assessment of timings as well as proper follow on course of action can be very subjective and situationally dependent thus requiring a high-level knowledge of the task scenario. The following items represent specific task elements that need to be taken into planning consideration when evaluating any BTS.

3.2.1.1 Terrain Profile

When analyzing items such as the amount of time that a helicopter is exposed to enemy fire or the choice of flight profile, etc., as an assessment of tactical flying, the profile of the terrain must be considered. As an example, in open, flat terrain a helicopter could be exposed constantly to a threat until beyond the engagement range of that threat, whereas hilly terrain might provide quick protection. This same scenario criterion will affect the choice of flight path and flight speed. As such knowledge of terrain profile in lieu of subjective assessment will be required to grade assessment criteria.

3.2.1.2 Time of Day

Time of day, as specifically related to low light or night conditions, will significantly alter what is considered safe and/or tactical flight. Even when operating at night under Night Vision Goggle (NVG) conditions aircraft will be flown at higher minimum altitudes than during daylight hours. Any assessment of tactical flight and/or station keeping type tasks should consider time of day as a mitigating factor.

3.2.1.3 Environment

Rain, fog and other obscuring phenomena can greatly influence the legal and safe flight envelope of a helicopter, especially in low level flight. Speed, altitude and object safe distance are all affected by degraded visual acuity and as such, knowledge of the environmental conditions present during the evaluated scenario need to be considered when evaluating and assessing BTS.

3.2.1.4 Mitigating Circumstances

Response times are also very situationally dependent as the operation and crewing of a helicopter is extremely complex and often influences task priorities. Take for example a crew that experiences enemy fire. Depending on the severity of the immediate threat and/or the amount of damage taken, the time taken to inform higher echelons could vary greatly and still be appropriate to the situation.

3.3 Assisting Technologies

There are several assisting technologies that would need to be resident as part of any analysis software to produce critical evaluation information. The following outline some of these technologies

3.3.1.1 Line of Sight (LOS)

There is no concept of terrain or elevation data resident within DIS network traffic. All positional information contained within the multiple DIS PDUs is encoded as earth-centered-earth-fixed (ECEF) which provides XYZ coordinates based on the earth’s center as the origin. As such any line of sight (LOS) calculations which consider terrain masking or even over-the-horizon (OTH) masking would require software that can reference a local terrain model. In addition to simply referencing the terrain, it is essential that the software reference the same, or highly correlated, terrain model as inconsistencies across vender implementations of terrain models can be significant. Additionally, it must be well understood whether items within the visual database such as buildings and trees, etc. are taken into consideration when calculating LOS or HAT. As an example, if an aircrew masks behind trees and the LOS software is only using terrain height in its calculations it may determine that the helicopter is exposed whereas it is masked.

3.3.1.2 Height above Terrain (HAT)

Like the LOS considerations presented above, any evaluation of flight profiles with respect to altitude would also require software that can reference a local terrain model. As many tactical flight profiles as described in the 1 Wing documentation reference altitude above ground level (AGL) this capability is highly desirable.

3.3.1.3 Visualization of Threat Systems

Over and above line-of-sight, many threat systems cannot be accurately modelled or visualized using a simple distance between entities. Non-spherical threat domes and the directionality of many Radio Frequency (RF)-based sensors should be accurately represented using either visual or physics based models if they are being used to evaluate their impact on potential BTS scenarios. Directionality can be determined from DIS network traffic in most cases (EntityState PDU + EmitterBeam PDU) however other potential factors affecting attenuation cannot. Depending on the desired fidelity of the evaluation, assisting software that is terrain and equipment aware could be employed to increase the realism of the evaluation.

3.3.1.4 Equipment Performance Parameters

Many of the metrics that could assist in assessing BTS can easily be extracted however they will need to be referenced against equipment performance parameters. These parameters can either be hard coded into the evaluation tool or reference an external database system. Examples of these type of parameters are things such as weapons ranges, weapon effects ranges, transmitter ranges, etc.

3.3.1.5 Voice Recognition

Analysis of DIS Transmission and Signal PDUs can be used to determine when any simulation entity ‘talks’ to another entity or even simulated groups such as supported unit or higher command. Although this information can confirm or deny communications and timeliness between elements, effective information transfer for voice communications can only be extracted via subject matter expert analysis or through voice recognition software. Although voice recognition software is likely not to be considered, this section aims to highlight what can and cannot be easily determined from network communications traffic.

3.4 Methodology

To conduct the assessment of feasibility of applying DIS traffic analysis against the assessment of Tactical Aviation Battle Task Standards (BTS), CogSim Technologies Inc. (CTI) first reviewed the available DIS packets/family and then specifically the information available from these packets. The remainder of section 3.4 is taken directly from the structure and content found in the Standard for Distributed Interactive Simulation (DIS) Application Protocols (DIS Steering Committee, 1998) and is included here for a quick reference to the items relevant this this analysis.

It should be noted that although not in common usage, the DIS Application Protocol defines the "Live Entity" family which provides a more streamlined version of some of the protocol data units (PDU) listed below. They functionally provide a smaller subset of the full PDU and are recognized by the "LE_" prefix to their parent PDU. As an example, the LE_Fire_PDU represents a subset of the Fire_PDU.

Although the Live Entity family of PDU are not used in the current CH-146 Griffin MRTT implementation, acknowledgement of them should be considered when implementing in software.

3.4.1 Distributed Interactive Simulation Standard

The Standard for Distributed Interactive Simulation (DIS) Application Protocols (DIS Steering Committee, 1998) defines the following 27 PDUs, which are organized into six protocol families:

1) Entity Information/Interaction
    a. Entity State PDU
    b. Collision PDU
2) Warfare
    a. Fire PDU
    b. Detonation PDU
3) Logistics
    a. Service Request PDU
    b. Resupply Offer PDU
    c. Resupply Received PDU
    d. Resupply Cancel PDU
    e. Repair Complete PDU
    f. Repair Response PDU
4) Simulation Management
    a. Start/Resume PDU
    b. Stop/Freeze PDU
    c. Acknowledge PDU
    d. Action Request PDU
    e. Action Response PDU
    f. Data Query PDU
    g. Set Data PDU
    h. Data PDU
    i. Event Report PDU
    j. Comment PDU
    k. Create Entity PDU

l. Remove Entity PDU

5) Distributed Emission Regeneration
   a. Electromagnetic Emission PDU
   b. Designator PDU
6) Radio Communications
   a. Transmitter PDU
   b. Signal PDU
   c. Receiver PDU

3.4.2 Entity Information/Interaction Group

3.4.2.1 Entity State PDU

The Entity State PDU shall communicate information about an entity's state. This includes state information that is necessary for the receiving simulation applications to represent the issuing entity in the simulation applications' own simulation.

The Entity State PDU shall contain the following information:

a) Identification of the entity that issued the PDU

b) Identification of the force to which the entity belongs

c) Issuing entity's specific entity type

d) Issuing entity's alternate entity type for use with the Guise function

e) Information about the location of the entity in the simulated world and its orientation, including

   i. Location with respect to the world
   ii. Velocity
   iii. Orientation
   iv. Dead reckoning parameters that should be employed when extrapolating the position of this entity (Values in this field shall include dead reckoning algorithm in use, linear acceleration, and angular velocity.)

f) Information required for representation of the entity's appearance including

   i. Appearance of the entity (e. g., normal, smoking, on fire, producing a dust cloud, etc.)
   ii. Markings
   iii. Number of articulation parameters and the parameter values to represent orientation of articulated parts
   iv. Presence (including types and numbers) of attached parts or stores

g) Capabilities of the entity, including

   i. Resupply
   ii. Repair

3.4.2.2 Collision PDU

The Collision PDU shall be used to communicate information about a collision between two simulated entities or between a simulated entity and another object in the simulated world (e.g., a cultural feature such as a bridge or building).

The Collision PDU shall contain the following information:

a) Identification of the entity that issued the PDU

b) Identification of the entity with which the issuing entity collided

c) Event identification of the specific event marked by the collision of the entities

d) Information for damage determination. This information, when available, shall be used by each entity to determine the extent of damage received during the collision, including

   i. Velocity vector of the issuing entity
   ii. Mass of the issuing entity
   iii. Location of impact in entity coordinates of the entity with which the issuing entity collided. Any of these three fields may be set to zero if data required for that field cannot be determined by the issuing entity.

e) Information identifying whether the collision should be modeled as an elastic or inelastic type collision

3.4.3 Warfare Group

Representation of weapons fire in a DIS exercise shall consist of the following sequence of events:

a) An entity fires a weapon. The firing of a weapon shall be communicated using a Fire PDU.

b) Munition is launched. The munition launched shall be modeled by the simulation application controlling the munition. If tracking data is required for the munition, it shall be assigned a unique entity identifier by the firing entity's simulation application. In addition to issuing the Fire PDU, the simulation application modeling the munition's behavior shall issue Entity State PDUs for the munition per the procedures for the use of the Entity State PDU (see 4.5.2). The munition, therefore, is represented as an entity. If tracking data is not required for the munition, the Munition ID field in the Fire PDU shall be MUNITION_NOT_TRACKED, and no Entity State PDUs shall be issued for this munition. Tracking data should be provided for a munition if representing its travel between firing and impact would affect the outcome of the simulation. This is generally the case if simulation entities can detect and react to the munition during the munition's travel.

c) Impact or detonation is communicated. The impact or detonation of a munition shall be communicated using a Detonation PDU. If the munition is not represented as an entity, detonation represents the end of its path. When a munition is represented as an entity, the termination of the existence of the munition entity is determined by the State bit in the Appearance Field set to Deactivated in the munition entity's Entity State PDU.

3.4.3.1 Fire PDU

The Fire PDU shall contain the following information effective at the instant the munition enters the simulated world:

a) Identification of the entity issuing the PDU

b) Identification of the intended target entity if known to the simulation application, otherwise, TARGET_ID_UNKNOWN

c) Identification of tracked munitions (munitions not tracked shall have a munition identification value of MUNITION_NOT_TRACKED)

d) Event identification of the specific event marked by the firing of an entity's weapon

e) Identification of the fire mission if known, otherwise NO_FIRE_MISSION

f) Information required for representation of the path and impact of the munition, including

    i. Location from which the munition was launched or fired

    ii. Type of munition fired

    iii. Warhead of the munition (if applicable, otherwise, it has a value of zero)

    iv. Fuse employed by the munition (if applicable, otherwise, it has a value of zero)

    v. Quantity and rate at which munition was fired

    vi. Initial velocity of the munition when visible effects of the launch first become apparent

    vii. Range (three dimension, straight-line distance) that firing entity's fire control system has assumed for computing the fire control solution

3.4.3.2 Detonation PDU

The Detonation PDU shall contain the following information:

a) Identification of the entity issuing the PDU.

b) Identification of the target entity if an entity is impacted, otherwise, NO_ENTITY_IMPACTED.

c) Identification of the munition being detonated. This identification shall be the same as the Munition ID in the Fire PDU for detonations preceded by a fire event, or the Entity ID in an

Entity State PDU for detonations not preceded by a Fire PDU.

d) Identification of the fire event responsible for the detonation. This shall be the same as the Event ID from the corresponding Fire PDU. If the detonation is not preceded by a corresponding fire event, then the Event Number field of the Event Identifier record shall be zero (e.g., land mine's detonation).

e) Information required for representation of the impact or detonation of the munition, including

i. Location with respect to the world

ii. Type of munition fired

iii. Warhead of the munition (if applicable, otherwise, it has a value of zero)

iv. Fuse employed by the munition (if applicable, otherwise, it has a value of zero)

v. Quantity and rate at which the munition was fired

vi. Velocity just before detonation/impact

vii. Location of detonation with respect to the target entity

viii. Detonation result

ix. Articulation parameters for any articulated parts of the target entity affected by the detonation

3.4.4 Distributed Emission Regeneration

The following assumptions shall be followed for DER in DIS:

a) Simulation applications with emitters shall simulate their emitter and shall output predefined, real time operational parameters via the DIS communications network.

b) Simulation applications with receivers shall regenerate the transmitter signal to the fidelity level required by that receiving simulation application. For electromagnetic emissions, regeneration shall be accomplished by using the operational parameters provided in the Electromagnetic Emissions PDU along with information from stored databases that describes the transmitter capabilities (i.e., beam patterns, etc.).

c) Scan patterns shall be regenerated based on beam-center data sent from the transmitter, coupled with receiver stored database parameters.

d) The DER approach for electromagnetic emissions contains provisions to allow emitters to communicate information on entities that are being tracked by the system. This capability allows tracking truth to be distinguished for such purposes as ensuring a fair fight in multi-fidelity applications and supporting monitoring systems. This capability is also required because the beam movement (or array control) in complex emitter systems (such as phased-array systems) occurs too fast to allow for electromagnetic emissions issuing separate PDUs for each beam position.

e) The DER approach for electromagnetic emissions allows deception jammers to communicate information to the emitter(s) for which the jamming is intended. This capability is provided to support indirect jamming techniques.

3.4.4.1 Electromagnetic Emission PDU

The Electromagnetic Emission PDU shall contain the following information:

a) Identification of the emitting entity.

b) Identification of the event.

c) Identification of the type of update information in PDU.

   i. A state update provides a full description of the emitter system(s) identified in the PDU. All active (emitting) systems and active beams will be included in the state update.

   ii. A change data update provides a method to allow changes of emitter state to be communicated between state updates.

d) Number of emitter systems for which information is being provided in the PDU.

e) Information for one or more emitter systems that are controlled by the entity, including

   i. Length of the emitter system data.

   ii. Number of beams (for each emitter system) for which information is being provided in the PDU.

   iii. Emitter system that includes the emitter name, function of the emission system, and emitter identification number.

   iv. Location of the emitter, which is the location of the antenna beam source.

   v. Information for one or more beams that the emitter system transmits, including

      - Length of the beam data.
      - Beam identification number for each beam.
      - Beam parameter index.
      - Fundamental parametric data, which is essentially data that can vary for a specific emitter system or can vary dynamically during system operation (even though this emitter system’s mode and beam functions are not changed). This data is also available to support applications of low-fidelity simulations that may not have the computational power to process high-fidelity regeneration models.
      - Beam function identifier.
      - Number of targets for which information is provided in the Track/Jam field of the PDU

for the beam being defined.

- High density Track/Jam field.
- Jamming mode sequence to define active jamming techniques being applied.
- Information for one or more targets that are in Track/Jam field, including -Track/Jam field that provides target site, application, and entity identifications for targets that the emitter identifies as being tracked or, in the case of a jamming emission, provides the site, application, entity, emitter identification, and beam identifications upon which the jamming emission is acting.

3.4.4.2 Designator PDU

The Designator PDU shall contain the following information:

a) Identification of the entity performing the designation

b) Code name for the designator system

c) Identification of the entity being designated (provided only if the designator spot is on an entity)

d) Code of the designator (e.g., laser code)

e) Output power of the designator

f) The designator wavelength

g) Designator spot position with respect to an entity (This data provides specific detail of the spot position with respect to a designated entity's coordinate system.)

h) Location of the designator spot in the world coordinate system

i) Dead reckoning parameters that should be employed when extrapolating the world coordinate position of the designator spot (Values in this field shall include the dead reckoning algorithm in use and linear acceleration.)

3.4.5 Radio Communications Group

Quantitative analysis of communications will primarily involve monitoring of the Radio Communications group. The following excerpt from the IEEE DIS standard outlines recognized radio usage:

a) Transmitting radio simulation applications shall output a Transmitter PDU and a Signal PDU to represent their state.

b) Receiving radio simulation applications shall reproduce the received signal to the fidelity level required by that receiver simulation. This shall be accomplished using the parameters provided in the Transmitter PDU and Signal PDU.

c) The location of the radio described by the PDUs shall be determined either from the radio's Transmitter PDU or, if greater accuracy is required, from the Entity State PDU for the entity of which the radio is a part.

d) A DIS entity shall be associated with every radio transmitter and receiver. This entity shall be identified in each Transmitter PDU or Receiver PDU. This entity may represent the radio itself or the vehicle that contains the radio.

e) Receiving radio simulation application may issue Receiver PDUs to reflect receiver state. These PDUs are for use by radio network monitors, data loggers, and similar systems.

The Radio Communications group consists of the following DIS packets:

3.4.5.1 Transmitter PDU

The Transmitter PDU shall contain the following information:

a) Identification of the entity that contains the radio transmitter

b) Identification of the transmitter that is being described

c) Identification of the type of transmitter that is being described State of the transmitter (whether it is off, on but not transmitting, or on and transmitting)

d) Source of the radio input (whether the pilot, co-pilot, 1st officer, etc.)

e) Location of the radiating portion of the antenna in both world and entity coordinates

f) Type of representation used for the radiation pattern from the antenna [The actual representation is described in the antenna pattern parameter, described in item n).]

g) Center frequency for transmission.

h) Bandwidth of the transmitter measured between the half-power (-3 dB) points (This value represents total bandwidth, not the deviation from the center frequency.)

i) Average power being transmitted.

j) Type of modulation used for transmission (This includes the spread-spectrum usage, details on modulation type, and the compatibility of the emissions from the subject transmitting device.)

k) Specification of the crypto or secure voice equipment if utilized (also provides information to ensure that the transmitting and receiving crypto gear are utilizing the same crypto key.)

l) Modulation type specific parameters that define the details of the radio frequency modulation used

m) Antenna pattern parameters that describe the radiation pattern from the antenna, its orientation in space, and the polarization of the radiation

Within the context of analysis, the transmitter can be used to monitor which agencies are being communicated with by observing the frequency and modulation parameters of all onboard radios. In addition, crypto and secure voice status are available to ensure proper configuration of the radio is maintained.

The transmitter mode can be used to detect when and how often transmissions are made. This information can be combined with timing to assess timeliness of transmission for mission critical tasks such as alerting the element to contacts, detections or incoming fire.

The input source can be observed when transmitting to determine allocation of crew duties for radio if this information is desired.

3.4.5.2 Signal PDU

The Signal PDU shall contain the following information:

a) Identification of the entity that is the source of the transmission.

b) Identification of the transmitter that is transmitting.

c) Specification of the encoding scheme utilized. For the large-scale interoperability of analog modulated audio communications, 8-bit mu-law encoding, sampled at 8 kHz [defined in ITU Recommendation G.711 (1988)] shall be supported by all DIS analog modulated radio simulations applications. The encoding scheme for DIS digital audio systems will be determined on a system by system basis. In addition, other encoding schemes may be negotiated between a set of radio simulators. The mechanism for this negotiation is outside the scope of the RCP. These negotiated encoding schemes may be utilized to support the special requirements of radio simulation types, to reduce network loading, or to provide for higher fidelity.

d) Specification of the type of TDL message included in the Signal PDU. It is set to zero if this is not a TDL message. When the Signal PDU carries a TDL message, the TDL type is a positive integer that represents the TDL type (e.g., link 4A, link 11, etc.).

e) Sample rate in samples per second for audio data. The data rate in bits per second for digital data.

f) Length of the data fields expressed in bits.

g) Number of individual audio/voice samples.

The signal PDU serves primarily as a data packet for the information sent out from a transmitter. Size and occurrence of these packets on the network can help fill out information on transmitter usage statistics.

Analysis or review of the Signal PDU would require decoding the data into voice for communications procedures assessment. The first level of decoding could be interpretation of voice comms by a subject matter expert (SME) to ensure proper and efficient information is being passed. Higher level processing could potentially be done using voice to text artificial intelligence software and a second pass analysis on the text to identify key words, phrases or information.

3.4.5.3 Receiver PDU

The Receiver PDU shall contain the following information:

a) Identification of the entity that is controlling the radio receiver

b) Identification of the receiver that is being described

c) State of the receiver (whether it is off, on but not receiving, or on and receiving)

d) Identification of the entity that is controlling the radio transmitter

e) Identification of the transmitter that is being described

f) Average power being received

The data fields contained within the Receiver PDU could be logged to assist in the overall information analysis of communications procedure, however it should be noted that the Receiver PDU is less common in usage than the Transmitter and Signal PDUs and as such may not offer much net gain.

3.5 Base Task Assessments

The following summary represents the available avenues for direct data collection and assessment. These items form the foundation of base events which as previously discussed, can be formed into higher level BTS evaluations.

3.5.1 Communications Procedures

3.5.1.1 Timings

As previously discussed, the event trigger to begin timing can be very subjective and vignette specific. Additionally, what is considered a reasonable response time to initiate communications can be very subjective. As such, extraction of response timings will need to have a very well defined start trigger for any given vignette. Even with a well-defined trigger event it may be easier to monitor “no comms within a given time frame” as a criterion over a ranking type assessment.

Table 2 – Communications Procedures: Timings

COMMS PROCEDURE – TIMINGS				
Measure	PDUs	Unit	Assessment	Evaluation
Alert Time	Transmission_PDU Entity_State_PDU	Seconds Location	The entity state PDU can be used to trigger the timer once an entity has entered a predefined zone or crossed a predefined event line. Detecting a radio call to the correct agency using the transmission PDU would stop the timer.	**Effective:** Element alerted within 10 seconds or higher report sent within 5 minutes **Needs Practice:** Element alerted within 30 seconds or higher report went within 10 minutes **Ineffective:** Element alerted more than 30 seconds or not at all. Higher report sent after 10 minutes or not at all
Alert Time	Transmission_PDU Entity_State_PDU	Seconds Location	The entity state PDU can be used to trigger the timer from the onset of a damage state change. Detecting a radio call to the correct agency using the transmission PDU would stop the timer.	**Effective:** Element alerted within 10 seconds or higher report sent within 5 minutes **Needs Practice:** Element alerted within 30 seconds or higher report went within 10 minutes **Ineffective:** Element alerted more than 30 seconds or not at all. Higher report sent after

				10 minutes or not at all
Alert Time	Transmission_PDU Detonation_PDU	Seconds	The detonation PDU could be used to trigger the timer should a detonation occur within a given radius of the entity. Detecting a radio call to the correct agency using the transmission PDU would stop the timer.	**Effective:** Element alerted within 10 seconds or higher report sent within 5 minutes **Needs Practice:** Element alerted within 30 seconds or higher report went within 10 minutes **Ineffective:** Element alerted more than 30 seconds or not at all. Higher report sent after 10 minutes or not at all
Alert Time	Transmission_PDU Fire_PDU	Seconds	The fire PDU could be used to trigger the timer should a fire event occur with the entity as the defined target or within a given radius of the entity. Detecting a radio call to the correct agency using the transmission PDU would stop the timer.	**Effective:** Element alerted within 10 seconds or higher report sent within 5 minutes **Needs Practice:** Element alerted within 30 seconds or higher report went within 10 minutes **Ineffective:** Element alerted more than 30 seconds or not at all. Higher report sent after 10 minutes or not at all

3.5.1.2 Correct agencies (contact)

In general, preflight duties would include implementation of a communications plan. This plan would include all required monitoring agencies and frequencies, element frequencies, supported unit frequencies, crypto and radio settings. The comms plan may also have a locational element which requires the entity to maintain communications with different agencies depending on their current location and/or time. The comms plan will also contain agencies and frequencies for contingencies such as call-for-fire and emergencies.

It should be noted that when working as part of an element, communications responsibilities may be spread across different aircraft. Careful vignette planning could allow for an assessment of comms procedure by monitoring the entities frequency and crypto settings based on time, location and events.

Table 3 – Communications Procedures: Correct Agencies

COMMS PROCEDURE – CORRECT AGENCIES				
Measure	PDUs	Unit	Assessment	Evaluation
Correct Agency	Transmission_PDU Entity_State_PDU	Frequency Location	The entity state PDU can be used to monitor the current entity location and cross reference the comms plan to ensure proper frequencies/agencies are being utilized.	**Effective:** Transmission sent to correct agency **Needs Practice:** Transmission sent to incorrect agency followed by transmission to correct agency **Ineffective:** Transmission sent to incorrect agency
Correct Agency	Transmission_PDU Detonation_PDU Fire_PDU	Frequency Event	The fire and detonation event PDUs can be used to trigger communications responses. These responses can cross reference the comms plan to ensure proper frequencies/agencies are being utilized.	**Effective:** Transmission sent to correct agency **Needs Practice:** Transmission sent to incorrect agency followed by transmission to correct agency **Ineffective:** Transmission sent to incorrect agency
Configuration	Transmission_PDU	Frequency Crypto Modulation	Radio configuration held within the transmission PDU can be used to ensure the proper employment of comms gear. These settings can be cross referenced to the comms plan to ensure proper employment.	**Effective:** Radio configured properly and transmission sent **Needs Practice:** Radio improperly configured but corrected **Ineffective:** Radio improperly configured

				and transmission not sent

3.5.1.3 Passage of information

Passage of information consists of an assessment of whether the right information is passed to the correct agencies at the correct time. This of course is both highly subjective and the data, although available from DIS radio calls, contains digital voice information and as such is not empirically measurable. As previously outlined in the assumptions, any form of assessment on passage of information would require as a minimum SME human-in-the-loop involvement and very likely lends itself to incorporation into some form of after action review (AAR) tool suite.

Table 4 – Communications Procedures: Passage of Information

COMMS PROCEDURE – PASSAGE OF INFORMATION				
Measure	PDUs	Unit	Assessment	Evaluation
Information	Signal_PDU Entity_State_PDU	Location	Signal PDU information could be listened to and recorded to ensure the proper information is being communicated by the aircrew for the events presented within the vignette. This would require the involvement of an SME.	**Effective:** Clear and properly formatted information passed **Needs Practice:** Unclear or improperly formatted information passed **Ineffective:** Incorrect information passed

3.5.1.4 Voice procedure

There is some information that can be data derived to assess voice procedure in an empirical manner. Over or under use of radio communications is not desirable especially in a highly fluid environment such as direct enemy engagement. Careful vignette design could provide an environment where monitored radio usage could be assessed as a measured criterion for communications procedures.

Table 5 – Communications Procedures: Voice Procedure

COMMS PROCEDURE – VOICE PROCEDURE				
Measure	PDUs	Unit	Assessment	Evaluation
Number of Transmissions	Transmission_PDU (Note: The Transmission_PDU is used as a single transmission often contain many Signal_PDU)	Count	Given an event trigger within a vignette designed to invoke radio communications, the number of radio transmissions can be collated and used in the overall assessment of proper voice procedures.	**Effective:** Succinct number of transmissions **Needs Practice:** Less than optimal number of transmissions sent **Ineffective:** Unnecessary number of transmissions sent
Length of Transmissions	Transmission_PDU (see previous note)	Time	Given an event trigger within a vignette designed to invoke radio communications, the average length of radio transmissions can be collated and used in the overall assessment of proper voice procedures.	**Effective:** Short and precise transmissions **Needs Practice:** Long transmissions used **Ineffective:** Unnecessarily long transmissions used
Proper Procedures	Signal_PDU		There are some instances of voice procedure such as call for fire, and standard reporting procedures such as SITREPs, STATREPs, etc. that utilize very rigid communications procedures. As outlined in the passage of information section, the employment of an SME human-in-the-loop could provide an assessment of voice	**Effective:** Contextually proper messages sent **Needs Practice:** Messages partially contextually correct **Ineffective:** Adhoc and/or incorrectly formatted messages

			procedures.	sent

3.5.2 Navigation

Precise navigation is a hallmark of tactical aviation. Route, speed and timings are all critical in both tactical and administrative flights. Even with the advent of GPS and beacon navigation aids the ability of a unit or element to maintain planned navigation is important. It may be desirable for a vignette to include a planned (and programmed) failure of on-board electronic systems. This would allow the aircrew to have their navigation map reading skills to be accessed without electronic aids. The following sections look at the relevant quantifiable measures.

3.5.2.1 Route Following

Table 6 – Navigation: Route Following

NAVIGATION – ROUTE FOLLOWING				
Measure	PDUs	Unit	Assessment	Evaluation
Path	Entity_State_PDU	Location	The world location of the entity can be monitored and compared against the predefined flight path. Deviations outside of a defined acceptable corridor could be flagged for both magnitude and time outside the corridor and used as a route following assessment.	**Effective:** Aircraft flown within 100m of planned track greater than 90% of route **Needs Practice:** Aircraft flown within 100m of planned track greater than 60% of route **Ineffective:** Aircraft flown within 100m of planned track less than 60% of route
Altitude	Entity_State_PDU	Meters	The world location of the entity can be monitored in conjunction with a terrain profile to determine the flight altitude.	**Effective:** Aircraft flown within 20m of planned altitude greater than 90%

			Variations in altitude off the predetermined route can be used for assessment.	of route **Needs Practice:** Aircraft flown within 20m of planned altitude greater than 60% of route **Ineffective:** Aircraft flown within 20m of planned altitude less than 60% of route
Waypoints	Entity_State_PDU	Location	Predefined waypoints in the planned route can be used to compare the actual flown path using the world location information contained in the entity state PDU.	**Effective:** All waypoints overflown by within 100m **Needs Practice:** More than 60% of waypoints overflown by within 100m **Ineffective:** Less than 60% of waypoints overflown by within 100m

3.5.2.2 Speed

Maintaining a planned speed during navigation is essential for several reasons. The primary reason for maintaining a flight planned speed is to ensure proper timings and coordination with other units and flight following. However, when part of an element or when escorting other aircraft some units might not be physically capable of maintaining a speed greater than planned. On the other side maintaining a slower speed may unnecessarily expose the unit or element to ground threats.

Table 7 – Navigation: Speed

NAVIGATION – SPEED				
Measure	PDUs	Unit	Assessment	Evaluation
Speed	Entity_State_PDU	Velocity Location	Given a flight plan and the intended speed for each leg, the entity state	**Effective:** Aircraft flown within 10kts of flight planned for more than 90%

			PDU can be used to monitor. Although continuous velocity information is available it may be more practical to average out the speed over any given leg by calculating the time to fly the leg (distance). Variations of flight planned speed may be used to assess overall navigation criteria.	of route **Needs Practice:** Aircraft flown within 10kts of flight planned for more than 60% of route **Ineffective:** Aircraft flown within 10kts of flight planned for less than 60% of route

3.5.2.3 Station Keeping

If the entity being assessed is flying either as part of an element or as the element lead, the ability of the element to maintain good tactical position within the element (station keeping) can be monitored via DIS network traffic. Accuracy of the elements station keeping may be used to assess navigation and/or tactical flight.

Table 8 – Navigation: Station Keeping

NAVIGATION – STATION KEEPING				
Measure	PDUs	Unit	Assessment	Evaluation
Relative Location	Entity_State_PDU	Meters	The world location information within the entity state PDU can be used to assess the relative distances between aircraft within an element. Any unit consistently too close or too far from their assigned station can be used as an assessment. It should be noted that stations are normally relative to another aircraft and can be hierarchical in nature so knowledge of the briefed formation for any given vignette will	**Effective:** Aircraft flown within 50m of element station for more than 90% of route **Needs Practice:** Aircraft flown within 50m of element station for more than 60% of route **Ineffective:** Aircraft flown within 50m of element station for less than 60% of route

			need to be considered.	
Relative Altitude	Entity_State_PDU	Meters	World location information in conjunction with terrain profile can be used to monitor station keeping within an element or potentially between elements as escort duties may assigned a different altitude profile for overwatch, etc.	**Effective:** Aircraft flown within 20m of planned altitude greater than 90% of route **Needs Practice:** Aircraft flown within 20m of planned altitude greater than 60% of route **Ineffective:** Aircraft flown within 20m of planned altitude less than 60% of route

3.5.2.4 Pick up/Drop Location

Accuracy of navigation in pick up/drop off locations are critical in many aspects of tactical navigation from airmobile operations to medivac and others. Pick up/drop off locations may be preplanned as part of mission preparation or fluid in the flow of an operation or in the case of a medevac or call for extraction. Failure to precisely navigate to a mission critical location in any of these instances could carry great consequence.

Table 9 – Navigation: Pickup/Drop Location

NAVIGATION – ACCURACY				
Measure	PDUs	Unit	Assessment	Evaluation
Location	Entity_State_PDU	Meters	The world location information within the entity state PDU can be used to assess the relative distances between flight planned and actual pick up/drop off locations.	**Effective:** Aircraft or element lands within 100m of planned location **Needs Practice:** Aircraft or element lands within 250m of planned location

				Ineffective: Aircraft or element land beyond 250m of planned location

3.5.2.5 Pick up/Drop Timings

Accuracy of timings in pick up/drop off locations are critical in many aspects of tactical navigation from airmobile operations to medivac and others. Pick up/drop off timings may be preplanned as part of mission preparation or fluid in the flow of an operation or in the case of a medevac or call for extraction. Failure to precisely adhere to a mission critical timing in any of these instances could carry great consequence.

Table 10 – Navigation: Pickup/Drop Timings

COMMS PROCEDURE – TIMINGS				
Measure	PDUs	Unit	Assessment	Evaluation
Time	Entity_State_PDU	Seconds	The world location information within the entity state PDU can be used in conjunction with mission timings to assess the relative accuracy of time-on-target (TOT) events.	**Effective:** Aircraft or element lands within 2 minutes of planned time **Needs Practice:** Aircraft or element lands within 5 minutes of planned time **Ineffective:** Aircraft or element lands outside of 5 minutes of planned time

3.5.3 Tactical Flying

Tactical flight over the battlefield, either alone or a part of an element, is a base level task. As opposed to an administrative flight, tactical flying assumes that hostile presence and/or hostile contact is a possibility. Safety and survivability is highly dependent on tactical flying.

As previously discussed in the section on assumptions, many of the evaluating criteria for tactical flight will require reference to terrain profile and LOS or view shed type analysis either in real time or in post processing. Additionally, hostile weapon and sensor performance profiles will be required in the assessment of exposure and threats.

Note: Line-of-sight (LOS) commonly refers to the visibility between two objects. View shed is a term used to described the volumetric total of all that can be seen from any given location.

It should also be noted again that acceptable tactical flight will be highly dependent on terrain, weather and illumination. These considerations are discussed above.

3.5.3.1 Exposure

Exposure in this case is limited to detection of presence from both visual and sensor systems and is not in response to a direct threat.

Table 11 – Tactical Flying: Exposure

TACTICAL FLYING – EXPOSURE				
Measure	PDUs	Unit	Assessment	Evaluation
Line of Sight	Entity_State_PDU	Location	Location information contained within the entity state PDU combined with knowledge of terrain profile and location of threats can be used to measure exposure. Line of sight or view shed calculations can be computed and length of exposure tallied. SME interpretation and/or terrain profiling would likely be required to interpret flight route choice and incorporate vignette specific tactical considerations.	**Effective:** Aircraft flown to minimize visual exposure for greater than 90% of flight **Needs Practice:** Aircraft flown to minimize visual exposure for greater than 60% of flight **Ineffective:** Aircraft flown with little or no regard to visual exposure
Altitude	Entity_State_PDU	Meters	Location information contained within the entity state PDU combined with knowledge of terrain profile and location of threats can be used to measure exposure with respect to	**Effective:** Aircraft flown within 20m of planned altitude greater than 90% of route

			flight altitude. This criterion has been separated from line-of-sight exposure as it can be evaluated against acceptable flight altitudes for the vignette conditions independent of flight route choice.	**Needs Practice:** Aircraft flown within 20m of planned altitude greater than 60% of route **Ineffective:** Aircraft flown within 20m of planned altitude less than 60% of route
Noise	Entity_State_PDU	Db	Location information contained within the entity state PDU combined with knowledge of terrain profile and location of threats can be used to measure noise exposure. Noise exposure can be tallied or overflight of known hostile locations could be flagged. SME interpretation and/or terrain profiling would likely be required to interpret flight route choice and incorporate vignette specific tactical considerations	**Effective:** Aircraft follows planned noise discipline throughout flight **Needs Practice:** Aircraft follows planned noise discipline for more than 70% of flight **Ineffective:** Aircraft follows planned noise discipline for less than 70% of flight
Lights	Entity_State_PDU	Lighting	Night flight and specifically NVG conditions requiring light discipline could check the entity appearance information available in the entity state PDU to check for light discipline adherence, specifically with navigation and anti-collision lights.	**Effective:** Aircraft follows planned light discipline throughout flight **Needs Practice:** Aircraft follows planned light discipline for more than 70% of flight **Ineffective:** Aircraft follows planned light discipline for less than 70% of flight
Comms	Transmission_PDU	Comms	Mission planning may impose restricted communications discipline for all or part of the flight. Failure to adhere to comms discipline could jeopardize the safety of the flight or mission integrity.	**Effective:** Aircraft follows planned comms discipline throughout flight **Needs Practice:** Aircraft follows planned comms discipline for more than 70% of flight

				Ineffective: Aircraft follows planned comms discipline for less than 70% of flight

3.5.3.2 Evading Fire

Evasion of fire in tactical flight could be planned or in response to an engagement. Evaluating the tactical soundness of either of these conditions would likely require careful vignette planning with SME input and/or SME evaluation of recorded results. Please refer to the section on trigger events for an explanation of what could define "taking fire".

Table 12 – Tactical Flying: Evading Fire

TACTICAL FLYING – EVADING FIRE				
Measure	PDUs	Unit	Assessment	Evaluation
Line of Sight	Entity_State_PDU Fire_PDU Detonation_PDU	Location	Location information contained within the entity state PDU combined with knowledge of terrain profile and location of threats can be used to measure exposure. Line of sight or view shed calculations can be computed along with knowledge of weapons systems engagement ranges and length of exposure tallied. SME interpretation and/or terrain profiling would likely be required to interpret flight route choice and incorporate vignette specific tactical considerations.	**Effective:** Upon taking fire the aircraft minimizes LOS more than 70% of exposure time **Needs Practice:** Upon taking fire the aircraft minimizes LOS more than 50% of exposure time **Ineffective:** Upon taking fire the aircraft minimizes LOS less than 50% of exposure time
Altitude	Entity_State_PDU	Meters	Location information contained within the entity state PDU combined with knowledge of terrain profile and location of threats can be used to measure	**Effective:** Upon sensor detection, the aircraft or element alters course immediately to avoid continued exposure

			exposure with respect to flight altitude. This criterion has been separated from line-of-sight exposure as it can be evaluated against acceptable flight altitudes for the vignette conditions independent of flight route choice.	**Needs Practice:** Upon sensor detection, the aircraft or element eventually alters course to avoid continued exposure **Ineffective:** Aircraft or element does not alter course and continues exposure to sensor
Orientation	Entity_State_PDU	Degrees	The aircrafts change in orientation relative to the direction of the threat can be used to evaluate the effectiveness of evasion.	**Effective:** Upon taking fire the aircraft or element alters course immediately to avoid continued exposure **Needs Practice:** Upon taking fire the aircraft or element eventually alters course to avoid continued exposure **Ineffective:** Aircraft or element does not alter course and continues exposure

3.5.3.3 Evading Sensor Threats

Evasion of sensor threats in tactical flight could be planned or in response to an engagement. Evaluating the tactical soundness of either of these conditions would likely require careful vignette planning with SME input and/or SME evaluation of recorded results.

Table 13 – Tactical Flying: Evading Sensor Threats

TACTICAL FLYING – EVADING SENSORS				
Measure	PDUs	Unit	Assessment	Evaluation

Line of Sight	Entity_State_PDU Fire_PDU Detonation_PDU	Location	Location information contained within the entity state PDU combined with knowledge of terrain profile and location of sensor threats can be used to measure exposure. Line of sight or view shed calculations can be computed along with knowledge of sensor system ranges and length of exposure tallied. SME interpretation and/or terrain profiling would likely be required to interpret flight route choice and incorporate vignette specific tactical considerations.	**Effective:** Upon sensor exposure, the aircraft minimizes LOS more than 70% of exposure time **Needs Practice:** Upon sensor exposure, the aircraft minimizes LOS more than 50% of exposure time **Ineffective:** Upon sensor exposure, the aircraft minimizes LOS less than 50% of exposure time
Altitude	Entity_State_PDU	Meters	Location information contained within the entity state PDU combined with knowledge of terrain profile and location of threats can be used to measure exposure with respect to flight altitude. This criterion has been separated from line-of-sight exposure as it can be evaluated against acceptable flight altitudes for the vignette conditions independent of flight route choice.	**Effective:** Upon sensor exposure, the aircraft minimizes LOS more than 70% of exposure time **Needs Practice:** Upon sensor exposure, the aircraft minimizes LOS more than 50% of exposure time **Ineffective:** Upon sensor exposure, the aircraft minimizes LOS less than 50% of exposure time
Orientation	Entity_State_PDU	Degrees	The aircraft's change in orientation relative to the direction of the threat can be used to evaluate the effectiveness of evasion.	**Effective:** Upon sensor detection, the aircraft or element alters course immediately to avoid continued exposure **Needs Practice:** Upon sensor detection, the aircraft or element eventually alters course to avoid continued exposure

				Ineffective: Aircraft or element does not alter course and continues exposure to sensor
EMCON	Entity_State_PDU Transmitter_PDU	Active	Radio emission information can be monitored from the transmitter PDU and evaluated against radio control conditions should they be present in the tactical scenario of the vignette	**Effective:** Aircraft follows planned EMCON discipline throughout flight **Needs Practice:** Aircraft follows planned EMCON discipline for more than 70% of flight **Ineffective:** Aircraft follows planned EMCON discipline for less than 70% of flight

3.5.4 Sensor Employment

Assessing sensor employment using DIS network traffic has the potential to be troublesome for several reasons. First, the representation of sensors is not standardized across simulation use and in many cases sensors are not represented at all in DIS traffic. Where they are represented and published they normally appear as their own entity attached to a parent entity or are represented as an articulated part of an entity. To draw sensor information from DIS traffic, an intimate knowledge of the underlying simulation system being assessed will be required. The following sections assume that the representations described are being utilized however as previously mentioned this may not be the case.

Secondly, it should also be noted that passive sensors such as radar warning receivers (RWR) and electro-optical (EO) / infrared (IR) imaging or detection systems are almost never represented in DIS traffic. Systems that emit RF or laser energy however, are typically represented.

3.5.4.1 Sensor Configuration & Employment

If a sensor is part of mission equipment and it is represented in DIS network traffic, then some measure of employment may be possible. Although employment of sensors has been identified as a base task, it may be difficult to evaluate employment beyond proper configuration and set up.

Table 14 – Sensor Employment: Sensors General

SENSORS GENERAL – CONFIGURATION & EMPLOYMENT				
Measure	PDUs	Unit	Assessment	Evaluation
Configuration	Entity_State_PDU	Multiple	Given the known mission requirements for the given vignette, proper configuration of the sensor and whether it is active may be assessable	**Effective:** Sensor equipment is configured and employed correctly **Needs Practice:** Sensor equipment is not initially configured or employed correctly but is corrected for **Ineffective:** Sensor equipment is either not configured or employed correctly
Accuracy	Entity_State_PDU	World Coordinates/ Orientation	If the sensor system is directional and represented as a child entity, the orientation can be obtained from the entity state PDU and assessed against mission criteria	**Effective:** Sensor system is employed effectively for the target or within the targeted area **Needs Practice:** Sensor system is employed effectively for the target or within the targeted area more than 50% of usage **Ineffective:** Sensor system is not employed effectively for the target or within the target area
Accuracy	Entity_State_PDU	Articulated Part	If the sensor system is directional and represented as an articulated party, the orientation can be obtained from the orientation of the articulated part combined with entity state PDU	**Effective:** Sensor system is employed effectively for the target or within the targeted area **Needs Practice:** Sensor system is

			orientation and assessed against mission criteria	employed effectively for the target or within the targeted area more than 50% of usage **Ineffective:** Sensor system is not employed effectively for the target or within the target area**:**

3.5.4.2 Laser Designator Configuration & Employment

If a laser designator is part of mission equipment it should be represented in DIS network traffic. As an active sensor/equipment employment of the laser designator has it a dedicated DIS PDU for network representation. Although employment of sensors has been identified as a base task, it could also be a subtask within the employment of indirect fire task. Utilization of laser designator could impact the assessment and rating of indirect weapons engagement either a positive or negative manner.

Table 15 – Sensor Employment: Laser Designator

LASER DESIGNATOR – CONFIGURATION & EMPLOYMENT				
Measure	PDUs	Unit	Assessment	Evaluation
Configuration	Designator_PDU	Code Power Wave Length	Given the known mission requirements for the given vignette, proper configuration of the laser designator can be assessed	**Effective:** Laser properly configured and employed **Needs Practice:** Laser improperly configured and employed but corrected **Ineffective:** Laser improperly configured and employed
Accuracy	Entity_State_PDU Designator_PDU	World Coordinates	The intended target of designation can be obtained from the designator PDU as well as the location of the	**Effective:** Target illuminated **Needs Practice:** Laser spot off

			designator spot. This spot can be compared to the actual location of the target to assess accuracy	target by less than 50m **Ineffective:** Target misidentified or laser spot off target by more than 50m
Safe Employment	Entity_State_PDU Designator_PDU	World Coordinates	Although not a weapon, a laser designator can have serious harmful effects on equipment and humans. Location of spot should be checked against locations of friendly and neutral units and assessed against safe employment criteria	**Effective:** No friendly or neutral units in vicinity of designation and proper attack vector **Needs Practice:** Friendly or neutral unit in vicinity of designation or attack vector greater than 90 degrees off designation line **Ineffective:** Friendly or neutral unit designated or attack vector greater than 135 degrees off designation line

3.5.5 Direct Fire Weapons Employment

The following subsections lay out the assessment of DIS network packets against assessing direct fire weapons employment. Direct fire weapons are those integral to the unit under evaluation. Examples of such direct fire weapons in tactical aviation would be door guns, rockets and air-to-ground guided munitions.

3.5.5.1 Weapons Selection & Employment

Employment of direct fire weapons should be monitored for correct selection of appropriate weapon for any given target as well as proper employment of weapon. Subject matter expert (SME) criteria tables for weapon/target combinations could be developed to assess against. Some degree of situational dependency should also be considered for employment differences as intended attack versus suppressing fire. Weapon selection and employment could impact the assessment and rating of direct weapons engagement either a positive or negative manner.

Table 16 – Direct Fire Weapons Employment: Selection and Employment

WEAPONS EFFECTS – SELECTION & EMPLOYMENT				
Measure	PDUs	Unit	Assessment	Evaluation
Weapons Selection	Detonation_PDU Entity_State_PDU	Munition/Entity Type	Munition entity identification should be checked against the entity identification of engaged units and assessed against weapons selection criteria such as hard/soft skinned targets, etc.	**Effective:** Weapons selection effective for target **Needs Practice:** Weapons selection somewhat effective for target **Ineffective:** Weapons selection ineffective for target
Weapons Selection	Detonation_PDU Entity_State_PDU	Munition Descriptor	Evaluation of the munition descriptor (warhead/fuse/quantity/rate) should be checked against previously mentioned target descriptions to assess effective weapons selection	**Effective:** Weapons selection effective for target **Needs Practice:** Weapons selection somewhat effective for target **Ineffective:** Weapons selection ineffective for target
Engagement Range	Fire_PDU Entity_State_PDU	World Coordinates	Engagement range can be extracted either from comparing the world locations of the weapon and the target or by accessing the range value in the FIRE PDU if employed. This range can be compared against the known effective range of the weapon choice to assess engagement effectiveness	**Effective:** Hostile units engaged within effective range of weapons **Needs Practice:** Hostile units engaged at the maximum effective range of weapons **Ineffective:** Hostile units engaged beyond effective range

				of weapons

3.5.5.2 Weapons Effect

Employment of direct fire weapons should be monitored for effectiveness of engagements. Accuracy and damage caused by weapons employment could impact the assessment and rating of direct weapons engagement in a positive or negative manner.

Table 17 – Direct Fire Weapons Employment: Weapons Effect

WEAPONS EFFECTS – WEAPONS EFFECT				
Measure	PDUs	Unit	Assessment	Evaluation
Proximity of fire	Entity_State_PDU Detonation_PDU	World Coordinates	Location of weapons impact should be checked against locations of hostile units and assessed against accuracy	**Effective:** Call for fire impacts within 100m of targeted hostile units **Needs Practice:** Call for fire impacts within 200m of targeted hostile units **Ineffective:** Call for fire impacts beyond 200m of targeted hostile units
Damage	Entity_State_PDU	Entity Appearance	Monitor entity appearance flags of hostile units near fire to detect damage or destruction from weapons employment	**Effective:** Majority of hostile units in target area are damaged or destroyed **Needs Practice:** Some hostile units in target area are damaged or destroyed

				Ineffective: No hostile units in target area are damaged or destroyed

3.5.5.3 Fratricide

Employment of direct fire weapons should be monitored for blue-on-blue engagements. Any detected blue-on-blue engagement could impact the assessment and rating of direct weapons engagement in a negative manner.

Table 18 – Direct Fire Weapons Employment: Fratricide

WEAPONS EFFECTS – FRATRICIDE				
Measure	PDUs	Unit	Assessment	Evaluation
Proximity of fire	Entity_State_PDU Detonation_PDU	World Coordinates	Location of weapons impact should be checked against locations of friendly units and assessed against no risk/danger close/engaged	**Effective:** Call for fire impacts beyond 200m of friendly units **Needs Practice:** Call for fire impacts within 200m of friendly unit **Ineffective:** Call for fire impacts within 100m of friendly unit
Damage	Entity_State_PDU	Entity Appearance	Monitor entity appearance flags of friendly units near fire to detect damage or destruction from weapons employment	**Effective:** Friendly units are undamaged by call for fire **Needs Practice:** Friendly units are damaged by call for fire **Ineffective:** Friendly units are destroyed or immobilized by call for fire

3.5.5.4 Collateral Damage

Employment of direct fire weapons should be monitored for collateral damage. Any detected collateral damage could impact the assessment and rating of direct weapons engagement in a negative manner.

Table 19 – Direct Fire Weapons Employment: Collateral Damage

WEAPONS EFFECTS – COLLATERAL DAMAGE				
Measure	PDUs	Unit	Assessment	Evaluation
Proximity of fire	Entity_State_PDU Detonation_PDU	World Coordinates	Location of weapons impact should be checked against locations of neutral units and assessed against no risk/danger close/engaged	**Effective:** Indirect fire impacts beyond 200m of neutral units **Needs Practice:** Indirect fire impacts within 200m of neutral units **Ineffective:** Indirect fire impacts within 100m of neutral units
Damage	Entity_State_PDU	Entity Appearance	Monitor entity appearance flags of neutral units near fire to detect damage or destruction from weapons employment	**Effective:** Neutral units are undamaged by call for fire **Needs Practice:** Neutral units receive damage by call for fire **Ineffective:** Neutral units are destroyed by call for fire

3.5.5.5 Taking fire/Damage

The exposure to hostile fire that the evaluated entity is subjected to during a direct weapons employment can be monitored and used to assess effectiveness. Assessment criteria for self-protection will very likely be very situationally dependent and as such SME evaluation criteria should be developed on a per vignette basis. Excessive or unnecessary exposure to fire could impact the assessment and rating of direct weapons engagement in a negative manner.

Table 20 – Direct Fire Weapons Employment: Self Protection

WEAPONS EFFECTS – SELF-PROTECTION				
Measure	PDUs	Unit	Assessment	Evaluation
Proximity of fire	Entity_State_PDU Detonation_PDU	World Coordinates	Location of weapons impact should be checked against location of own ship	**Effective:** Hostile units engaged beyond effective range of hostile weapons **Needs Practice:** Hostile units engaged near effective range of hostile weapons **Ineffective:** Hostile units engaged within effective range of hostile weapons
Exposure to fire: Range	Fire_PDU Entity_State_PDU	World Coordinates	Engagement range can be extracted either from comparing the world locations of the weapon(s) and the own ship or by accessing the range value in the FIRE PDU if employed. This range can be compared against the known effective range of the weapon to assess the exposure to threat	**Effective:** Hostile units engaged beyond effective range of hostile weapons **Needs Practice:** Hostile units engaged near effective range of hostile weapons **Ineffective:** Hostile units engaged within effective range of hostile weapons

Exposure to fire: Time	Entity_State_PDU Detonation_PDU	Time	The amount of time that the own ship is exposed to hostile fire can be tracked and assessed against a situationally developed risk/reward matrix for the vignette	**Effective:** Crew effectively minimizes exposure to hostile fire **Needs Practice:** Minimal attempt to reduce exposure to hostile fire **Ineffective:** No attempt to reduce exposure to hostile fire
Damage	Entity_State_PDU	Entity Appearance	Monitor entity appearance flags of own ship to detect damage or destruction from weapons employment	**Effective:** Aircraft receives minimal or no damage from hostile fire **Needs Practice:** Aircraft receives damage from hostile fire **Ineffective:** Aircraft is destroyed or immobilized by hostile fire

3.5.6 Indirect Weapons Employment

The following subsections lay out the assessment of DIS network packets against assessing indirect fire weapons employment. Indirect fire weapons are those not integral to the unit under evaluation. Examples of such indirect fire weapons in tactical aviation would be mortars, artillery, or employment of controlled gunships or fast-air assets. Employment of mortars and/or artillery would normally be categorized as airborne-forward-observer (A-FO) duties and employment of gunships or fast-air would normally be categorized as airborne-forward-air-controller (A-FAC) duties.

3.5.6.1 Comms procedure

Effective communications procedures are critical to the employment of indirect fire and as such should be considered in the evaluation of this criteria as laid out in the previous base task. Unfortunately, the core of effective communications is hard to assess in a purely data derived manner and will likely require vignette specific SME evaluation over and above what can be extracted from DIS traffic.

3.5.6.2 Weapons Selection & Employment

Employment of indirect fire weapons should be monitored for correct selection of appropriate weapon for any given target as well as proper employment of weapon. It should be noted that the A-FO will only have some control over the weapons employed against a call-for-fire and that the Fire Support Coordination Center (FSCC) may answer the call what whatever is available at the time. Subject matter expert (SME) criteria tables for weapon/target combinations could be developed to assess against. Some degree of situational dependency should also be considered for employment differences as intended attack versus suppressing fire. Weapon selection and employment could impact the assessment and rating of indirect weapons engagement either a positive or negative manner.

Table 21 – Indirect Fire Weapons Employment: Selection and Employment

WEAPONS EFFECTS – SELECTION & EMPLOYMENT				
Measure	PDUs	Unit	Assessment	Evaluation
Weapons Selection	Detonation_PDU Entity_State_PDU	Munition/Entity Type	Munition entity identification should be checked against the entity identification of engaged units and assessed against weapons selection criteria such as hard/soft skinned targets, etc.	**Effective:** Weapons selection effective for target **Needs Practice:** Weapons selection somewhat effective for target **Ineffective:** Weapons selection ineffective for target
Weapons Selection	Detonation_PDU Entity_State_PDU	Munition Descriptor	Evaluation of the munition descriptor (warhead/fuse/quantity/rate) should be checked against previously mentioned target descriptions to assess effective weapons selection	**Effective:** Weapons selection effective for target **Needs Practice:** Weapons selection somewhat effective for target **Ineffective:** Weapons selection ineffective for target

Engagement Range	Fire_PDU Entity_State_PDU	World Coordinates	Engagement range can be extracted either from comparing the world locations of the weapon and the target or by accessing the range value in the FIRE PDU if employed. This range can be compared against the known effective range of the weapon choice to assess engagement effectiveness	**Effective:** Hostile units engaged within effective range of weapons **Needs Practice:** Hostile units engaged at the maximum effective range of weapons **Ineffective:** Hostile units engaged beyond effective range of weapons

3.5.6.3 Weapons Effect

Employment of direct fire weapons should be monitored for effectiveness of engagements. Accuracy and damage caused by weapons employment could impact the assessment and rating of direct weapons engagement in a positive or negative manner.

Table 22 – Indirect Fire Weapons Employment: Weapons Effect

WEAPONS EFFECTS – WEAPONS EFFECT				
Measure	PDUs	Unit	Assessment	Evaluation
Proximity of fire	Entity_State_PDU Detonation_PDU	World Coordinates	Location of weapons impact should be checked against locations of hostile units and assessed against accuracy	**Effective:** Call for fire impacts within 100m of targeted hostile units **Needs Practice:** Call for fire impacts within 200m of targeted hostile units **Ineffective:** Call for fire impacts beyond 200m of targeted hostile units

Damage	Entity_State_PDU	Entity Appearance	Monitor entity appearance flags of hostile units near fire to detect damage or destruction from weapons employment	**Effective:** Majority of hostile units in target area are damaged or destroyed **Needs Practice:** Some hostile units in target area are damaged or destroyed **Ineffective:** No hostile units in target area are damaged or destroyed

3.5.6.4 Fratricide

Employment of direct fire weapons should be monitored for blue-on-blue engagements. Any detected blue-on-blue engagement could impact the assessment and rating of direct weapons engagement in a negative manner.

Table 23 – Indirect Fire Weapons Employment: Fratricide

WEAPONS EFFECTS – FRATRICIDE				
Measure	PDUs	Unit	Assessment	Evaluation
Proximity of fire	Entity_State_PDU Detonation_PDU	World Coordinates	Location of weapons impact should be checked against locations of friendly units and assessed against no risk/danger close/engaged	**Effective:** Call for fire impacts beyond 200m of friendly units **Needs Practice:** Call for fire impacts within 200m of friendly unit **Ineffective:** Call for fire impacts within 100m of friendly unit

Damage	Entity_State_PDU	Entity Appearance	Monitor entity appearance flags of friendly units near fire to detect damage or destruction from weapons employment	**Effective:** Friendly units are undamaged by call for fire **Needs Practice:** Friendly units are damaged by call for fire **Ineffective:** Friendly units are destroyed or immobilized by call for fire

3.5.6.5 Collateral Damage

Employment of direct fire weapons should be monitored for collateral damage. Any detected collateral damage could impact the assessment and rating of direct weapons engagement in a negative manner.

Table 24 – Indirect Fire Weapons Employment: Collateral Damage

WEAPONS EFFECTS – COLLATERAL DAMAGE				
Measure	PDUs	Unit	Assessment	Evaluation
Proximity of fire	Entity_State_PDU Detonation_PDU	World Coordinates	Location of weapons impact should be checked against locations of neutral units and assessed against no risk/danger close/engaged	**Effective:** Indirect fire impacts beyond 200m of neutral units **Needs Practice:** Indirect fire impacts within 200m of neutral units **Ineffective:** Indirect fire impacts within 100m of neutral units
Damage	Entity_State_PDU	Entity Appearance	Monitor entity appearance flags of neutral units near fire to detect damage or destruction from weapons employment	**Effective:** Neutral units are undamaged by call for fire **Needs Practice:** Neutral units

				receive damage by call for fire **Ineffective:** Neutral units are destroyed by call for fire

3.5.6.6 Taking fire/Damage

The exposure to hostile fire that the evaluated entity is subjected to during a direct weapons employment can be monitored and used to assess effectiveness. Assessment criteria for self-protection will very likely be very situationally dependent and as such SME evaluation criteria should be developed on a per vignette basis. Excessive or unnecessary exposure to fire could impact the assessment and rating of direct weapons engagement in a negative manner.

Table 25 – Direct Fire Weapons Employment: Self Protection

WEAPONS EFFECTS – SELF-PROTECTION				
Measure	PDUs	Unit	Assessment	Evaluation
Proximity of fire	Entity_State_PDU Detonation_PDU	World Coordinates	Location of weapons impact should be checked against location of own ship	**Effective:** Hostile units engaged beyond effective range of hostile weapons **Needs Practice:** Hostile units engaged near effective range of hostile weapons **Ineffective:** Hostile units engaged within effective range of hostile weapons
Exposure to fire: Range	Fire_PDU Entity_State_PDU	World Coordinates	Engagement range can be extracted either from comparing the world locations of the weapon(s) and the own	**Effective:** Hostile units engaged beyond effective range of hostile weapons

			ship or by accessing the range value in the FIRE PDU if employed. This range can be compared against the known effective range of the weapon to assess the exposure to threat	**Needs Practice:** Hostile units engaged near effective range of hostile weapons **Ineffective:** Hostile units engaged within effective range of hostile weapons
Exposure to fire: Time	Entity_State_PDU Detonation_PDU	Time	The amount of time that the own ship is exposed to hostile fire can be tracked and assessed against a situationally developed risk/reward matrix for the vignette	**Effective:** Crew effectively minimizes exposure to hostile fire **Needs Practice:** Minimal attempt to reduce exposure to hostile fire **Ineffective:** No attempt to reduce exposure to hostile fire
Damage	Entity_State_PDU	Entity Appearance	Monitor entity appearance flags of own ship to detect damage or destruction from weapons employment	**Effective:** Aircraft receives minimal or no damage from hostile fire **Needs Practice:** Aircraft receives damage from hostile fire **Ineffective:** Aircraft is destroyed or immobilized by hostile fire

3.6 Composite Task Analysis

The following section itemizes the remainder of the BTS that have been categorized as composite tasks. These tasks have no unique measurable criteria but are instead collections of base tasks that are applicable to the specific task. As such the following sections present them broken down by the previously described base tasks assessed by their specific criteria as laid out in the B-GA-446.

The Base Tasks column of the following tables list all the base tasks defined in the previous section. The Assessment column references the criteria (by number and sub-letter where appropriate) listed in the BTS.

3.6.1 REACT TO DIRECT SURFACE-TO-AIR FIRE

Table 26 – React to Direct Surface-To-Air Fire

REACT TO DIRECT SURFACE-TO-AIR FIRE	
Base Tasks	Assessment
COMMS PROCEDURE	2 Report enemy fire and origin 3 Send contact report to higher
NAVIGATION	
TACTICAL FLYING	1a Evasive flight 4a Manoeuver to engage 4b Manoeuver to observe 4c Withdraw
SENSOR EMPLOYMENT	4b Designate (possibly)
DIRECT FIRE WEAPONS EMPLOYMENT	1b Return fire 4a Engage with direct fire
INDIRECT WEAPONS EMPLOYMENT	4b Engage with indirect fire

3.6.2 REACT TO IR OR RF MISSILE ENGAGEMENT

Table 27 – React to IR OR RF Missile Engagement

REACT TO IR OR RF MISSILE ENGAGEMENT	
Base Tasks	Assessment
COMMS PROCEDURE	4 Engagement passed to element 6 Contact report to higher

NAVIGATION	5 Adjust flight route
TACTICAL FLYING	3 Evasive flight 5 Adjust flight path 7a Manoeuvre to engage 7b Manoeuvre to observe 7c Withdraw
SENSOR EMPLOYMENT	1c DEWS configured 1d ASE enabled and armed 7b Designate 8 EMCON
DIRECT FIRE WEAPONS EMPLOYMENT	7a Engage with direct fire
INDIRECT WEAPONS EMPLOYMENT	7b Engage with indirect fire

3.6.3 REACT TO RADAR OR LASER ILLUMINATION

Table 28 – React to Radar or Laser Illumination

REACT TO RADAR OR LASER ILLUMINATION	
Base Tasks	Assessment
COMMS PROCEDURE	6 Brief element 7 Contact report to higher
NAVIGATION	4 Adjust flight route
TACTICAL FLYING	3a Evasive flight 3c Terrain mask and withdraw 3d Maintain standoff and terrain masking and continue 4 Adjust flight profile 8a Avoid and egress 8b Manoeuvre to bypass 8c Manoeuvre to observe
SENSOR EMPLOYMENT	1c DEWS configured 1d ASE enabled and armed 8c Designate 9 EMCON
DIRECT FIRE WEAPONS EMPLOYMENT	
INDIRECT WEAPONS EMPLOYMENT	8c Engage with indirect fire

3.6.4 REACT TO AIR-TO-AIR FIGHTER ATTACK

Table 29 – React to Air-To-Air Fighter Attack

REACT TO DIRECT SURFACE-TO-AIR FIRE	
Base Tasks	Assessment
COMMS PROCEDURE	3 Reports threat to appropriate agencies
NAVIGATION	1 Conduct mission to known threat 4 Evade as required
TACTICAL FLYING	1 Conduct mission to known threat 4 Evade as required
SENSOR EMPLOYMENT	2 Identify hostile aircraft with DEWS
DIRECT FIRE WEAPONS EMPLOYMENT	
INDIRECT WEAPONS EMPLOYMENT	

3.6.5 REACT TO AIR-TO-AIR HELICOPTER ATTACK

Table 30 – React to Air-To-Air Helicopter Attack

REACT TO AIR-TO-AIR HELICOPTER ATTACK	
Base Tasks	Assessment
COMMS PROCEDURE	3 Contact report to higher
NAVIGATION	1 Conduct mission 4 Evade threat
TACTICAL FLYING	1 Conduct mission 4 Evade threat
SENSOR EMPLOYMENT	2 Identification of threat
DIRECT FIRE WEAPONS EMPLOYMENT	
INDIRECT WEAPONS EMPLOYMENT	

3.6.6 EXECUTE AN INSERTION

Table 31 – Execute an Insertion

EXECUTE AN INSERTION	
Base Tasks	Assessment
COMMS PROCEDURE	All
NAVIGATION	3 Aircraft loading and pick up 4a Enroute 6 Insertion
TACTICAL FLYING	4a Enroute 6 Insertion
SENSOR EMPLOYMENT	4 Force protection
DIRECT FIRE WEAPONS EMPLOYMENT	4c Contingency fire support
INDIRECT WEAPONS EMPLOYMENT	4c Contingency fire support

3.6.7 EXECUTE AN EXTRACTION

Table 32 – Execute an Extraction

EXECUTE AN EXTRACTION	
Base Tasks	Assessment
COMMS PROCEDURE	3a Enroute 5 Extraction
NAVIGATION	3a Enroute 5 Extraction
TACTICAL FLYING	3 Force protection
SENSOR EMPLOYMENT	3c Contingency fire support
DIRECT FIRE WEAPONS EMPLOYMENT	3c Contingency fire support
INDIRECT WEAPONS EMPLOYMENT	3a Enroute 5 Extraction

3.6.8 EXECUTE TACTICAL RESUPPLY AND TACTICAL MOVEMENT OF EQUIPMENT

Table 33 –Execute Tactical Resupply and Tactical Movement of Equipment

EXECUTE TACTICAL RESUPPLY AND TACTICAL MOVEMENT OF EQUIPMENT	
Base Tasks	Assessment
COMMS PROCEDURE	All
NAVIGATION	3 Pickup 4 Drop off
TACTICAL FLYING	3 Pickup 4 Drop off
SENSOR EMPLOYMENT	
DIRECT FIRE WEAPONS EMPLOYMENT	
INDIRECT WEAPONS EMPLOYMENT	

3.6.9 EXECUTE LOGISTICAL AIRLIFT

Table 34 – Execute Logistical Airlift

EXECUTE LOGISTICAL AIRLIFT	
Base Tasks	Assessment
COMMS PROCEDURE	All
NAVIGATION	2 Loading 3 Delivery
TACTICAL FLYING	2 Loading 3 Delivery
SENSOR EMPLOYMENT	5 Risk management
DIRECT FIRE WEAPONS EMPLOYMENT	
INDIRECT WEAPONS EMPLOYMENT	

3.6.10 CONDUCT TACTICAL TROOP AIRLIFT

Table 35 – Tactical Troop Airlift

TACTICAL TROOP AIRLIFT	
Base Tasks	Assessment
COMMS PROCEDURE	All
NAVIGATION	2 Loading 3 Delivery
TACTICAL FLYING	2 Loading 3 Delivery
SENSOR EMPLOYMENT	5 Risk management
DIRECT FIRE WEAPONS EMPLOYMENT	
INDIRECT WEAPONS EMPLOYMENT	

3.6.11 EXECUTE AIRMOBILE/AIR ASSAULT OPERATIONS

Table 36 – Execute Airmobile/Air Assault Operations

EXECUTE AIRMOBILE/AIR ASSAULT OPERATIONS	
Base Tasks	Assessment
COMMS PROCEDURE	8 Support of operation
NAVIGATION	3 Troop insertion 4 Surveillance
TACTICAL FLYING	3 Troop insertion 4 Surveillance 5 Protection
SENSOR EMPLOYMENT	4 Surveillance
DIRECT FIRE WEAPONS EMPLOYMENT	5 Protection 6 Fire support for insertion 7 Fire support after insertion
INDIRECT WEAPONS EMPLOYMENT	5 Protection 6 Fire support for insertion 7 Fire support after insertion

3.6.12 REACT TO DOWNED AIRCRAFT

Table 37 – React to Downed Aircraft

REACT TO DOWNE AIRCRAFT	
Base Tasks	Assessment
COMMS PROCEDURE	1 Situational awareness 5 Coordination with ground forces
NAVIGATION	6 Personnel recovery
TACTICAL FLYING	6 Personnel recovery
SENSOR EMPLOYMENT	
DIRECT FIRE WEAPONS EMPLOYMENT	6 Contingency
INDIRECT WEAPONS EMPLOYMENT	6 Contingency

3.6.13 EXECUTE AN AVIATION SCREEN

Table 38 – Execute an Aviation Screen

EXECUTE AN AVIATION SCREEN	
Base Tasks	Assessment
COMMS PROCEDURE	4 Coordinate with appropriate agencies 10 Contact & Situation reports as necessary
NAVIGATION	3 Manoeuvre as required 6 Surveillance of avenues of approach
TACTICAL FLYING	3 Manoeuvre as required 6 Surveillance of avenues of approach
SENSOR EMPLOYMENT	5 Use sensors effectively 6 Surveillance of avenues of approach
DIRECT FIRE WEAPONS EMPLOYMENT	8 Destroy enemy forces
INDIRECT WEAPONS EMPLOYMENT	9 Destroy enemy forces

3.6.14 EXECUTE A ROUTE RECONNAISSANCE

Table 39 – Execute a Route Reconnaissance

EXECUTE A ROUTE RECONNAISSANCE	
Base Tasks	Assessment
COMMS PROCEDURE	8 Contact & Situation reports
NAVIGATION	3 Manoeuvre as required 4 Conduct route recce 6 React to threats
TACTICAL FLYING	3 Manoeuvre as required 4 Conduct route recce 6 React to threats
SENSOR EMPLOYMENT	5 Use sensors effectively
DIRECT FIRE WEAPONS EMPLOYMENT	6 React to threats
INDIRECT WEAPONS EMPLOYMENT	7 Fire support

3.6.15 EXECUTE A ZONE/AREA RECONNAISSANCE

Table 40 – Execute a Zone/Area Reconnaissance

EXECUTE A ZONE/AREA RECONNAISSANCE	
Base Tasks	Assessment
COMMS PROCEDURE	8 Contact & Situation reports 10 Contact & Situation reports
NAVIGATION	3 Manoeuvre as required 4 Conduct zone/area recce 7 React to threats 9 Avoid decisive engagement
TACTICAL FLYING	3 Manoeuvre as required 4 Conduct zone/area recce 7 React to threats 9 Avoid decisive engagement
SENSOR EMPLOYMENT	5 Use sensors effectively

DIRECT FIRE WEAPONS EMPLOYMENT	7 React to threats
INDIRECT WEAPONS EMPLOYMENT	8 Fire support

3.6.16 EXECUTE RECONNAISSANCE TASK

Table 41 – Execute a Reconnaissance Task

EXECUTE A RECONNAISSANCE TASK	
Base Tasks	Assessment
COMMS PROCEDURE	3 Establish comms with appropriate agencies 8 Contact and Situation reports
NAVIGATION	2 Manoeuvre as required 4 Conduct reconnaissance 6 React to threats
TACTICAL FLYING	2 Manoeuvre as required 4 Conduct reconnaissance 6 React to threats
SENSOR EMPLOYMENT	5 Use sensors effectively
DIRECT FIRE WEAPONS EMPLOYMENT	6 React to threats
INDIRECT WEAPONS EMPLOYMENT	7 Direction of fire

3.6.17 EXECUTE A CLOSE COMBAT ATTACK

Table 42 – Execute a Close Combat Attack

REACT TO DIRECT SURFACE-TO-AIR FIRE	
Base Tasks	Assessment
COMMS PROCEDURE	1b Establish comms with friendly ground element 1c Target handover brief 4 Brief engagement plan 7 Pass battle damage assessment (BDA)
NAVIGATION	1a Link with friendly ground element 6 Engage targets

TACTICAL FLYING	1a Link with friendly ground element 6 Engage targets
SENSOR EMPLOYMENT	
DIRECT FIRE WEAPONS EMPLOYMENT	6 Engage targets
INDIRECT WEAPONS EMPLOYMENT	

3.6.18 EXECUTE AN INTERDICTION ATTACK

Table 43 – Execute an Interdiction Attack

EXECUTE AN INTERDICTION ATTACK	
Base Tasks	Assessment
COMMS PROCEDURE	2 Synchronize attack with other elements involved 6 Engagement plan is clearly briefed 9 Battle damage assessment (BDA) passed to higher
NAVIGATION	3 Target or target area positively identified 7 Target engaged
TACTICAL FLYING	3 Target or target area positively identified 4 Position for attack 7 Target engaged
SENSOR EMPLOYMENT	
DIRECT FIRE WEAPONS EMPLOYMENT	7 Target engaged
INDIRECT WEAPONS EMPLOYMENT	8 Fire support as required

3.6.19 EXECUTE AIRBORNE CONVOY ESCORT

Table 44 – Execute Airborne Convoy Escort

EXECUTE AIRBORNE CONVOY ESCORT	
Base Tasks	Assessment
COMMS PROCEDURE	5 Establish and maintain comms with supported unit

NAVIGATION	3 Reconnoiter route
TACTICAL FLYING	3 Reconnoiter route
SENSOR EMPLOYMENT	6 Utilize sensors
DIRECT FIRE WEAPONS EMPLOYMENT	4a Direct fire engagement
INDIRECT WEAPONS EMPLOYMENT	4b Indirect fire engagement

3.6.20 EXECUTE AN AVIATION GUARD

Table 45 –Execute an Aviation Guard

EXECUTE AN AVIATION GUARD	
Base Tasks	Assessment
COMMS PROCEDURE	4 Establish comms with appropriate agencies 10 Contact & Situation reports as necessary
NAVIGATION	3 Manoeuvre as required 6 Maintain surveillance
TACTICAL FLYING	3 Manoeuvre as required 6 Maintain surveillance
SENSOR EMPLOYMENT	5 Use sensors effectively
DIRECT FIRE WEAPONS EMPLOYMENT	8 Engage hostile forces with direct fire
INDIRECT WEAPONS EMPLOYMENT	9 Engage hostile forces with indirect fire

3.6.21 CONDUCT AERIAL ESCORT

Table 46 – Conduct Aerial Escort

CONDUCT AERIAL ESCORT	
Base Tasks	Assessment
COMMS PROCEDURE	3 Directs PF to manoeuvre as required to avoid threats

NAVIGATION	2 Enroute escort 7 React to threats
TACTICAL FLYING	2 Enroute escort 4 Over watch 5 Ensure departure path secure 7 React to threats
SENSOR EMPLOYMENT	6 Use appropriately
DIRECT FIRE WEAPONS EMPLOYMENT	7 React to threats
INDIRECT WEAPONS EMPLOYMENT	7 React to threats

3.6.22 CONDUCT AREA SECURITY OPERATIONS

Table 47 – Conduct Area Security Operations

CONDUCT AREA SECURITY OPERATIONS	
Base Tasks	Assessment
COMMS PROCEDURE	4 Establish and maintain comms with ground force
NAVIGATION	2 Manoeuvre to detect enemy
TACTICAL FLYING	2 Manoeuvre to detect enemy 3 Engage threats
SENSOR EMPLOYMENT	5 Efficiently uses sensors
DIRECT FIRE WEAPONS EMPLOYMENT	3 Engage threats
INDIRECT WEAPONS EMPLOYMENT	3 Engage threats

3.7 Vignette Example

The following walk through is provided to outline the envisioned process and work flow of evaluating a BTS using data collection. The example is not intended to be authoritative but instead a possible implementation. For this example, the CONDUCT AERIAL ESCORT BTS will be examined.

3.7.1 Scenario Preparation

Scenario preparation would be done to scope the task to be evaluated and provide reusable starting material to the crews. The work can be equated to exercise planning and/or scoping out the mission events list. Planned events such as encountering hostile actions should be planned and enforced by route restrictions etc. to ensure planned events are triggered. Force laydown including friendly, neutral and hostiles should be done for the scenario to include scripted actions for all forces. As well predetermined trigger events should be decided.

Once scenario creation has been completed, a mission package should be developed which would be presented to the evaluated crew prior to mission planning. This information should include the following:

a) Weather information

b) Intelligence package including rules of engagement (ROE)

c) Mission overview and specific details including:

   i. Comms plan

   ii. Point of departure and timing

   iii. RV location and timing if escorted entities are not integral

   iv. Mission specific waypoints

   v. Mission success criteria

3.7.2 Mission Planning

Once a crew has received the scenario information package they will need preparation time for mission planning. Mission planning should be monitored and guided if required to ensure planned events will be valid and come into play. How much crew planning is allowed or required will need to be determined. For example, the crew may be presented with waypoints and timings and allowed to plan their own routes or the routes may be preplanned and given to the crew.

Once the crew has completed their mission planning, there will likely be a requirement to review and potentially tweak scenario software triggers and events. Time should be planned into the evaluation to allow for this work.

3.7.3 Mission Execution

The following fictitious mission execution is provided as an example:

- Crew departs and flies planned route to RV point: Tactical flying and navigation is evaluated over this route

- Crew rendezvous with escorted unit: Communications and navigation are evaluated

- Crew escorts unit along flight planned route: Navigation and tactical flying are evaluated

- Flight encounters ground fire (trigger point): Reaction to direct ground fire and evading direct fire is evaluated

- Flight resumes aerial escort duties and continues to destination: Navigation and tactical flying are evaluated
- Enemy fire is encountered at destination (trigger point): Employment of direct and potentially indirect fire is evaluated
- Mission could terminate or continue to evaluate more BTS

3.7.4 Data Collation

Data gathered is analyzed and assembled into a crew debrief package outlining the specific BTS that were evaluated and the assessments generated.

3.7.5 Crew Debrief

Air crew is assembled along with SME and possibly with the aid of a debriefing system to review BTS and mission assessment

4 Conclusions and Recommendations

4.1 Conclusions

Although inherently subjective in nature, it should be possible to establish a base level of assessment for Battle Task Standards (BTS). It will be critical to establish the base tasks first and vet the analysis with subject matter experts to validate the results over a large range of conditions. Once the base level tasks have been established and validated, composite tasks can be created along with well-designed scenarios to invoke testable reactions from the aircrew to be evaluated.

The following conclusions are also offered:

1. Early engagement with subject matter experts (SMEs) will be crucial for the interpretation of subjectively evaluated tasks into definable measures of criteria. SMEs will also be critical in the create of vignettes that are both tactically sound and capable of providing control conditions for task evaluation

2. Develop and test base tasks thoroughly prior to attempting to program and assess. As the base tasks represent the measurable criterion, they must be validated thoroughly prior to building scenarios and assessing composite tasks.

3. Establish and implement an option matrix for interpreting results that attempts to clarify higher level assumptions that cannot be uniquely controlled by scenario design. These options should be validated with SMEs and guide the assessment of unforeseen reactions to scenario events.

4.2 Recommendations

In summary, CTI recommends that:

1. Some manner of supporting software (e.g., a library or service), capable of correlating DIS location information to terrain data, be adopted or developed. Additional capabilities, such as LOS and view shed analysis, would be highly desirable.

2. Implementation of an after-action-review (AAR) system to work in conjunction with C-PETS be considered to provide a mechanism to support subjective assessment and to provide a more in-depth capability to present multi-faceted and multi-dimensional results back to the evaluated crew.

5 References

DIS Steering Committee. (1998). IEEE standard for distributed interactive simulation-application protocols. *IEEE Standard*, *1278*.