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Advanced Vetronics Architecture for a Net-Enabled Combat Environment (ADVANCE) Technology Demonstration Human Factors Engineering (HFE) Definition Project

Mission Functions Task Analysis (MFTA) Final Report

A. Scipione, J. Armstrong, J. Brooks and M. Espenant
Greenley & Associates

Contract Scientific Authority:
R.H. Chesney
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Advanced Vetronics Architecture for a Net-Enabled Combat Environment (ADVANCE) Technology Demonstration (TD)

Human Factors Engineering (HFE) Definition Project

Mission Functions Task Analysis (MFTA)

Final Report

Completed by:

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1 Scope

This document is an Interim Report for a project entitled "The Advanced Vehicle Architecture for a Net-Enabled Combat Environment (ADVANCE) Technology Demonstration Human Factors Engineering (HFE) Definition Project. The purpose of this Interim Report is to detail the development of a Mission, Function, and Task Analysis (MFTA) for the ADVANCE project. This report is submitted by Greenley & Associates Incorporated (G&A) of Ottawa, Ontario, Canada in support of Public Works and Government Services Canada (PWGSC) contract No W7714-030816 Task Number 2005-165.

1.1 Identification

The ADVANCE TD was implemented to design and evaluate a series of advanced vehicle concepts such as: the integration of a multi-layered Vetronics network and a fully Active Suspension to exploit the potential of a Vetronics architecture in the network-centric battlefield of the Army of Tomorrow (AoT). The ADVANCE project is in its Definition Phase and requires the development of a Mission, Function, and Task Analysis to identify "missing" areas requiring future work during the latter phases. The MFTA is based on MFTAs developed for previous relevant projects, and is further extended to include additional tasks associated with net-enabled combat.

1.2 Background

Military vehicles include numerous electrical and electronic systems that are controlled and monitored by the crew. In current vehicles, system control and monitoring is facilitated by standalone user interfaces (UIs) that are specific to an individual sub-system. As vehicles became more complex, the number of standalone controls and displays has increased. Combat vehicles also include a variety of optical systems, which are used by the crew for driving, local situational awareness (SA), surveillance and for target acquisition. Furthermore, recent net-enabled operations allow a considerable amount of information in relation to the crew's environment (e.g., own vehicle position, systems status, contact detection, etc.) to be available through both internal and external sources. Net enabled operations also allow information to be available to dismounts, other nearby vehicles, and the Command and Control (C2) system.

Modern vehicle systems integration (Vetronics) is based on distributed control and network connected sensors and communications systems which provide the ability to integrate all vehicle functions through a common Operator-Machine Interface (OMI). This interface is also exploited to support other combat functions including communications and command and control. However, the integration of information on a single OMI may become too complex for a crewmember to efficiently operate, especially during high stress situations, as well as sustained operations when the crew is fatigued.

To achieve the most simplistic OMI, the crew workstation and the OMI software must be designed with a comprehensive understanding of: crew task requirements, the crew's relative priorities, task schedules, task completion times, and task type (e.g., cognitive, vigilance, fine motor control, etc.). Requirements must be categorised and prioritized to develop simple and effective interfaces that will facilitate the crew in maintaining situational awareness and in rapidly responding to combat threats. Furthermore, designing a common crewstation can decrease individual training across multiple vehicle platforms for common functionalities.

Though the Vetronics architecture could potentially integrate a very large subset of components both on and off a vehicle platform, the resources and time available for the ADVANCE TD are limited. Therefore, some non-critical network functions will be emulated rather than implemented using actual hardware. The components that could feasibly lend themselves to emulation, while preserving the requirements of the demonstrator must be determined, along with their associated costs, schedule and integration risk.

1.3 ADVANCE TD Objectives

The ADVANCE TD aims to demonstrate improved crew performance through a completely integrated multi-layered Vetronics network, whereby all subsystems are accessible from any node on a vehicle. System controls and displays will be integrated and shared among each crewmember's workstation, and through the Land Command Support System (LCSS). Information from the Vetronics system will also be accessible from external platforms. The C2 system, other vehicles, dismounts and unmanned aerial and ground vehicles (UAVs/UGVs) will be able to receive data and commands through the Vetronics network. The project also aims to design a system that facilitates diagnostic and prognostic evaluation from the same interface ports to increase maintainability.

A secondary objective of the TDP is to develop and integrate a fully Active Suspension to exploit the potential of the Vetronics architecture and to demonstrate the benefits of a stabilized and levelled platform.

This project will provide information to a number of ongoing Major Crown Acquisition projects, which have identified the requirement to conduct mobile surveillance and engagements from combat vehicles that are currently limited to static applications. It is envisaged that Active Suspension will significantly increase the effectiveness of the crew, while reducing the impact of vibration and mechanical shock on the vehicle and cargo.

The ADVANCE TD is not focussed on designing technical solutions and crew interfaces for a single vehicle configuration. The project focuses on developing crew interfaces that can be readily adapted and reconfigured to a broad range of roles as well as to provide support to these roles and hardware configurations that may evolve over time. As a result, requirements must be developed to determine which tasks will be required in a particular configuration. Furthermore, the workstation interface must be generic and adaptable to multiple functions through software re-configuration.

1.4 Document Overview

This document outlines the results of an initial Mission, Function, and Task Analysis for the Definition Phase of the ADVANCE TD. The analysis focuses on the operators and system capabilities of Canadian Forces (CF) Armoured Fighting Vehicles (AFVs) within the Army of Tomorrow timeframe. The range of AFV functional requirements including Command and Control and net-enabled Combat Operations that may be impacted through the introduction of advanced Vetronics and Active Suspension technologies are included in this analysis.

Subsequent iterations of this MFTA will be used as a basis for defining the system requirements and incorporating future technologies and capabilities into the system design. The MFTA will also assist in the resolution of outstanding issues raised through the ADVANCE TD and identified in the ADVANCE Stakeholder Document (Ref. 1). These analyses will also provide inputs to current Major Crown Acquisition projects such as the Mobile Gun System (MGS), TOW Under Armour (TUA), and Multi-Mission Effects Vehicle (MMEV), by determining the impact of the ADVANCE technologies on vehicle capabilities.

1.5 MFTA Objectives

This MFTA is an interim report, provides an initial definition of the function and tasks relevant to AFV operations within the scope of the ADVANCE TD. Future analysis is required to provide detailed task breakdowns, Operator allocations, system requirements and to extend the results of this MFTA to all vehicle platforms. This MFTA was developed to aid the future definition of:

- The system functions that should be machine implemented or software controlled, and the system functions that should be reserved for the human Operator/Maintainer;
- The tasks that Operators and Maintainers must accomplish;
- The system requirements, potential equipment, and human/equipment requirements; and
- Operator and Maintainer involvement in the system to establish and analyze: crew size; equipment procedures; and skill, training and communication requirements.

1.6 Document Structure

This MFTA Interim Report has the following structure:

- Scope: Presents the background and overall project objectives;
- Reference Documents: Contains references for the documents used during the development of the MFTA;
- Method: Summarises the method used to develop the MFTA;
- Results: Summarises the MFTA results;
- Discussion: Discusses the results of the MFTA; and
- Acronyms: Provides the acronyms used in this report.

2 Reference Documents

The following documents of were referenced during the development of the Mission, Function, and Task Analysis.

2.1 ADVANCE TD Reference Documents

1. Espenant, M., Scipione, A., Armstrong, J. & Brooks, J. (2006). *ADVANCE HFE Definition Project: Stakeholder Control Document Rationalization.* ADVANCE Interim Project Report to DAVPM 8-4-4.

2.2 Additional Armoured Fighting Vehicles Resource Documents

2. Armstrong, J., Lai, G., Brooks, J., and Williams, S. (2006). *Multi Mission Virtual Vehicle Mission, Function and Task Analysis Version 2.* Project Report to General Dynamics Canada (In Press).
3. Brooks, J., Armstrong, J., and Williams, S. (2004). *Multi Mission Virtual Vehicle Mission, Function and Task Analysis Version 1.* Project Report to General Dynamics Canada.
4. Brooks, J. and Greenley, M. (1998). *Battle Group and Combat Team Command & Control Information System User Requirements*. Report to Defence and Civil Institute of Environmental Medicine.
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6. Greenley, M. and Brooks, J. (1996). *Human Factors Analysis of ALFCS Function Allocation.* Project Report to the Department of National Defence.
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9. Wells, P., Banbury, S., and Brooks, J. (2006). *Mission, Function Task Analysis (MFTA) of the ALERT-Enhanced Coyote Reconnaissance & Surveillance Vehicle*. Project Report to General Dynamics Canada.

2.3 Canadian Force Documentation

10. Government of Canada (2004). *The Force Deployment Concept for the Army*. Department of National Defence Position Paper.
11. Directorate of Land Strategic Concepts (2003). *Future Force: Concepts for Future Army Capabilities*. Department of National Defence Position Paper.
12. Maurer, LCol M.C. (2005). *Project Charter: Canadian Army of Tomorrow Force Employment Concept.* Director General Land Concept Development, Department of National Defence.

2.4 Human Factors Reference Documents

13. Obrien, T.G. and Charlton, S.G. (1996). *Handbook of Human Factors Testing and Evaluation*. New Jersey: Lawrence Erlbaum Associates.
14. Price, H.E. (1985). *The Allocation of Functions in Systems*. Human Factors, 27(1), 33-45.

3 Method

3.1 Overview

The MFTA was performed as an iterative process that was developed over a series of analyses conducted by the Human Factors (HF) team. In the context of the ADVANCE TD, the bulk of the analysis was derived from previous project experience in the AFV domain and from inputs provided by AFV Subject Matter Experts (SMEs). The analysis considered the concepts defined as part of the Future Force Employment Concepts for the Army of Tomorrow timeframe (2010-2015), where the capabilities and equipment are projected to be fielded.

3.2 Mission Analysis

The mission analysis was conducted to define the high-level goals that the ADVANCE technologies must satisfy. The mission analysis was used to:

- Fully examine the system application in each anticipated operational environment;
- Explore 'what-if' contingencies for various mission scenarios;
- Provide input into functional analyses to be utilised in the system analysis;
- Provide a framework for subsequent function and task analysis through the identification of mission scenarios; and
- Provide input into identifying the user community, including identification of user characteristics such as physical and cognitive capabilities, and clothing and equipment.

As part of the mission analysis, mission scenarios were developed to describe the intended operational roles of ADVANCE platforms as well as to provide justification for assigning equipment and capabilities as part of the overall employment concept. The mission scenarios describe the sequence of actions and events associated with the execution of a particular mission, which provide the foundation for building the functional and task analyses.

3.3 Function Analysis

Function analyses are conducted to divide the system into its component functions to which Operators, hardware, or software can then be allocated. Functions are broad categories of activities performed by the system, and all functions can be sub-divided into more detailed functions or levels. The detailed analysis of functions is necessary to determine system requirements, possible equipment, and human/equipment combinations, in order to effectively identify which functions should be performed by equipment and which functions should be performed by Operators. The function analysis provides the framework for further task analysis to be completed, by breaking high-level functions into their lowest-level sub-components, in order to determine task allocation to an Operator, Maintainer, or to a system.

The foundation of the function analyses was derived primarily from previous AFV experience as well as through a review meeting held with ADVANCE stakeholders. An Abstract Functional Hierarchy was developed to provide a generic analysis and function flow. The Abstract Functional Hierarchy provides a high-level description of typical AFV operations and is not restrictive to a specific platform.

3.3.1 Function Flow Diagrams

When mission details were finalized, the Abstract Hierarchy was used as the basis for further analysis and the development of function flows (Annex A). This also provided the framework to complete the remainder of the function analysis process by structuring the function flows into an easily interpretable format.

3.4 Task Analysis

Due to the broad range of vehicle systems and capabilities that are implicated within the ADVANCE TD, it was beyond the scope of the current project to either task analyse the full range of current systems or task synthesize future systems. A substantial body of AFV literature exists documenting platform specific behaviours and interactions that are of interest to the ADVANCE TD. Documented within this literature are results of task analyses specific to some of the platforms within the scope of ADVANCE. Thus, this body of literature has been assessed to determine the degree of relevance to the ADVANCE TD and to identify technologies currently lacking within the literature that will require further analysis.

4 Results

This section contains the MFTA results that have been completed for the Definition Phase of the ADVANCE TD. The detailed function flows are provided in Annex A. Task flows related to specific platforms are obtainable through the relevant reference documentation.

This section discusses the results of the following:

- Mission Analysis (Section 4.1): Discusses the application of ADVANCE technologies within the AoT timeframe, the potential of ADVANCE technologies to enhance performance in the five Operational Functions (Command, Act, Sense, Shield, Sustain), identifies the Operational Scenarios that ADVANCE technologies will have the ability to support, and provides a description of the conceptual crew.
- Function Analysis (Section 4.2): Identifies the highest level system functions for the ADVANCE TD. The function analysis presents the decomposition of each high-level function into its sub-functions (function flows), along with identifying the the perceived implications of ADVANCE technologies for these functions on Operator and system performance.
- Task Analysis (Section 4.3): Discusses projects within the CF that involved the completion of a task analysis of a vehicle platform that are of interest to the ADVANCE TD. The task analyses results are provided, along with the identification of platforms and functionality that have not yet been assessed using the task analysis approach.

4.1 Mission Analysis

The mission analysis covers the following areas:

- Concept Army of Tomorrow Force Developments: explores the inputs and sources of development for the Army of Tomorrow force structure and reviews the high-level goals and framework of the AoT force;
- Conceptual ORBAT: details the conceptual order of battle for the Canadian Army of Tomorrow and focuses on vehicle systems likely to be affected by the ADVANCE TD;
- Mission Scenarios: provide the basic structure of example scenarios that are intended to be representative of the full spectrum of activities that ADVANCE platforms would likely encounter;
- Conceptual Crew: provides an initial overview of the impact of ADVANCE technologies on crewing and Crew Resource Management (CRM); and
- User: identifies an initial overview of the potential impact on the user, including training, and the future implications for recruitment.

4.1.1 Concept Army of Tomorrow Force Development

In response to political changes and global security issues, the Canadian Army is adapting its current capabilities. There are currently three Canadian Army time transformation horizons:

- The Army of Today: the force is managed in the current business plan and is projected outward to a period of 4 years;
- The Army of Tomorrow/Interim Army: focuses on the force in the 5 to 10 year timeframe. There are two analysis models: the Interim Army 5 years from present, when current acquisition projects are complete, and The Army of Tomorrow which focuses 10 years from present; and

- The Army of the Future: the Army of the Future will always be conceptual and will never exist. The Army of the Future planning process includes long-term futuristic concepts in the 10 to 25 year timeframe.

The ADVANCE TD focuses on the application of AFV technologies within the Army of Tomorrow structure in the 5 to 10 year timeframe. Recognizing the range of possible missions and potential operating environments, the AoT is structured to be a medium-weight, multi-purpose, combat capable force. Furthermore, the AoT is a flexible, modular army that can be configured to manage a variety of threats capable of applying the five operational functions, which include Act, Command, Sense, Shield and Sustain, across the full spectrum of conflict.

The current concept for the AoT includes transitioning from traditional, heavy-weight armoured forces to a medium-weight, streamlined, smaller, lighter and simpler force, using lighter armoured, wheeled vehicles to improve deployability, while decreasing maintenance and sustainment requirements. Additionally, this will increase agility, enhancing the ability to operate in complex terrain. Although a smaller, lighter force, the AoT will retain a high degree of protection and firepower through the exploitation of emerging technologies, particularly through the use of advanced information gathering techniques and widespread employment of precision munitions.

The integration of ADVANCE technologies across the full-spectrum of Light Armoured Vehicle (LAV) and other vehicle-based platforms (e.g., Heavy Logistics Vehicle Wheeled; HLVW) directly supports the transition towards a highly versatile, medium-weight capability for the Army. The use of reconfigurable common crew-stations across the LAV and other vehicle-based platforms is also expected to provide increased flexibility and reduced training requirements for the LAV and other vehicle fleet.

Relevant guiding principles, from the Strategic, Operational and Tactical, and Force Generation perspectives were derived from the CA Force Employment Concept (Refs. 10, 11, 12) for AoT operations for the ADVANCE TD. The impact of ADVANCE on these guiding principles is discussed in Sections 4.1.1.1 to 4.1.1.3.

4.1.1.1 Strategic

The CA Force Employment Concept identifies the following guiding principles for future Strategic Operations:

- Expeditionary forces shall provide maximum strategic value to a joint force and potential coalition partners (e.g. U.S., UK) and shall be rapidly deployable, modernized, interoperable and sustainable;
- Balance the force structure to accomplish a broad range of potential missions in a more complex security environment through the provision of specialized capabilities.
- Mitigate organizational risks through disciplined capability-based planning.
- Mitigate operational risk through the attachment of Army forces to capable and complementary Allied formations and maintenance of National command.

The ADVANCE TD has significant opportunities to impact strategic operations within the CF. In the context of inter-operability, the integration of Vetronics systems must facilitate the rapid integration of information with coalition partners to maximize Canada’s ability to participate in coalition operations. Therefore, the specification of the technical and data requirements to facilitate interoperability is critical, as is the specification of appropriate AFV technologies and capabilities to increase the operational effectiveness of the CF when integrated within allied formations as well as to support National command.

4.1.1.2 Operational and Tactical

The CA Force Employment Concept identifies the following guiding principles for future Operational and Tactical Operations:

- Increase agility by moving to a command-centric, knowledge-based doctrine that achieves integration of information which manoeuvres at lower levels and devolves decision-making authority.
- Improve firepower through increased precision and responsiveness and through the introduction of non-lethal means.
- Improve protection against symmetric and asymmetric threats through integration of defensive measures and shared situational awareness.
- Simplify and lighten the overall force structure to ease the sustainment burden

ADVANCE Vetronics systems will support the progression towards command-centric operations whereby lower level tactical units will manage the conduct of unit-based operations and individual vehicle platforms. Improvements to Situation Awareness through the dissemination of ISTAR information will also improve the responsiveness of tactical units to the dynamic modern battlefield, as well as improving the ability to respond to asymmetric threats. However, it is currently unclear as to what level of information is best suited for various levels of the ORBAT to maximize the flexibility and efficiency of operations without overburdening Operators with extraneous information.

The ability to maintain an up-to-date awareness of vehicle health and status information should also provide the ability to make improvements to maintenance and sustainable programs for AFVs. There is also the potential to change the current time-based maintenance programs towards a predictive model that tracks component degradation in real-time. However, an analysis of the technical complexity of advanced Active Suspension and Vetronics systems must be assessed to determine the cost and difficulty associated with maintaining these systems.

4.1.1.3 Force Generation

The CA Force Employment Concept identifies the following guiding principles for future Force Generation:

- Optimize for complex terrain, while remaining adaptable for other missions with a more flexible, modular approach to the integration of capabilities.
- Rationalize functional capabilities and manage readiness at Army level to ensure efficiency and effectiveness in force generation.
- Improve the training system to maintain sufficient formation level expertise while focusing on realistic preparation of units for operations.

The ADVANCE TD has the potential to align AFV operations and design within the future Force Generation concepts. The conduct of a detailed MFTA on AFV operations will aid in the identification of the operational roles, functional capabilities and requirements across the Army. The resulting development of common crewstations and rapidly reconfigurable systems should then improve modularity and flexibility for the Army to respond to a range of operational scenarios.

The impact of ADVANCE technologies on the training system will require further assessment. Cross-training across vehicle platforms will likely increase overall Operator skill level when compared to traditional AFVs, especially in the context of rapidly deployable units that require the maintenance of high skill levels. The current army-wide recruiting structure that supports rapid and mass recruiting through conscription during war may no longer apply for the specialized weapons system of the future. This recruiting model will have to adapt for aspects of the army capability where complex weapons systems are staffed by small but highly trained teams. However, given that the future force will likely be constructed of existing CF personnel, current training systems must adapt to meet the requirements of the future Force and provide appropriate training to increase the current capabilities of the operating community.

4.1.2 Conceptual ORBAT

The ADVANCE TD aims to support the guidance principles outlined above by providing integrated technologies across a variety of LAV and other vehicle-based platforms to support net-centric operations and to improve the existing operational capabilities of the LAV and other vehicle fleets. The systems under evaluation for ADVANCE focus on enhancing performance across all five operational functions, which include:

- **Command**: Integration of all operational functions into a single, comprehensive strategic, operational or tactical level concept. Responsible for the integration of all other functions to attain specific operational goals.
- **Act**: Integration of manoeuvre, firepower and offensive information operations to achieve a desired effect and end-state through the synchronized application of the entire array of available capabilities, including lethal and non-lethal means.
- **Sense**: Integrated sensor and sensor analysis capabilities into a single concept. Shifts from previous sensor and information stovepipes allow for a comprehensive sensor data fusion and all source analysis within a single system. Commanders are provided with timely and relevant knowledge.
- **Shield**: Provides for the protection of a forces survivability and freedom of action. A layered, integrated and fully dimensional operational function that seeks to prevent adverse impact on friendly forces in any domain (e.g., physical, electromagnetic, cyber) that could affect survivability or freedom of action.
- **Sustain**: Integration of strategic, operational and tactical levels of support to generate and maintain force capability. Integrates the provision of materiel and personnel support to ensure the sustainment of combat power.

The key technologies under exploration in ADVANCE that support the operational functions identified above include:

- Integrated Multi-Layered Vetronics Network; and
- Fully Active Suspension System.

4.1.2.1 Integrated Vetronics

The integration of a Vetronics network has the potential to influence a range of systems including high-level command structures, individual vehicle platforms, dismounted soldiers and UAVs/UGVs in each of the five operational functions. Vetronics may directly impact performance by facilitating the following:

- Common Crewstations: A common crewstation will reduce the configuration requirements specific to individual vehicle platforms. Implementing a common look and feel across crewstations may also reduce training requirements, and facilitate the cross-training of Operators across platforms;
- Reconfigurable Crewstations: The integration of Vetronics will facilitate crew interfaces to be readily adapted and reconfigured for a broad range of roles;

- Remote Operation of Systems: Vetronics may facilitate the control and management of remote vehicle systems. The integration of Vetronics may provide the capability to rapidly distribute information from remote vehicle platforms;
- Information Distribution/Data Exchange: The C2 system, other vehicles, dismounts and unmanned aerial and ground vehicles (UAVs/UGVs) will be able to receive data and commands through the Vetronics network. Information can be integrated into a Common Operating Picture (COP) and incorporate significant data fusion capabilities to minimize information redundancy;
- Integrated Simulation Training Capability: The integration of Vetronics systems may support the development of in-vehicle training systems that would reduce the requirement for off-board simulation systems and that would support mission rehearsal. Data capture technology could also be used to record data for mission play-back and after-action reviews.
- Systems Diagnostics and Monitoring: The integration of Vetronics systems may provide the ability to conduct remote system diagnostics and assist in the recognition and identification of system failures while in-situ. Integrated vetronics systems will also support the fusion of multiple on-board sensors (e.g. Radar/IR/MAWS) as part of DAS and LSAS capabilities, as well as support power management activities for the vehicle (e.g., maximize silent watch capabilities).

4.1.2.2 Active Suspension System

The integration of an Active Suspension system across the LAV fleet has the potential to influence vehicle level performance by providing:

- Improved Mobility (Operational and Tactical): The integration of Active Suspension may facilitate greater mobility over a wider range of terrain types, thereby improving planning and increasing the number of possible routes. Active Suspension may improve operational mobility and increase the range of conditions in which vehicle systems could be operated while the vehicle is mobile;
- Improved Stability: Active Suspension may provide stabilization for both sight and weapons. This will increase the range of conditions in which a vehicle can accurately and successfully engage targets and conduct surveillance operations;
- Decreased Vibration: The reduction of vibration may improve crew performance by increasing an Operator's ability to conduct tasks and operate systems while mobile. The reduction of vibration may also increase work duration by decreasing Operator fatigue; and
- Improved Maintainability: Through reductions in vehicle vibration, vehicle components should experience reduced wear and increased longevity. Reductions in associated maintenance costs should also be expected due to decreases in equipment failure and longer preventative maintenance intervals.

4.1.2.3 Key Operational Roles

The projected improvements on system performance due to the implementation of ADVANCE technologies will be dependant on the operational roles for a particular vehicle configuration. Therefore, it is necessary to clearly define the expected operational roles for LAV-based platforms within the AoT timeframe. Table 1 provides the complete range of operational roles for LAV-based vehicle platforms in support of army operations.

Table 1: ADVANCE Operational Roles

	PLATFORM						
Operational Role	HLVW	LAV III	MMEV	MGS	TUA	COYOTE	BISON
Direct Fire		✓	✓	✓	✓	✓	
Precision Non-Line of Sight (P-NLOS)			✓				
Ground Based Air Defence (GBAD)			✓				
*ISTAR (e.g., all potential surveillance and reconnaissance assets)	✓	✓	✓	✓	✓	✓	✓
Personnel Transport	✓	✓					✓
Medical	✓	✓					✓
Maintenance and Recovery	✓	✓					✓
Command Post		✓					✓
Communications		✓					✓
Logistics	✓						

* Intelligence, Surveillance and Target Acquisition and Reconnaissance

4.1.3 Operational Scenarios

Operational scenarios were developed to identify the anticipated range of missions in which the LAV and other vehicle-based fleet, with ADVANCE technologies implemented, will participate during the AoT timeframe. Each operational scenario provides a framework in which the operational roles (Section 4.2.3; Table 1) are executed.

Mission analysis and mission scenarios developed for previous projects, including the simulation-based Army Experiment 8 series of experiments at the Army Simulation Centre, as well as scenarios developed for the MMEV TD, provided an appropriate foundation for the exploration of Army of Tomorrow concepts relevant to the ADVANCE TD. Previous project material was reused and integrated within the existing analysis where applicable. The operational scenarios for the ADVANCE TD include:

- **Protect Point Asset (Airport Defence):** The Protect Point Asset (Airport Defence) will involve Blue forces defending a recently seized Air Point of Disembarkation (APOD) on the edge of Red territory in semi-mountainous terrain;
- **Advance to Contact (Open Terrain).** In the Advance to Contact (Open Terrain) scenario, the Blue force must travel an extended distance through a partially settled area;
- **Urban Ambush**. The Urban Ambush will involve Blue forces defending against a local ambush within an urban area and attempting to regain control of a Base of Operations; and
- **Spoiling Attack.** The Spoiling Attack will involve the Blue forces conducting an attack on the Red forces outside of an urban area.

The employment concepts depicted in the scenarios are based on a Direct Fire Squadron (DFS) sub-unit in support of a LAV Infantry Battalion. The DFS involves a MGS Squadron lead as the sub-unit advances slightly ahead of, or along with, the LAV IIIs of the lead infantry platoons. The LAV TUA troop provides immediate direct overwatch support and the MMEV troop provides Precision Non-Line of Sight and Air Defence overwatch from a stand off position.

Further efforts are required to define mission scenarios that encompass operational roles and environments that extend beyond combat oriented operations to include activities associated with sustained operations (e.g., 72 hr operations), transitions from low to high threat environments and direct peace support roles that are not associated with active combat. The impact of ADVANCE technologies may not be adequately addressed without extending the current set of mission scenarios to these domains.

4.1.4 Conceptual Crew

The conceptual crew includes all Operators and support systems required for the conduct of the operational scenarios. Since ADVANCE is investigating concepts across multiple platforms, the crewing requirements need to be determined on a platform specific basis. The crewing requirements will also be dependent on the Common Crewstation Design (CCD) that is implemented across platforms.

The application of a common crewstation design should facilitate transfer of training across platforms.

The introduction of ADVANCE technologies may provide the ability to introduce varying levels of systems automation. Systems automation may increase the potential for AFV crews to operate multiple systems simultaneously.

Systems automation may facilitate a reduction in an AFVs crew size. However, the integration of systems automation has the implication of differentially affecting in-vehicle and out-of-vehicle tasks. For example, systems automation may reduce crew requirements within the vehicle, but will not affect the crew requirements for out-of vehicle tasks (e.g., maintenance tasks), making a reduction in crew size unfeasible. The costs of system automation, along with the functions that systems automation would best support, need further analysis.

The mission analysis did not incorporate an analysis of a fielded system, and did not account for sustained AFV operations. To determine whether a reduction in crew size is feasible, further analysis must incorporate actual fielded task timings, especially during sustained operations, as this will identify performance implications of reduced crew rest cycles.

4.2 Function Analyses

The scenarios and force structure concepts described in the mission analysis were used as the basis for an initial abstract function analysis. The highest level system functions in the analysis include: 1. Systems Management; 2. Combat Operations Management; 3. Command and Control Management; 4. Navigation Management; and 5. Vehicle Maintainability Management (Figure 1). The high-level functions were derived from previous AFV design experience and discussions with AFV crews, but incorporate characteristics specific to the ADVANCE project and AoT concepts.

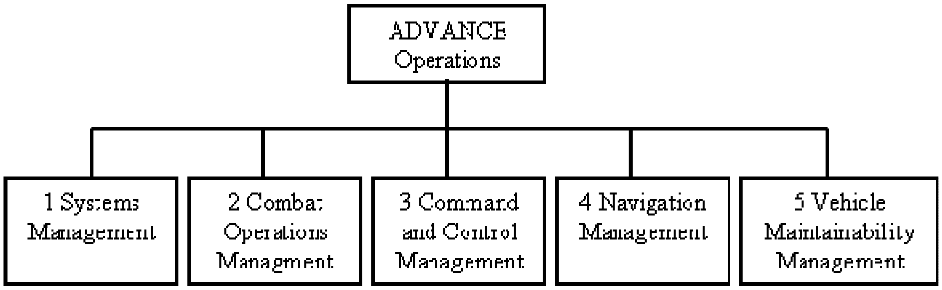


Figure 1: High-Level ADVANCE Functions

Each high-level functional grouping was then used to conduct preliminary function analyses. These were used as the basis for the development of more detailed function flows completed during the second iteration of the analysis and used to isolate functionality for system sub-components. Each of these high-level functions is decomposed into sub-functions in the Function Flow Diagrams presented in Annex A. The high-level functions, and their sub-component functions are described in Sections 4.2.1 to 4.2.5. The sub-functions described in Sections 4.2.1 to 4.2.5 will require further analysis to develop more detailed descriptions of the systems' characteristics. The perceived implications of ADVANCE technologies for these functions/sub-functions on Operator and systems performance are also identified.

4.2.1 Systems Management (Function Ref. 1)

The Systems Management function incorporates all high-level system start-up and shutdown functions. The System Management function flow is divided into: Configuration of Own Vehicle Systems and Configuration of Other Vehicle Systems. Configuration functions for both Own Vehicle Systems and Other Vehicle Systems include: Communications, External Sensors, Internal Sensors, Weapons, and Internal Sub-Systems (Own Vehicle only). To maximize the benefit of ADVANCE technologies, the following issue should be considered:

- A common crewstation design may significantly reduce the configuration requirements specific to individual vehicle platforms and may also facilitate the control and management of other vehicle systems (e.g. UAVs/UGVs). Implementing a common look and feel (CLF) across crewstations may also reduce training requirements, and facilitate the cross-training of Operators across platforms.

4.2.1.1 Configure Communications (Functions Ref. 1.1.1) and Configure Data Network (Function Ref. 1.2.1)

The Configure Communications sub-function includes: Configuration of the Vehicle Radio Systems and Configuration of the Data Networks. The Configure Data Network sub-function includes: Change Data Network Display Defaults and Configuration Characteristics. These systems provide the ability to exchange information with other vehicles, personnel and command level entities. Each of these systems incorporates default settings and configuration characteristics that can be modified by the Operator. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- Vetronics features that should be considered within the ADVANCE TD include:
    - Nature and type of information to be transmitted (e.g., vehicle/health status, video feeds, sensor imagery);
    - Recipient of the information (e.g., Command Post (CP), Troop Vehicles);
    - Refresh and data transfer rates;

  - Data encryption;
  - Configuration of remote vehicle access;
  - Communication with other vehicles (e.g., UAVs/UAGs); and
  - Configuration of network fire systems.

- Initial default settings should be mission specific. Mission details could be pre-specified, and provided to the Operator as part of the mission orders/brief. This will alleviate the requirement to perform extensive system reconfiguration for each mission.
- Information could be received with an electronic order set requiring only an acknowledgement of the configuration items. This would eliminate the time it would originally take to configure settings, and will likely prevent Operators from making configuration errors.

4.2.1.2 Configure External Sensors (Function Refs. 1.1.2, 1.2.2)

The Configure External Sensors sub-function provides the ability to modify sensor specific settings for a range of systems including: Radar, Combat ID, and EO (electro-optical) cameras. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- Automatic sensor configuration is preferred (e.g., polarity, gain, etc.) to reduce Operator workload. However, the Operator should have the ability to manually configure the sensor settings if required.
- Vetronics may support the use of a single integrated sensor that provides sense capabilities to multiple onboard vehicle systems (e.g., a Local Situation Awareness System (LSAS) that provides sensor data for the DAS, Missile Approach Warning System (MAWS), and ATDR and serves as the primary engagement sight for the vehicle).

4.2.1.3 Configure Internal Sensors (Function Refs. 1.1.3, 1.2.3)

The Configure Internal Sensors sub-function provides the ability to modify sensor specific settings for a range of systems including: Automatic Fire Extinguisher System, Vehicle/Health Status, and Inertial Navigation System. To maximize the benefit of ADVANCE technologies, the following issue should be considered:

- This sub-function requires further analysis to provide detailed descriptions of the systems, characteristics and sub-components.

4.2.1.4 Configure Weapons (Function Refs. 1.1.4, 1.2.4)

The Configure Weapons sub-function is further divided into Defensive Aides Suite (DAS) Counter-Measures and Offensive Weapons. Both weapon systems incorporate default settings, configuration characteristics, modes (DAS) and loaded/armed/ready characteristics (Offensive Weapons), ammunition count boar/barrel status, fault indicators that can be modified by the Operator. To maximize the benefit of ADVANCE technologies, the following issue should be considered:

- The DAS Weapons could include a range of components such as: an acoustic sensor, multi-function laser, hard kill capability, laser warning receiver, missile approach warning system, and multi-barrel grenade discharger.

4.2.1.5 Configure Internal Sub-Systems – Own Vehicle Only (Function Refs. 1.1.5)

The Configure Internal Sub-Systems sub-function describes the management of both physical and operating characteristics of the vehicle, including the configuration of Active Suspension characteristics such as the operating mode and the height actuators. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- The Operator has control of the Active Suspension's start-up and shut-down.
- Additional Active Suspension characteristics must be further defined in subsequent analysis.

4.2.2 Combat Operations (Function Ref. 2)

The Combat Operations Management function flow includes all functions related to engaging a contact across all operational roles (e.g., Direct Fire, G-BAD, Recce). The functions include: Contact Detection, Identification, Classification, Prioritization and Engagement, as well as functions associated with Network Combat Management. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- The integration of Vetronics may provide the capability to rapidly distribute sensor information from any platform on the battlefield, including UAVs/UGVs and remote sensors. This information can be integrated into a Common Operating Picture and incorporate significant data fusion capabilities to minimize information redundancy. In addition, the integrated Vetronics network may support the conduct of network-fire across all assets, including dismounted infantry.
- Unlike current AFVs that use multiple sensor systems for DAS, engagement and local situation awareness, Vetronics may support a single sensor that is integrated across all vehicle functions. In the context of combat operations, a single sensor that supports all weapon systems independently would significantly enhance the ability to conduct multiple simultaneous engagements while concurrently conducting target acquisition and other vehicle functions.
- The integration of automatic target detection, recognition, and tracking may improve combat operations for all vehicle platforms.
- Sensor stability should improve as a result of Active Suspension, which should significantly improve overall combat operations from target detection to prosecution.

4.2.2.1 Contact Detection (Function Ref. 2.1)

The Contact Detection sub-function includes: Search for a Contact, Perceive a Contact and Localize a Contact. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

Through the implementation of Vetronics:

- The ability to share battlefield information across the Vetronics network may enable contact detection and target acquisition to be conducted in a distributed manner. This has the potential to significantly enhance battlefield effectiveness and survivability by providing non-localized target detection capabilities enhancing situational awareness.
- The transmission of contact information through the network should be provided with minimal latency.
- A centralized network management system must be established to manage data fusion to minimize information redundancy from multiple sensors in the network-centric battlefield.

Through the implementation of Active Suspension:

- Overall vehicle stability may be enhanced, increasing the range of terrain types that a platform can simultaneously maneuver and use sensors.
- Sensor size and weight may be decreased due to the reduced requirements for highly stabilized and durable systems.

- An increase in vehicle stability may reduce the effects of vibration on the Operator, in the frequency that impacts the Operator's ability to interact with the vehicle systems. This may increase the range of conditions in which the Operator can monitor and manage surveillance and sensor systems for target detection.

4.2.2.2 Contact Identification (Function Ref. 2.2)

The Contact Identification sub-function involves the identification of the contact type after it has been detected, based on the contact's perceived characteristics (e.g., contact is a wheeled vehicle, truck, aircraft, etc.). Contact identification can occur as a cognitive process on the part of the Operator or can be facilitated through the integration of automated decision aids such as target detection and identification systems. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

Through the implementation of Vetronics:

- Real-time updates of all Blue force and Red force entities in the battlefield could be provided, thereby enhancing Situation Awareness and reducing the requirement for CID systems.
- Sensor stability should improve as a result of Active Suspension, which should improve contact identification while on the move.

4.2.2.3 Contact Classification (Function Ref. 2.3)

The Contact Classification sub-function involves the classification of a contact to determine the contact's threat status. Contact classification can occur as a cognitive process on the part of the Operator or can be facilitated through the integration of automated decision aids such as target classification systems. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- Through highly integrated battle management systems, Vetronics may enhance an Operator's ability to classify targets based on real-time tactical information.
- Shared tactical information and a COP may reduce fratricide by providing accurate classification of Blue force entities.
- Sensor stability should improve as a result of Active Suspension, which should improve contact classification while on the move.

4.2.2.4 Contact Prioritization (Function Ref. 2.4)

The Contact Prioritization sub-function includes: the Assessment of a Contact's Threat Status, the Assessment of Orders, and the Integration of these Assessments. Assessing the contact's threat status involves an assessment of the contact's capabilities, position and classification of the contact threat priority. Integration of these assessments involves the integration and prioritization of available data and then determining a course of action. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- Vetronics may improve battlefield management and contact prioritization through the provision of shared tactical information and an integrated COP.
- The amount of shared information attainable through Vetronics may be comprehensive. It is currently unclear how shared information will be managed in a Command and Control network. Current command structures may not be capable of managing the quantity of information that can be shared through the COP.

4.2.2.5 Contact Engagement (Function Ref. 2.5)

The Contact Engagement sub-function includes: Select Contact, Select Weapon, Acquire Target, Fire Weapon and Validate Weapon Effect. A single engagement sub-function is used to describe the behaviour of all offensive weapons to ensure that the task flows for each weapon system are as similar as possible in order to reduce the system's training requirements. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- Vetronics may improve battlefield management and Contact Prioritization through the provision of shared tactical information and an integrated COP. This may also enhance situational awareness and improve battlefield efficiency by explicitly pairing targets to effectors.
- Active Suspension may facilitate contact engagement by improving tactical battlefield mobility and performance of sensors and weapon systems through improved stabilization.

4.2.2.6 Network Combat Management (Function Ref. 2.6)

The Network Combat Management sub-function includes: Request from Network and Make External Engagement Requests (calling for fire). The Request from Network sub-function involves the following: Receive Network Request, Assess Own Status, Integrate Network Request and Assessment, and Respond to Network Request. The External Engagement Request (calling for fire) sub-function includes: Select Target, Communicate Target Information to Network and Confirm Weapon Effect. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- Vetronics may provide the capability to conduct digital combat management through the land-forces datalink system. This system may require minimal Operator interaction in order to transmit the relevant target coordinates and to coordinate fire; and
- Vehicles must also have the capability to conduct voice-based network combat management to support degraded modes of operation. This system will require extensive Operator involvement in order to transmit the relevant target coordinates and to coordinate fire.

4.2.3 Command and Control Management (Function Ref. 3)

The Command and Control function flow incorporates functions related to Battle Management, Situational Awareness and Communications.

4.2.3.1 Battle Management (Function Ref. 3.1)

Battle Management includes: Receive Orders (incoming and existing orders such as airspace and ground control measures and associated mission text), Prioritize Orders, Verify Orders, Develop Plan and Review Plan. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- The concept of 'orders' encompasses all order types, including mission orders, warning orders and fragmented orders.
- Acknowledgement of mission orders and plans is also a communications sub-function.
- To maintain workload at a manageable level, information must be filtered and only distributed to the relevant entities.

4.2.3.2 Situational Awareness (Function Ref. 3.2)

The Situational Awareness sub-function is further divided into: Status Monitoring and Status Projection. Both Status Monitoring and Status Projection include the following sub-functions: Own Vehicle Status, Air Activity Status, Ground Activity Status, Other Vehicle Status and Environmental

Conditions Status. To maximize the benefit of ADVANCE technologies, the following issue should be considered:

- Vetronics may provide an overview of the health status of all Blue force entities. To provide maximum benefits of shared information, the Blue force picture should be updated frequently. The optimal update rate must be determined.

4.2.3.3 Communications (Function Ref. 3.3)

The Communications sub-function includes: Communicating the Mission Order and Communicating the Mission Status. The Communicate the Mission Order sub-function is further divided into: Selecting Mission Order Recipients, Sending a Mission Order, Receiving a Mission Order and Confirming a Mission Order. The Communicate the Mission Status sub-function is divided into: Send Status Information and Receive Status Information. These communication activities may encompass a combination of digital and voice communications. To maximize the benefit of ADVANCE technologies, the following issue should be considered:

- The integration of vetronics enabled battle management systems will support the digital transmission of pertinent communications such as mission orders, vehicle health, status and contact reports.

4.2.4 Navigation Management (Function Ref. 4)

The Navigation Management function flow involves all functions related to vehicle driving and navigation. While in command of the vehicle, the Operators will require the ability to manoeuvre the vehicle and plan navigation routes. Navigation Management is divided into Own Vehicle and Other Vehicle, which is further sub-divided into Route Management, Route Execution Monitoring and Vehicle Manoeuvring. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- Common crewstations implemented across platforms may increase flexibility and reduce training requirements.
- Other vehicle navigation functions (e.g., UAVs/UGVs) should follow the same design principles and methods of interaction (e.g., route management, vehicle manoeuvring) as own vehicle navigation.

4.2.4.1 Own Vehicle (Function Ref. 4.1)

4.2.4.1.1 Route Management (Function Ref. 4.1.1)

There are a number of route management sub-functions that must be performed by the Operator including: Perform Route Reconnaissance, Determine Route, Plot Route and Edit Route. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- Integrated tactical displays and digital maps may improve route planning, way point generation, and shared way points.
- The addition of tactical navigation systems may impact crew resource management by providing additional functionality to the AFV Driver, thereby reducing requirements for the Crew Commander (CC) to generate and communicate detailed navigation plans. The personnel impact of providing additional functionality to the AFV Driver needs to be assessed further (i.e., what skill level of the AFV Driver would be required?).
- The integration of Vetronics systems may provide the ability to conduct predictive analysis of terrain based on positional information and digital terrain data. This may contribute to the development of navigation aids (e.g., automatic route planning) to reduce Operator workload.

- The integration of Active Suspension should facilitate greater mobility over a wider range of terrain types while conforming to equipment parameters, thereby improving planning and increasing the number of possible routes as compared to using conventional systems without Active Suspension implemented.

4.2.4.1.2 Route Execution Monitoring (Function Ref. 4.1.2)

The Route Execution Monitoring sub-function includes: Monitor Route Plan, Monitor Route Obstacles and Monitor Route Time. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- Navigation aids (e.g., automatic route planning) may reduce Operator workload.
- The integration of Active Suspension monitoring systems and automatic navigation systems may allow for predictive analysis of terrain to assist in the prevention of manoeuvres that exceed vehicle safety limits.

4.2.4.1.3 Vehicle Manoeuvring (Function Ref. 4.1.3)

The Vehicle Manoeuvring sub-function includes: Adjust Vehicle Heading and Adjust Vehicle Speed. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- Active Suspension may improve operational mobility and increase the range of conditions in which vehicle systems could be operated while the vehicle is mobile. However, further research is required to determine the relative changes in Operator performance due to Active Suspension while mobile versus unstabilized platforms.

4.2.4.2 Other Vehicle (Function Ref. 4.2)

Other Vehicle Navigation includes the following sub-tasks: Route Management, Route Execution Monitoring, and Other Vehicle Manoeuvring. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- Other Vehicle Navigation functions (e.g., UAVs/UGVs) should follow the same design principles and methods of interaction (e.g., Route Management, Vehicle Manoeuvring) as Own Vehicle Navigation.
- The displays and functions used to operate other vehicles should be consistent with own vehicle displays and functions to reduce Operator workload and training.

4.2.5 Vehicle Maintainability Management (Function Ref. 5)

The Vehicle Maintainability Management function includes the sub-functions: Preventative Maintenance Management and Corrective Maintenance Management. These maintenance functions span all Levels and Lines of maintenance that are performed for AFVs.

4.2.5.1 Preventative Maintenance Mangement (Function Ref. 5.1)

Preventative Maintenance Management defines all activities that occur on scheduled intervals to ensure the safe and adequate operation of all AFV systems. The introduction of ADVANCE technologies has the potential to impact maintenance activities. To maximize the benefit of ADVANCE technologies, the following issues should be considered:

- The integration of Vetronics systems should provide the ability to record system status and vehicle health data in a manageable format that could be integrated within a vehicle tracking system to track degradations in vehicle health over time. This data should enhance the ability to predict system failures and develop adaptable preventative maintenance strategies to increase the overall lifespan of components and reduce the downtime associated with system failure. It should also provide sufficient data to improve the efficiency of supply chain management by predicting component requests from depots, system manufacturers, etc.

- The integration of Active Suspension technologies will likely result in changes to currently implemented preventative maintenance schedules to account for the increased longevity of system components due to reduced vibration.
- The introduction of complex Vetronics and Active Suspension systems may result in an additional maintenance burden if the associated components are costly and difficult to maintain.

4.2.5.2 Corrective Maintenance Mangement (Function Ref. 5.2)

Corrective Maintenance Management is further divided into the following: System Status Monitoring, and Vehicle Fault Management. System Status Monitoring is sub-divided into Own Vehicle Status Monitoring and Other Vehicle Status Monitoring. To maximize the benefit of ADVANCE technologies, the following issues should be considered::

- The integration of Vetronics systems should provide the ability to conduct remote system diagnostics and assist in the recognition and identification of system failures while in-situ. Vehicle health status can then be monitored in real-time by maintainers in support of Combat Units in the field.
- Due to the complexity of Active Suspension components, there is concern regarding the degree of component failures or loss of power that can occur prior to disabling or reducing vehicle operability or adversely impacting Operator performance. The point at which maintenance activities can not be conducted in field to restore vehicle status to an acceptable level of operability must be determined. This is essential for high-threat environments where vehicle survivability will be heavily dependant on the durability of Active Suspension components.
- The difficulty of repairing both Active Suspension and Vetronics systems must be addressed to ensure that an adequate level of maintenance is supportable while in deployed operations to ensure that fleet operability is maintained to an acceptable level. The difficulty of repair and mean-time-between-failures (MTBF) must be analyzed to ensure that Second Line maintenance capabilities are not adversely affected.
- Operator and Maintainer training must be assessed to determine the degree of training required to support the maintenance activities associated with Active Suspension and Vetronics systems.
- Redundant systems must exist to ensure failures in the Vetronics system will not disable the fundamental operations of the vehicle. Degraded modes of operation must still be supported.

4.3 Task Analyses

A comprehensive collection of literature exists that documents the results of task analyses that have been conducted within the CF and abroad on vehicle platforms that are of interest to the ADVANCE TD. The results of these task analyses are summarized in Sections 4.3.1 to 4.3.4. Platforms and functionality that have not yet been assessed using the task analysis approach are also identified.

Previous task analyses conducted include:

- Advanced Land Fire Control System (ALFCS) project;
- Coyote Risk Reduction Unit (RRU) / Advanced Linked Extended Reconnaissance and Targeting (ALERT) TD;
- Multi-Mission Effects Vehicle TD; and
- ARC3RRO Project.

4.3.1 Advanced Land Fire Control System Project

The ALFCS was a major project conducted for Defence R&D Canada (DRDC) to demonstrate technologies that will improve the engagement performance of an AFV as well as to increase the AFV's survivability on the battlefield. ALFCS focussed on short duration engagements from the time of intervisibility between a host and target to the destruction or neutralization of the target. The project investigated the following technologies:

- Fire Control System (FCS) technologies: included the integration of an autoloader and subsequent crew reduction and a series of automatic detection and tracking features;
- Operator Machine Interface technologies: included relaxed view sight displays, enhanced control handles, use of programmable push buttons in a fully-integrated control panel, simplified state and mode controls, and direct voice input.
- Defensive Aides Suite technologies: included the integration of high-accuracy laser warning receivers and a number of potential countermeasures such as multi-spectral smoke and counter-fire using the advanced FCS features.

The technologies were evaluated in reference to the integration of fire control systems across a range of AFV platforms, including LAVs and Main Battle Tanks (MBTs). The project also determined what combinations of the new technologies produced the greatest enhancement of engagement performance.

Integral to the conduct of ALFCS was the integration of a HF program to support the design and evaluation of the AFV technologies. A Mission, Function and Task Analysis was conducted on the range of functions and tasks associated with the conduct of a typical engagement sequence within the context of AFV operations. The Leopard C1 was used as the primary source of information to form the basis of the task analysis. As new technologies were introduced throughout the project, the function and task analysis was updated to demonstrate the resulting impact of the new technologies (e.g. Integrated Fire Control Systems, DAS) on Operator and system performance. The highest level functions analyses in ALFCS are illustrated in Figure 2.

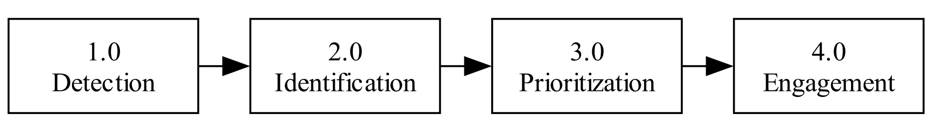


Figure 2: Highest Level ALFCS Functions

4.3.2 Coyote Risk Reduction Unit / ALERT

The ALERT TD was established to research, develop and evaluate the experimental impact of a series of enhancements to the Coyote reconnaissance and surveillance vehicle. These enhancements included data fusion, and automatic target detection and recognition technologies integrated into a re-design of the Surveillance Operator's (SO) workstation.

The Human Factors effort during the ALERT TD included activities related to the analysis of Coyote reconnaissance and surveillance missions, and analyses of the functions and tasks undertaken by the Coyote's crewmembers during these missions, particularly by the SO and the Crew Commander. These analyses were used to inform the design and development of the Soldier Machine Interface (SMI), and its verification and validation using a combination of user groups, laboratory evaluations and field demonstrations.

A task analysis was conducted based on the results of the mission and function analyses, as well as the function allocation, to create a systematic inventory of the Coyote tasks which would then be used for subsequent design, development and evaluation of the SMI. Tasks that were identified as critical (i.e., tasks relating to safety, mission effectiveness, efficiency, system reliability and/or cost) merited a more detailed task analysis. The highest level functions assessed during the ALERT MFTA are shown in Figure 3.

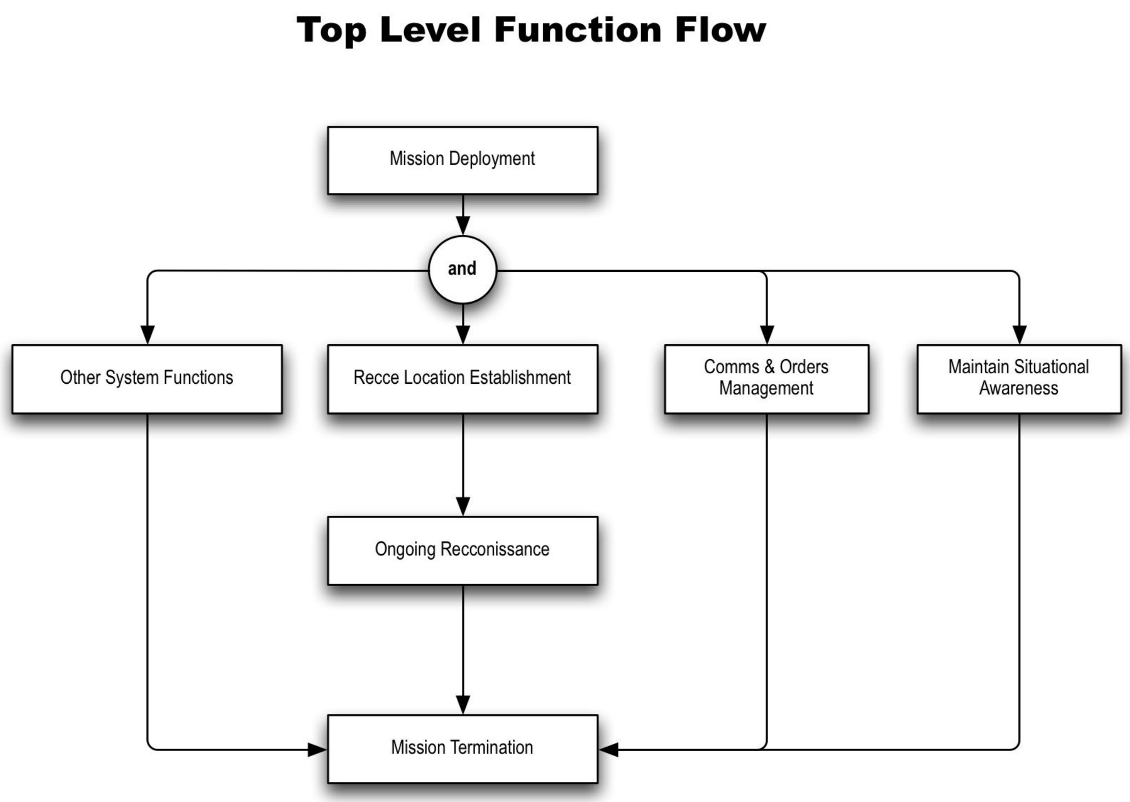


Figure 3: Highest Level Alert Functions

4.3.3 Multi-Mission Effects Vehicle

The Multi-Missions Effects Vehicle (MMEV) MFTA was performed as an iterative process over a series of analyses. Two comprehensive iterations were conducted during the analysis, which consisted of a refinement of the preliminary abstract, missions, functions and goals.

Initially the MMEV TD was focused towards the Army of the Future timeframe, around 2020-2025. The MMEV TD was re-aligned to focus towards the Army of Tomorrow timeframe, around 2010-2015. This re-alignment was performed to better support the Canadian Forces Army Transformation Plan, which provides a plan for transforming from the Army of Today to the Army of Tomorrow. With this re-alignment, the MMEV TD was positioned to better support the Army Transformation

Plan, and its near-term Major Crown Acquisition programs such as the MMEV and Mobile Gun System.

4.3.3.1 MMEV Build 1

The MFTA conducted was part of the pre-realignment effort focused on the MMEV concept that evolved from work completed at Defence R&D Canada, as well as concepts explored by the Director Land Strategic Concepts (DLSC). The concept involved a wheeled vehicle with the following capabilities:

- Vehicle built on a Light Armoured Vehicle III chassis or future equivalent;
- Direct/Indirect fire capability;
- Advanced Self-Guided High-Value Missile with Surface to Surface Missile (SSM) and Surface to Air Missile Capability (SAM);
- CRV7 guided rockets for low value targets;
- Grenade Launcher for anti-personnel and soft-shell vehicles;
- Machine Gun, coaxially mounted with the Grenade Launcher;
- Network fires;
- Battlefield Combat Identification (BCID);
- Uninhabited Air Vehicle with perch, hover, and auto-navigation capability;
- Network C2 including the sharing of sensor and vehicle data among troops, Satellites, and UAV/UGVs to coordinate activity;
- Multi-mission capability;
- Ability to change mission ‘on the fly’;
- Operated by a 2 person crew: a Crew Commander and a Gunner (GNR);
- Crew Commander and Gunner sights with Day/TI, Auto Detection System;
- 360 degree camera views;
- Fire Control sensors;
- Automatic Target Detection and Recognition (ATDR) on all sensors and platforms; and
- DAS sensors with soft- and hard-kill countermeasures.

The MMEV Build 1 MFTA focused on advanced technologies expected to exist within the Army of the Future timeframe. Therefore, the resulting function and task analysis was focused on defining the behaviours of these systems.

The scenarios and force structure concepts described in the MMEV Build 1 mission analysis were used as a basis for the development of an initial abstract function analysis. The highest level system functions in the analysis were derived from previous AFV design experience and previous discussions with AFV crews, but also incorporated characteristics specific to the MMEV project and Future Army concepts. These high-level functions are illustrated in Figure 4.

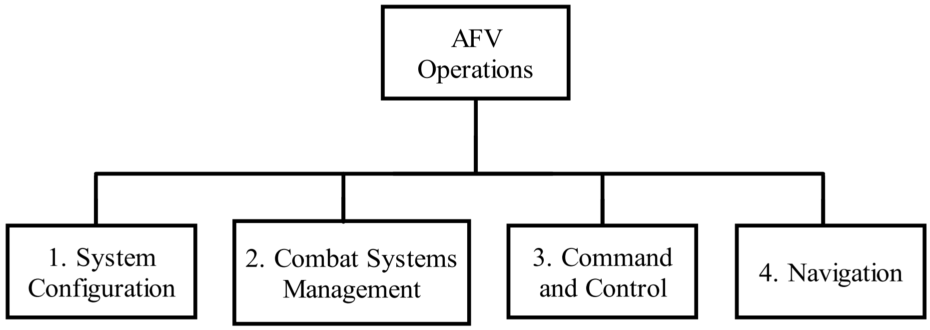


Figure 4: High-level MMEV Functions

These high-level functional groupings were used to conduct a preliminary function and task analysis that was used as the basis for the development of the more detailed function and task flows conducted during the second iteration in order to isolate functionality for system subcomponents.

4.3.3.2 MMEV Build 2

The MMEV TD Build 2 effort was re-aligned to directly support the MMEV Major Crown Acquisition program. Since the TDP was realigned, the Version 1 MFTA was updated in order to satisfy the new project requirements. The MMEV's proposed capabilities were modified to reflect the level of technology expected to be fielded with the MMEV in the Army of Tomorrow timeframe.

Discussions with the MMEV TDP teams identified an initial set of vehicle characteristics including:

- Built on a Light Armoured Vehicle III chassis or future equivalent;
- DF/NLOS/GBAD/ ISTAR capability;
- Network fires;
- Battlefield Combat Identification;
- Multi-mission capability;
- Ability to change missions 'on the fly';
- Operated by a three person crew; and
- DAS sensors with soft- and hard-kill countermeasures.

More detailed characteristics are provided in Table 2.

Table 2: Detailed MMEV Characteristics

Characteristic	Value
Maximum Detection Range	
Air Defence (AD) Radar	35 km
Ground Radar (Moving Target Indicator: MTI)	8 km
(Ground and AD radars cannot operate simultaneously)	
Forward Looking Infrared (FLIR)	25 km
Color Low Light Television (LLTV)	20 km
EO Search-on-Move	Yes
AD Radar Detection / Recognition-on-Move	Yes
Panospheric Camera System	Yes
Non-Line Of Sight (NLOS) Missile Firing-on-Move	Mode dependent
Air Defence Anti-Tank System (ADATS) Missile Firing-on-Move	NO
Low Cost Precision Kill (LCPK) Firing-on-Move	Yes
Improved Battle Management C4I (BMC4I)	Yes
Laser Target Designator	Yes – 10 km range
Laser Range Finder	Yes – 10 km range
Advanced DAS	Yes

The Abstract Hierarchy developed in the Build 1 MFTA provided a suitable and generic analysis and function flow that allowed the preliminary function allocation and task analysis to be completed. There were no required changes to the abstract hierarchy as part of the re-alignment process.

As part of the realignment process, the MFTA Version 1 task flows were modified to reflect changes in vehicle capabilities for the MMVV B2 design, resulting in both the creation of new task flows and the removal of flows that were no longer applicable to the design of the system (e.g. UAV Control).

4.3.4 ARC3RRO

The ARC3RRO project is developing an update of the Crew Commander Terminal (CCT) for the Air Defence Anti-Tank System vehicle. The updated CCT combines enhanced functionality with touch screen capability in a ruggedised notebook PC format

A functional analysis was conducted on the functional capabilities of the ADATS detachment commander Radar Operator's workstation. The function analysis was specific to the capabilities of an implemented system, and did not abstract to the functionality of a GBAD asset. In addition, there is a lack of information related to task sequencing and timing with respect to an operational setting. Figure 5 illustrates the high-level functions assessed for the ARC3RRO project.

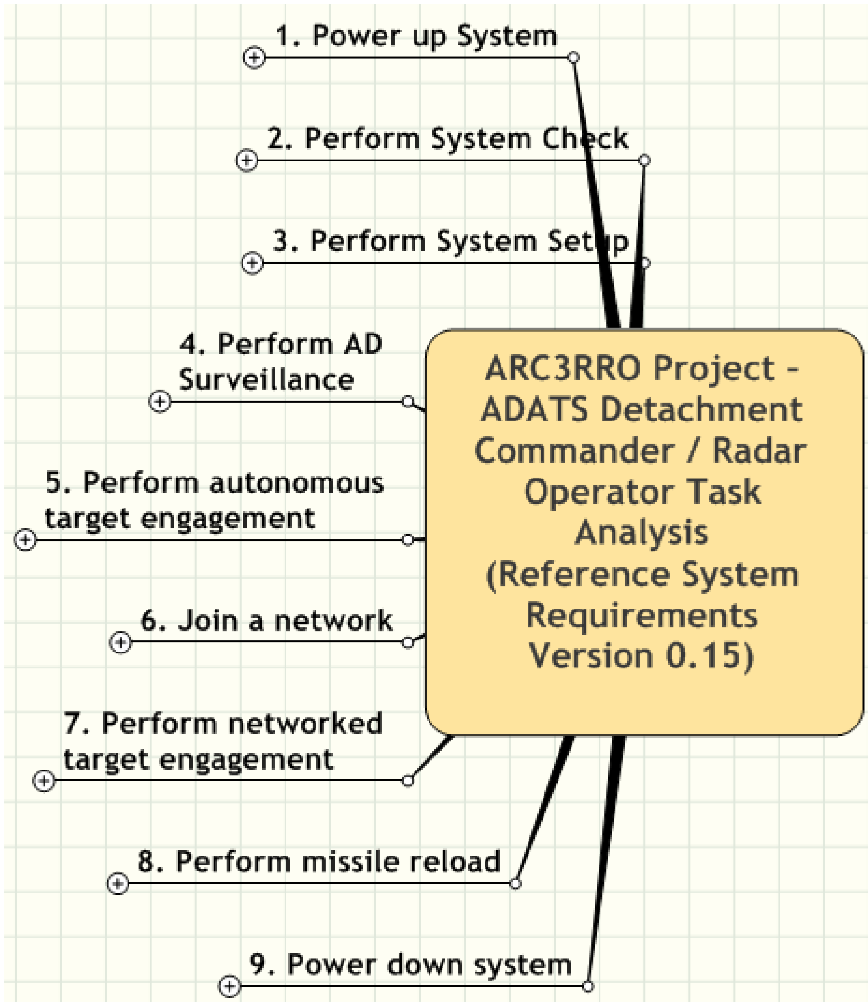


Figure 5: ARC3RRO Functional Analysis

4.3.5 Current Deficiencies

Currently, there is a lack of information detailing the functions and tasks related to the conduct of many aspects of AFV operations. In terms of the documentation available, there are also significant gaps in the breadth and depth of information that was analysed such as:

- ALFCS: Restricted to offensive and defensive direct-fire operations exclusively. Had limited analysis of Battlefield Management System (BMS) based command and control, external communications, command and control or navigation functions within the AFV domain.
- ALERT: Focused exclusively at the Sensor Operator's crewstation to support design efforts. Some analysis was conducted on integrated UAV operations within the context of the Sensor Officer crewstation. The project did not focus on detailed functions and tasks related to crew based activities involving mission planning, command and control, crew resource management, weapon systems, or navigation.
- MMEV: Detailed analysis of offensive and defensive operations encompassing direct fire, P-NLOS and the engagement aspects of GBAD. Network centric operations were examined only in the context of target engagement processes. Examination of navigation tasks were only in relation to the use of digital maps and integrated navigation systems.

- ARC3RRO: The system manufacturer performed analysis exclusively on the functionality of the ARC3RRO system, and not as a user-based Mission, Function and Task Analysis.

The existing analyses for the ALFCS, ALERT, MMEV, and ARC3RRO projects were sufficient to detail some aspects of the ADVANCE functions identified in Section 4.2. However, to adequately assess the impact of ADVANCE technologies on AFV performance, additional task analysis activities should be conducted on those functions that have not been analysed in detail.

Table 3 illustrates a prioritized list of the ADVANCE functional areas requiring further analyses.

Table 3: ADVANCE Functional Areas Requiring Further Analyses

Task ADVANCE Functional Operations		**Available Analysis**	**Further Analysis Required (Low/Medium/High Priority)**
1 Systems Management	1.1 Own Vehicle Systems Configurations	MMEV MFTA V1 MMEV MFTA V2 ALFCS ALERT/Coyote RRU ARC3RRO	Low
	1.2 Other Vehicle Systems Configurations	MMEV MFTA V2 ALERT/Coyote RRU	Medium
2 Combat Operations Management	2 Combat Operations Management (General)	MMEV MFTA V1 MMEV MFTA V2 ALFCS	Low
	2.6 Network Combat Management	MMEV MFTA V1 MMEV MFTA V2	Medium
3 Command and Control Management	3.1 Battle Management	MMEV MFTA V1 MMEV MFTA V2 ALFCS	High
	3.2 Situational Awareness	MMEV MFTA V1 MMEV MFTA V2	High
	3.3 Communications	MMEV MFTA V1 MMEV MFTA V2 ALERT/Coyote RRU	High
4 Navigation Management	4 Navigation Management (General)	MMEV MFTA V1 MMEV MFTA V2	Low
5 Vehicle Maintainability Management	5 Vehicle Maintainability Management (General)	Missing	High

5 Discussion

This initial Mission, Function, and Task Analysis describes the ADVANCE capabilities in relation to AFVs within the CF. The MFTA is based on MFTAs developed for previous relevant projects, and is further extended to include additional tasks associated with net-enabled combat.

At this Definition Stage of the project, many areas that have been analysed within the MFTA were noted as requiring further exploration as the ADVANCE TD evolves. Though the existing analysis provides a solid starting-point for the ADVANCE TD, the depth and breadth of the current analysis, including missions, functions, and tasks is not sufficient to identify the precise impacts of ADVANCE technologies on AFV performance.

The operational scenarios identified within this document provide an adequate range of missions from which to explore AFV operations and are primarily based on current doctrine and Tactics, Techniques, and Procedures (TTPs). Further enhancements to the identified scenarios should be conducted to incorporate a better understanding of the impact of network-centric operations, including GBAD and precision fire capabilities on the modern battlefield, as well as incorporate a broad-spectrum analysis of the logistics and maintenance aspects of modern warfare.

These enhancements to the operational scenarios will then support the validation and verification of the current function analysis to ensure that a representative set of AFV functions has been adequately identified, as well as provide a framework from which to conduct functional allocation activities. Further analyses should also be conducted to refine and detail the task analysis presented reporting this MFTA to resolve the identified deficiencies within the currently available task data that will be crucial to the development of OMI concepts and User Requirements in support of the ADVANCE TD.

5.1 Training/Personnel/HR/Career Progression

The introduction of ADVANCE technologies is predicted to affect Operator training by:

- Common crewstations will facilitate cross-training among crewmembers and across vehicle platforms.
- The reduction of individual platform training and the opportunity that is created to focus on tactics, techniques, procedures and doctrine
- The requirement for cross-training will likely increase the overall Operator skill level when compared to traditional AFVs. The current army-wide recruiting structure that supports rapid and mass recruiting through conscription during war may no longer apply for the specialized weapons system of the future. The recruiting model will have to adapt for aspects of the army capability where complex weapons systems are staffed by small but highly trained teams.
    - Modifying AFV technology will have the potential to reduce training requirements since systems and interfaces will be simpler and easier to use. However, this may be offset by the increased level of distributed information in a network centric battlefield as well as the changing roles of AFV operators when faced with advanced sensor and weapon technologies.
    - The trade offs discussed above should be explored, analyzed and documented further during the course of the ADVANCE project.

5.2 Crew Resource Management

The introduction of ADVANCE technologies is predicted to affect the CRM structures of AFVs by:

- CRM strategies need to be determined to clearly identify and define the roles and responsibilities of each crewmember. This will ensure that any function can be performed at any crewstation.
- The crew should be cross-trained on the operation of other vehicle systems. This will positively impact AFV operations since cross-training will facilitate additional Operators (e.g., Driver, Loader) to assume duties and responsibilities of other crewmembers during sustained operations. By increasing the frequency of crew work/rest cycles the risk of increased fatigue, and decreased performance due to sustained operations is minimized. To support this role, cross training will have to be sufficiently in-depth in order for all crewmembers to be effective at operating all vehicle systems to an adequate proficiency level.
- By transferring more responsibility to the Driver, other crewmembers will be more readily available to attend to other combat tasks, allowing for increased response times and Situational awareness.
- Cross-training will have significant impact on the number of personnel who must be trained for a fielded system, and will increase overall training requirements, career paths and recruiting. The impact of a common crewstation design across vehicle platforms on training must be determined. The training community should be consulted when designing the common crewstation since the new common crewstation design may ultimately impact or change the Standard Operating Procedures (SOPs) and Tactics, Techniques, and Procedures of armoured vehicle operations.
- The reduction of vibration facilitated by Active Suspension may improve crew performance by increasing an Operator's ability to conduct tasks and operate systems while mobile.
- The reduction of vibration facilitated by Active Suspension may also increase work duration by decreasing Operator fatigue. This may affect the crew duty cycle, vehicle manning, and crew replacement.

5.3 Maintainability

The introduction of ADVANCE technologies is predicted to affect Operator and system performance by:

- Common systems and displays will increase the ease of maintainability, since the same procedures and maintenance process could be used across platforms. Furthermore, replacement parts for the common systems and displays should not differ between platforms.
- The integration of Vetronics systems may provide the ability to record system status and vehicle health data, which may enhance the ability to predict system failures.
- The integration of Vetronics systems should provide the ability to conduct remote system diagnostics and assist in the recognition and identification of system failures while in-situ. Vehicle health status can then be monitored in real-time by maintainers in support of Combat Units in the field.

- Vetronics may be able to predict system failures (i.e., system fault prediction), which will lead to cost savings. System failure prediction will facilitate the development of adaptable preventative maintenance strategies to increase the overall lifespan of components and reduce the downtime associated with system failure.
- The extent to which the Active Suspension and Vetronics systems can be maintained while deployed must be determined to ensure that fleet operability is maintained to an acceptable level. Furthermore, the extent to which the Active Suspension and Vetronics systems can be maintained when in the field will depend on the tools requried to conduct maintenance activities.
- The trade-offs between supporting degraded modes of operation versus the capability to rapidly maintain and repair a system to 100% capacity in the field must be determined. It must be determined whether a redundant system should exist to ensure failures in the Vetronics system will not disable the fundamental operations of the vehicle.

5.4 Operational Sustainability

The introduction of ADVANCE technologies is predicted to affect Operator and system performance by:

- Active Suspension will reduce vibration, potentially increasing the amount of time crewmembers can remain in the vehicle.
- A back-up system must exist, such that if Vetronics fails, the vehicle is not immobilized.
- The vehicle should be able to be operated from any crew position within the vehicle.
- Active Suspension may provide stabilization for both sight and weapons. This will increase the range of conditions in which a vehicle can accurately and successfully engage targets and conduct surveillance operations.

5.5 Shared Displays

The introduction of ADVANCE technologies will impact the development and use of shared displays by:

- Past research in armoured vehicle crewstation design has identified a requirement to provide operators with the ability to share tactical information between crewmembers. Due to the complexity of the modern battlefield and the requirement for crewmembers to take an active role in determining vehicle tactics and interpreting the surrounding battlespace, it is critical that tactical information is easily accessible and that the representation of tactical information is maintained between operators. Therefore, tactical information should be presented in a manner that enables Operators to easily access a dedicated and centralized tactical display, such as tactical maps and battle management systems.
- Shared displays will provide the potential for information to be shared among crewmembers in real-time (e.g., white-board capability). This will ensure that all crewmembers have the same understanding of the task being described.
- The extent to which a Driver can be made an integral part of crew, that is, an integral part of the total capabilities or functions of the vehicle, must be further analysed.

5.6 Common Crewstation Design

The introduction of ADVANCE technologies will facilitate the integration of common crewstations within the vehicle.

- Where possible, crewstations should be consistent in design to provide the Operators with a consistent display layout. Each crewstation should provide a combination of sight displays and reconfigurable secondary displays. The secondary displays provide the Operator with the ability to rapidly display and control information such as:
    - Own Vehicle Navigation;
    - Other Vehicle Navigation;
    - Combat Status and DAS System;
    - Radar; and
    - BMS.

  It is assumed that the interface for the secondary displays will operate using a consistent rule-base that minimizes the requirement for Operators to learn different behaviours to interact with the diverse vehicle systems. For example, navigation tasks related to own vehicle and other vehicle systems are assumed to be displayed and operated in a similar manner, and are both accessible through the secondary displays. This also applies across vehicles (e.g. Coyote and MMEV systems) as well as to the remote control of own vehicle.
- CCD will provide the ability for all crewmembers to access vehicle sensors (e.g., LSAS) for any crewstation. Providing the driver with access to these systems should significantly increase situational awareness by increasing the number of “eyes” to the outside of the vehicle.
- The anthropometrics (range of size, shape, and gender) of the crewmembers must be considered, along with their clothing and equipment. The implementation of Vetronics (reduction of weight and availability of ‘free space’) may positively impact the vehicle design.

5.7 Network Centric Operations

The introduction of ADVANCE technologies is predicted to affect Operator and system performance in the following ways:

- If the Command Center is disabled, a redundant system must exist on the vehicle level to continue to provide data fusion for that platform.
- There is a potential that wrong data could be broadcasted to all vehicles (e.g., incorrect identification of a contact). It must be determined how faulty information will get filtered.
- The minimization of digital data transmission latency is critical.
- Increased sharing of information between vehicles and with dismounts will increase the opportunity for global understanding of a situation and/or orders. The type of information that should be shared among vehicles and dismounts must be determined.

5.8 System Automation

The introduction of ADVANCE technologies is predicted to provide the ability to introduce varying levels of systems automation within the scope of AFV system design. This will likely affect performance by:

- Since task flows can occur simultaneously, there is significant potential for AVF crews to be very busy when using multiple systems. In order to maximize the crew’s ability to respond to events during these high-intensity situations, the task flows assume that the system has a high degree of automation. Major systems that could incorporate automatic capabilities include:

  - Automatic Navigation for Own and Other Vehicles (e.g., UAVs/UGVs);
  - Automatic Target Detection and Recognition System;
  - Auto Engagement System, including target tracking and auto-weapon selection; and
  - Defensive Aides Suite system.

- Upon start up, the default system configuration includes an optimized set for all automatic systems based upon the SOP, user preferences (defined by a unique User ID), and technical capabilities of the system.
- By providing a very high degree of automation, AFVs may be able operate successfully with staff similar to those available via the current recruiting mechanisms for today's Army. However, system automation also has associated costs such as decreased situational awareness when in degraded modes of operation, reduced ability for the Operators to diagnose system faults, and difficulties associated with trust and automated systems. Automation can also be financially costly to develop and has significant technological challenges.
- This MFTA contained limited function allocation analysis with all the systems and with actual battlefield tasks, resulting in further analysis to be completed. The analysis must be completed in the field as compared to a lab, to ensure that actual task timings are captured.

5.9 Advisories, Cautions and Warnings (ACW)

The introduction of ADVANCE technologies should be tailored to integrate ACWs to improve Operator performance as follows:

- In order to reduce the requirement for Operators to interface with the system to view ACWs, it is recommended that all ACWs are integrated directly with the primary sight display through the use of an ACW specific symbology set in combination with an appropriate auditory warnings system. This will increase the likelihood that Operators will detect ACWs as well as prevent the Operators from diverting attention to attend to a separate ACW system on a secondary display.

6 Conclusion

This interim document presents the results of an initial Mission, Function, and Task Analysis for ADVANCE capabilities in relation to AFVs within the CF. The MFTA is based on MFTAs developed for previous relevant projects, such as ALFCS and MMEV, and is further extended to include additional tasks associated with net-enabled combat.

As the ADVANCE TD is currently in the Definition Stage of the project, the MFTA requires further efforts to provide a detailed framework from which to evolve the user requirements documentation, define the operational roles for AFVs within the net-centric environment, and explore the impacts of Vetronics and AS systems on AFV operations. Significant involvement from the AFV operational community will be required to aid in the identification and definition of missing areas within the existing analysis. As the MFTA continues to be iterated throughout the design cycle, additional data elements will be included in the task analysis to support additional interface design and training, as well as to highlight issues for usability testing and human performance evaluation.

During this Definition Stage of the project, the following activities will also be completed:

- User Requirements: User Requirements will be identified and characterized for AFVs in a future battlefield, focusing on user requirements for operation in a net-enabled environment.
- Experimental and Test Plan: Experimental and Test Plans will be developed, outlining the assessment strategy for future system evaluations. The plan will outline the requirements for the system evaluations, and will provide a plan to conduct the experimentation. The system evaluations will focus on the effectiveness of the SMI, including human performance, usability, crewstation ergonomics and human computer interaction.
- HSI and HFE Program Plan: The HSI and HFE Program Plan will detail and schedule future HSI and HFE activities for the project's implementation phase. The HSI and HFE plan will detail the following activities: verification of user and technical requirements, the conduct of HSI and HFE analysis to provide HFE design input to the SMI, the conduct of user groups, and the planning and execution of experimental trials.

7 Acronyms

ACW	Advisories, Cautions, and Warnings
ADATS	Air Defence Anti-Tank System
AD Radar	Air Defence Radar
ADVANCE	Advanced Vehicle Architecture for a Net-Enabled Combat Environment
AFV	Armoured Fighting Vehicle
ALERT	Advanced Linked Extended Reconnaissance and Targeting
ALFCS	Advanced Land Fire Control System
AoT	Army of Tomorrow
APOD	Air Point of Disembarkation
ATDR	Automatic Target Detection and Recognition
BCID	Battlefield Combat Identification
BMC4I	Battle Management C4I
BMS	Battlefield Management System
C2	Command and Control
CC	Crew Commander
CCD	Common Crewstation Design
CCT	Crew Commander Terminal
CF	Canadian Forces
CID	Combat Identification
CLF	Common Look and Feel
COP	Common Operating Picture
CP	Command Post
CRM	Crew Resource Management
DAS	Defensive Aides Suite
DFS	Direct Fire Squadron
DLSC	Director Land Strategic Concepts
DRDC	Defence R&D Canada
EO	Electro-optical
FCS	Fire Control Systems
FLIR	Forward Looking Infrared
G&A	Greenley & Associates Inc.

GBAD	Ground Based Air Defence
GNR	Gunner
HF	Human Factors
HFE	Human Factors Engineering
HLVW	Heavy Logistics Vehicle Wheeled
IFF	Identification Friend or Foe
ISTAR	Intelligence, Surveillance and Target Acquisition and Reconnaissance
LAV	Light Armoured Vehicle
LCPK	Low Cost Precision Kill
LCSS	Land Command Support System
LLTV	Low Light Television
LSAS	Local Situational Awareness System
MBT	Main Battle Tank
MFTA	Mission Functions Task Analysis
MGS	Mobile Gun System
MMEV	Multi-Mission Effects Vehicle
MMVV	Multi-Mission Virtual Vehicle
MTI	Moving Target Indicator
NLOS	Non-Line of Sight
OMI	Operator Machine Interface
P-NLOS	Precision Non-Line of Sight
PWGSC	Public Works and Government Services Canada
RRU	Risk Reduction Unit
SA	Situation Awareness
SAM	Surface to Air Missile
SME	Subject Matter Expert
SMI	Soldier Machine Interface
SO	Surveillance Operator
SOP	Standard Operating Procedure
SSM	Surface to Surface Missile
TD	Technology Demonstration
TTP	Tactics, Techniques, and Procedures
TUA	TOW Under Armour

UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
UI	User Interfaces

Annex A

ADVANCE Function Flow Table and Diagrams

Task	
	ADVANCE Operations
1	Systems Management
1.1	Own Vehicle Systems Configuration
1.1.1	Configure Communications
1.1.1.1	Configure Radio
1.1.1.1.1	Change Radio Defaults
1.1.1.1.2	Change Radio Configuration Characteristics
1.1.1.2	Configure Data Network
1.1.1.2.1	Change Data Network Display Defaults
1.1.1.2.2	Change Data Network Configuration Characteristics
1.1.2	Configure External Sensors
1.1.2.1	Configure Local Situational Awareness System
1.1.2.1.1	Change Local Situational Awareness System Display Defaults
1.1.2.1.2	Change Local Situational Awareness System Configuration Characteristics
1.1.2.2	Configure DAS Sensors
1.1.2.2.1	Change DAS Sensors Display Defaults
1.1.2.2.2	Change DAS Sensors Configuration Characteristics
1.1.2.3	Configure IR Sensor
1.1.2.3.1	Change IR Sensor Display Defaults
1.1.2.3.2	Change IR Sensor Configuration Characteristics
1.1.2.4	Configure II Sensor
1.1.2.4.1	Change II Sensor Display Defaults
1.1.2.4.2	Change II Sensor Configuration Characteristics
1.1.2.5	Configure Radar Sensor
1.1.2.5.1	Change Radar Sensor Display Defaults
1.1.2.5.2	Change Radar Sensor Configuration Characteristics

1.1.2.6	Configure GPS Sensor
1.1.2.6.1	Change GPS Sensor Display Defaults
1.1.2.6.2	Change GPS Sensor Configuration Characteristics
1.1.2.7	Configure Combat ID Sensor
1.1.2.7.1	Change Combat ID Sensor Display Defaults
1.1.2.7.2	Change Combat ID Sensor Configuration Characteristics
1.1.3	Configure Internal Sensors
1.1.3.1	Configure Fire Suppression System Sensor
1.1.3.1.1	Change Fire Suppression System Sensor Display Defaults
1.1.3.1.2	Change Fire Suppression System Sensor Configuration Characteristics
1.1.3.2	Configure Health / Status Sensors
1.1.3.2.1	Change Health / Status Sensor Display Defaults
1.1.3.2.2	Change Health / Status Sensor Configuration Characteristics
1.1.3.3	Configure Inertial Navigation System Sensor
1.1.3.3.1	Change Inertial Navigation System Sensor Display Defaults
1.1.3.3.2	Change Inertial Navigation System Sensor Configuration Characteristics
1.1.4	Configure Weapons
1.1.4.1	Configure DAS Counter-Measures
1.1.4.1.1	Change DAS Mode
1.1.4.1.2	Change DAS Weapon Configuration Characteristics
1.1.4.2	Configure Offensive Weapons
1.1.4.2.1	Change Offensive Weapon Defaults
1.1.4.2.2	Change Offensive Weapon Configuration Characteristics
1.1.4.2.3	Change Offensive Weapon Loaded/Armed/Ready Characteristics
1.1.5	Configure Internal Sub-Systems
1.1.5.1	Configure Vehicle Climate
1.1.5.1.1	Change Vehicle Temperature
1.1.5.1.2	Change Vehicle Air Circulation
1.1.5.2	Configure Seating

1.1.5.2.1	Adjust Seat Height and Angle
1.1.5.2.2	Adjust Seat Proximity to Displays
1.1.5.3	Configure Displays
1.1.5.3.1	Change Display Location
1.1.5.3.2	Change Display Attributes
1.1.5.4	Configure Vehicle Propulsion
1.1.5.5	Configure Active Suspension
1.1.5.5.1	Change Mode
1.1.5.5.2	Change Height Actuator
1.1.5.6	Configure Vehicle NBCD
1.2	Other Vehicle Systems Configuration
1.2.1	Configure Data Network
1.2.1.1	Change Data Network Display Defaults
1.2.1.2	Change Data Network Configuration Characteristics
1.2.2	Configure External Sensors
1.2.2.1	Configure Local Situational Awareness System
1.2.2.1.1	Change Local Situational Awareness System Display Defaults
1.2.2.1.2	Change Local Situational Awareness System Configuration Characteristics
1.2.2.2	Configure DAS Sensors
1.2.2.2.1	Change DAS Sensors Display Defaults
1.2.2.2.2	Change DAS Sensors Configuration Characteristics
1.2.2.3	Configure IR Sensor
1.2.2.3.1	Change IR Sensor Dsiplay Defaults
1.2.2.3.2	Change IR Sensor Configuration Characteristics
1.2.2.4	Configure II Sensor
1.2.2.4.1	Change II Sensor Display Defaults
1.2.2.4.2	Change II Sensor Configuration Characteristics
1.2.2.5	Configure Radar Sensor

1.2.2.5.1	Change Radar Sensor Display Defaults
1.2.2.5.2	Change Radar Sensor Configuration Characteristics
1.2.2.6	Configure GPS Sensor
1.2.2.6.1	Change GPS Sensor Display Defaults
1.2.2.6.2	Change GPS Sensor Configuration Characteristics
1.2.2.7	Configure Combat ID Sensor
1.2.2.7.1	Change Combat ID Sensor Display Defaults
1.2.2.7.2	Change Combat ID Sensor Configuration Characteristics
1.2.3	Configure Internal Sensors
1.2.3.1	Configure Fire Suppression System Sensor
1.2.3.1.1	Change Fire Suppression System Sensor Display Defaults
1.2.3.1.2	Change Fire Suppression System Sensor Configuration Characteristics
1.2.3.2	Configure Health / Status Sensors
1.2.3.2.1	Change Health / Status Sensor Display Defaults
1.2.3.2.2	Change Health / Status Sensor Configuration Characteristics
1.2.3.3	Configure Inertial Navigation System Sensor
1.2.3.3.1	Change Inertial Navigation System Sensor Display Defaults
1.2.3.3.2	Change Inertial Navigation System Sensor Configuration Characteristics
1.2.4	Configure Weapons
1.2.4.1	Configure DAS Counter-Measures
1.2.4.1.1	Change DAS Mode
1.2.4.1.2	Change DAS Weapon Configuration Characteristics
1.2.4.2	Configure Offensive Weapons
1.2.4.2.1	Change Offensive Weapon Defaults
1.2.4.2.2	Change Offensive Weapon Configuration Characteristics
1.2.4.2.3	Change Offensive Weapon Loaded/Armed/Ready Characteristics
2	Combat Operations Management
2.1	Contact Detection
2.1.1	Search for Contact

2.1.1.1	Define Search Field
2.1.1.2	Select Search Strategy
2.1.1.3	Select Search Mode
2.1.1.4	Activate Search Aid
2.1.1.5	Perform Search
2.1.2	Perceive Contact
2.1.2.1	Perceive Contact Signatures
2.1.2.2	Perceive Number of Contacts
2.1.3	Localize Contact
2.1.3.1	Determine Range to Contact
2.1.3.2	Determine Absolute/Relative Position of Contact
2.2	Contact Identification
2.3	Contact Classification
2.4	Contact Prioritization
2.4.1	Assess Contact Threat
2.4.1.1	Assess Contact Capabilities
2.4.1.2	Assess Contact Position
2.4.1.3	Classify Contact Threat Priority
2.4.2	Assess Orders
2.4.3	Integrate Assessments
2.4.3.1	Integrate/Prioritize Data
2.4.3.2	Select Course of Action
2.5	Contact Engagement
2.5.1	Select Contact
2.5.2	Select Weapon
2.5.3	Acquire Target
2.5.4	Fire Weapon
2.5.5	Validate Weapon Effect
2.6	Network Combat Management

2.6.1	Request from Network
2.6.1.1	Receive Network Request
2.6.1.2	Assess Own Vehicle Status
2.6.1.3	Integrate Network Request and Assessment
2.6.1.4	Respond to Network Request
2.6.2	External Engagement Request (Calling for Fire)
2.6.2.1	Select Target
2.6.2.2	Communicate Target Information to Network
2.6.2.3	Confirm Weapon Effect
3	Command and Control Management
3.1	Battle Management
3.1.1	Review Orders
3.1.1.1	Review Mission
3.1.1.2	Review Airspace Control Measures
3.1.1.3	Review Ground Control Measures
3.1.2	Prioritize Orders
3.1.3	Verify Orders
3.1.4	Develop Plan
3.1.5	Review Plan
3.2	Situational Awareness
3.2.1	Status Monitoring
3.2.1.1	Monitor Own Vehicle Status
3.2.1.1.1	Vehicle Positional Monitoring
3.2.1.1.2	Vehicle Cautions and Warnings Monitoring
3.2.1.1.3	Vehicle Weapon and Ammunition Monitoring
3.2.1.1.4	Vehicle Speed Monitoring
3.2.1.1.5	Vehicle Health Status Monitoring
3.2.1.1.6	Vehicle Sensor Status Monitoring
3.2.1.1.7	Vehicle Communication Status Monitoring

3.2.1.2	Monitor Air Activity Status
3.2.1.2.1	Monitor Enemy Status
3.2.1.2.2	Monitor Friendly Status
3.2.1.2.3	Monitor Non-Combatant Status
3.2.1.2.4	Monitor Unknown Status
3.2.1.3	Monitor Ground Activity Status
3.2.1.3.1	Monitor Enemy Status
3.2.1.3.2	Monitor Friendly Status
3.2.1.3.3	Monitor Non-Combatant Status
3.2.1.3.4	Monitor Unknown Status
3.2.1.4	Monitor Other Vehicle Status
3.2.1.4.1	Other Vehicle Positional Monitoring
3.2.1.4.2	Other Vehicle Cautions and Warnings Monitoring
3.2.1.4.3	Other Vehicle Weapon and Ammunition Monitoring
3.2.1.4.4	Other Vehicle Speed Monitoring
3.2.1.4.5	Other Vehicle Health Status Monitoring
3.2.1.4.6	Other Vehicle Sensor Status Monitoring
3.2.1.4.7	Other Vehicle Communication Status Monitoring
3.2.1.5	Monitor Environmental Conditions Status
3.2.2	Status Projection
3.2.2.1	Project Own Vehicle Status
3.2.2.2	Project Air Activity Status
3.2.2.2.1	Project Enemy Status
3.2.2.2.2	Project Friendly Status
3.2.2.2.3	Project Non-Combatant Status
3.2.2.2.4	Project Unknown Status
3.2.2.3	Project Ground Activity Status
3.2.2.3.1	Project Enemy Status
3.2.2.3.2	Project Friendly Status

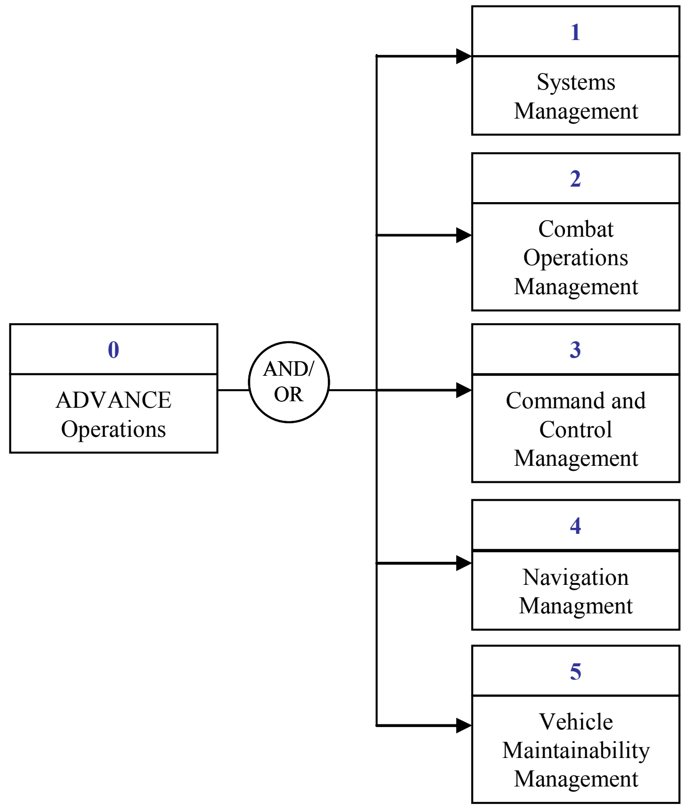
3.2.2.3.3	Project Non-Combatant Status
3.2.2.3.4	Project Unknown Status
3.2.2.4	Project Other Vehicle Status
3.2.2.5	Project Environmental Conditions Status
3.3	Communications
3.3.1	Communicate Mission Order
3.3.1.1	Selecting Mission Order Recipients
3.3.1.2	Send a Mission Order
3.3.1.3	Receive a Mission Order
3.3.1.4	Confirm a Mission Order
3.3.2	Communicate Mission Status
3.3.2.1	Send Status Information
3.3.2.1.1	Send Own Vehicle Status
3.3.2.1.2	Send Air Activity Status
3.3.2.1.2.1	Send Enemy Status
3.3.2.1.2.2	Send Friendly Status
3.3.2.1.2.3	Send Non-Combatant Status
3.3.2.1.2.4	Send Unknown Status
3.3.2.1.3	Send Ground Activity Status
3.3.2.1.3.1	Send Enemy Status
3.3.2.1.3.2	Send Friendly Status
3.3.2.1.3.3	Send Non-Combatant Status
3.3.2.1.3.4	Send Unknown Status
3.3.2.1.4	Send Other Vehicle Status
3.3.2.1.5	Send Environmental Conditions Status
3.3.2.2	Receive Status Information
3.3.2.2.1	Receive Air Activity Status
3.3.2.2.1.1	Receive Enemy Status
3.3.2.2.1.2	Receive Friendly Status

3.3.2.2.1.3	Receive Non-Combatant Status
3.3.2.2.1.4	Receive Unknown Status
3.3.2.2.2	Receive Ground Activity Status
3.3.2.2.2.1	Receive Enemy Status
3.3.2.2.2.2	Receive Friendly Status
3.3.2.2.2.3	Receive Non-Combatant Status
3.3.2.2.2.4	Receive Unknown Status
3.3.2.2.3	Receive Other Vehicle Status
3.3.2.2.4	Receive Environmental Conditions Status
4	Navigation Management
4.1	Own Vehicle Navigation
4.1.1	Route Management
4.1.1.1	Perform Route Reconnaissance
4.1.1.2	Determine Route
4.1.1.3	Plot Route
4.1.1.4	Edit Route
4.1.2	Route Execution Monitoring
4.1.2.1	Monitor Route Plan
4.1.2.2	Monitor Route Obstacles
4.1.2.3	Monitor Route Time
4.1.3	Vehicle Maneuvering
4.1.3.1	Adjust Vehicle Heading
4.1.3.2	Adjust Vehicle Speed
4.2	Other Vehicle Navigation
4.2.1	Route Management
4.2.1.1	Perform Route Reconnaissance
4.2.1.2	Determine Route
4.2.1.3	Plot Route
4.2.1.4	Edit Route

4.2.2	Route Execution Monitoring
4.2.2.1	Monitor Route Plan
4.2.2.2	Monitor Route Obstacles
4.2.2.3	Monitor Route Time
4.2.3	Other Vehicle Maneuvering
4.2.3.1	Adjust Other Vehicle Orientation
4.2.3.2	Adjust Other Vehicle Position
4.2.3.3	Adjust Other Vehicle Speed
5	Vehicle Maintainability Management
5.1	Preventative Maintenance Management
5.2	Corrective Maintenance Managament
5.2.1	System Status Monitoring
5.2.1.1	Own Vehicle Status Monitoring
5.2.1.1.1	Communications Status Monitoring
5.2.1.1.1.1	Radio Status Monitoring
5.2.1.1.1.2	Data Network Status Monitoring
5.2.1.1.2	External Sensors Status Monitoring
5.2.1.1.2.1	Local Situational Awareness System Monitoring
5.2.1.1.2.2	DAS Sensor Status Monitoring
5.2.1.1.2.3	Heat/IR Sensor Status Monitoring
5.2.1.1.2.4	II Sensor Status Monitoring
5.2.1.1.2.5	Radar Sensor Status Monitoring
5.2.1.1.2.6	GPS Sensor Status Monitoring
5.2.1.1.2.7	Combat ID Sensor Status Monitoring
5.2.1.1.3	Internal Sensors Status Monitoring
5.2.1.1.3.1	Automatic Fire Extinguisher System Sensor Status Monitoring
5.2.1.1.3.2	Health / Status Sensors Status Monitoring
5.2.1.1.3.3	Inertial Navigation System Sensor Status Monitoring
5.2.1.1.4	Weapons Status Monitoring

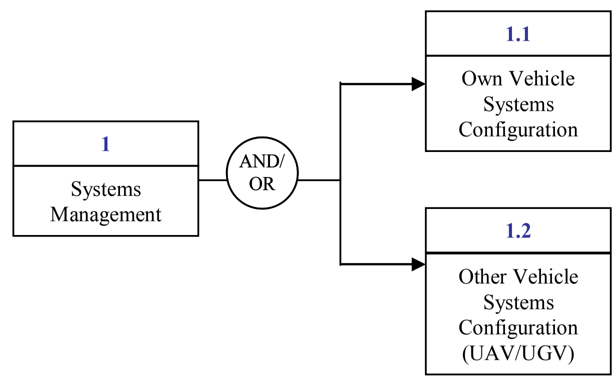
5.2.1.1.4.1	DAS Weapons Status Monitoring
5.2.1.1.4.2	Offensive Weapons Status Monitoring
5.2.1.1.5	Internal Sub-Systems Status Monitoring
5.2.1.1.5.1	Environmental System Status Monitoring
5.2.1.1.5.2	Displays Status Monitoring
5.2.1.1.5.3	Vehicle Propulsion Status Monitoring
5.2.1.1.5.4	Active Suspension Status Monitoring
5.2.1.1.5.5	NBCD Status Monitoring
5.2.1.1.5.6	Fire Control System Status Monitoring
5.2.1.1.5.7	Power System Status Monitoring
5.2.1.1.5.8	Electrical System Status Monitoring
5.2.1.1.5.9	Battle Management System (BMS) Status Monitoring
5.2.1.1.5.10	Armour System Status Monitoring
5.2.1.1.5.11	Turret Status Monitoring
5.2.1.1.5.12	Fuel Status Monitoring
5.2.1.1.5.13	Brake System Status Monitoring
5.2.1.2	Other Vehicle Status Monitoring
5.2.1.2.1	Communications Status Monitoring
5.2.1.2.2	External Sensors Status Monitoring
5.2.1.2.3	Internal Sensors Status Monitoring
5.2.1.2.4	Weapons Status Monitoring
5.2.1.2.5	Internal Sub-Systems Status Monitoring
5.2.2	Vehicle Fault Management
5.2.2.1	Fault Detection
5.2.2.2	Fault Identification
5.2.2.3	Fault Diagnostic/Classification
5.2.2.4	Fault Prioritization
5.2.2.5	Fault Assignment
5.2.2.6	Fault Repair

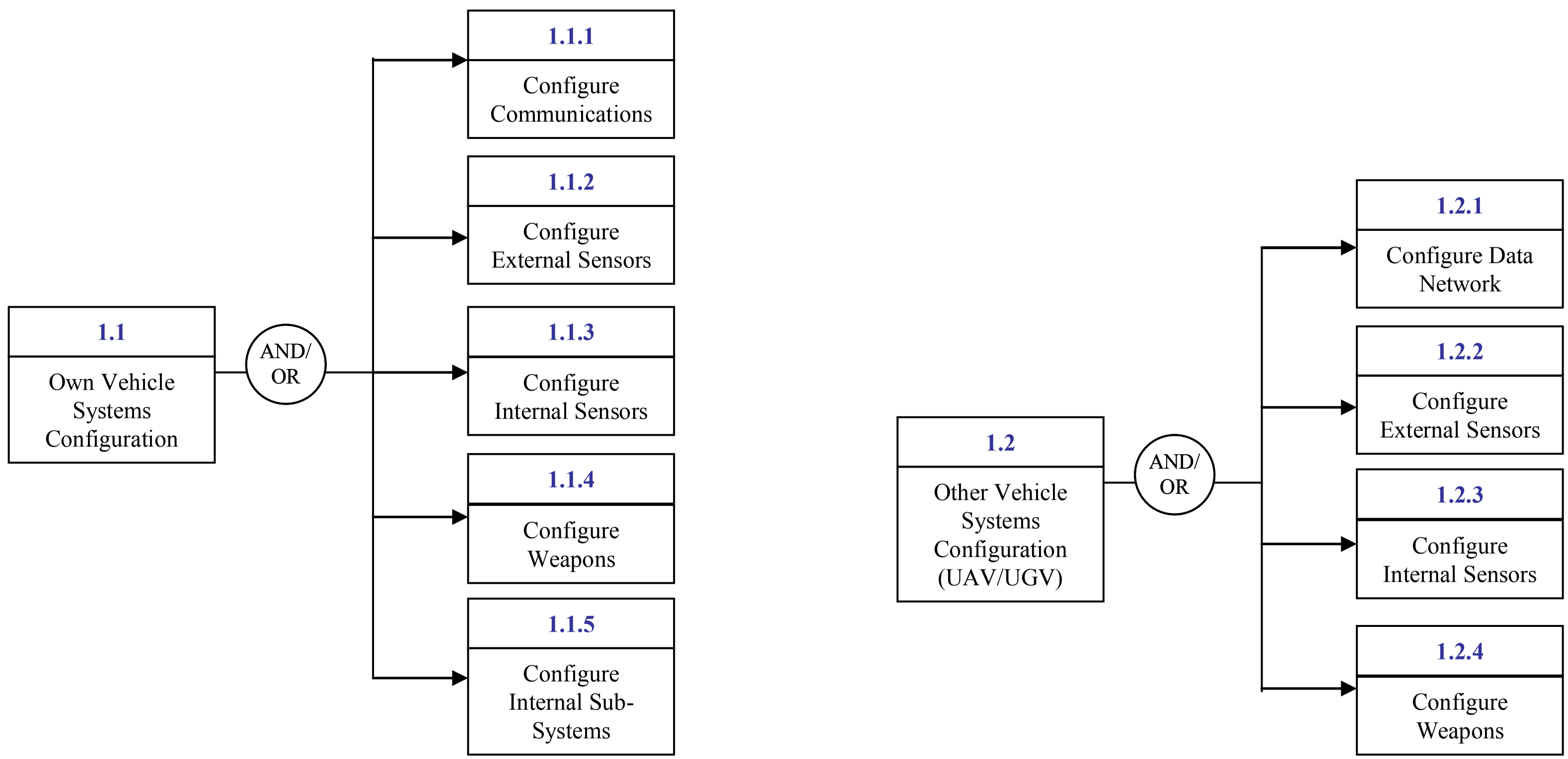
ADVANCE Highest-Level Function Flow



1 Systems Management

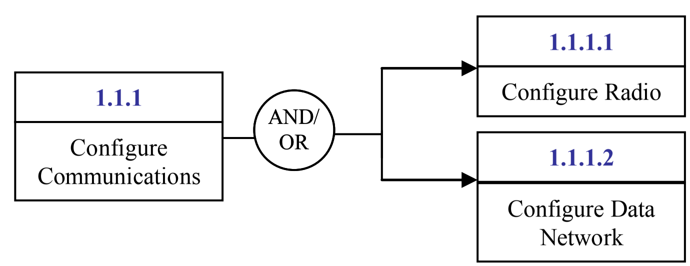
1.1 Own Vehicle Systems Configuration & 1.2 Other Vehicle Systems Configuration

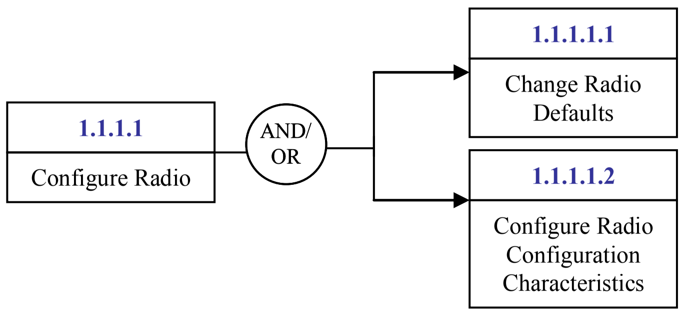


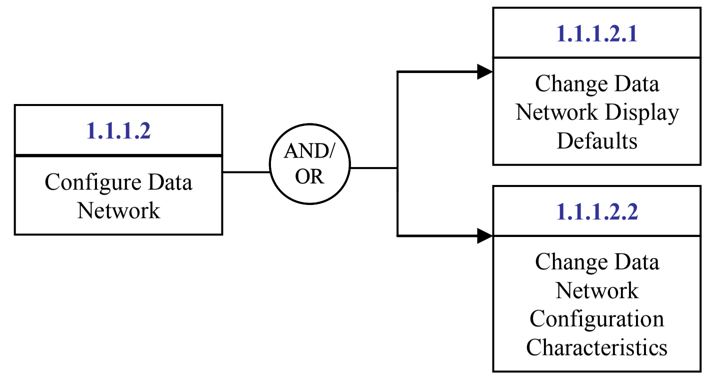


1 Systems Management

1.1 Own Vehicle Systems Configuration; 1.1.1 Configure Communications

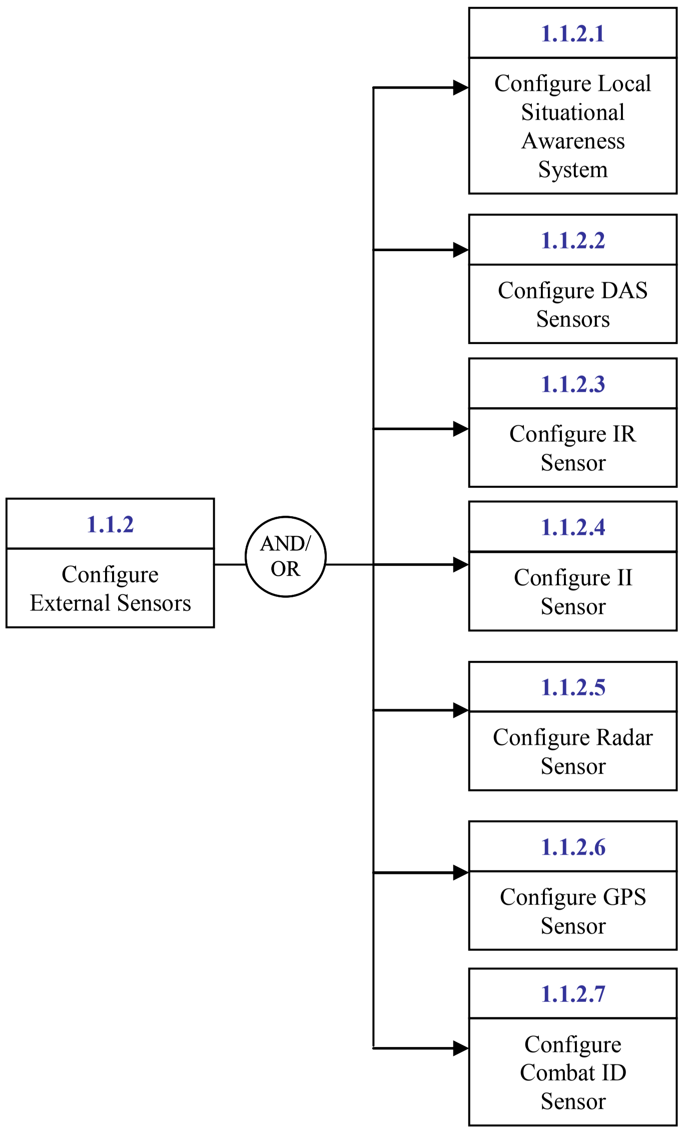


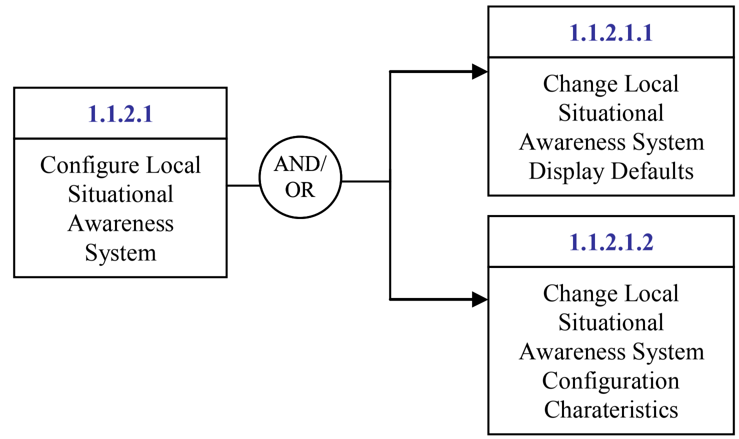

1.1.1.1
Configure Radio
AND/
OR
1.1.1.1.1
Change Radio Defaults
1.1.1.1.2
Configure Radio Configuration Characteristics

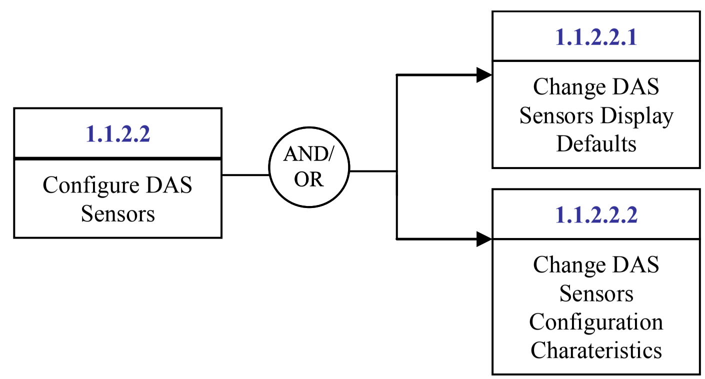

1.1.1.2
Configure Data Network
AND/
OR
1.1.1.2.1
Change Data Network Display Defaults
1.1.1.2.2
Change Data Network Configuration Characteristics

1 Systems Management

1.1 Own Vehicle Systems Configuration; 1.1.2 Configure External Sensors

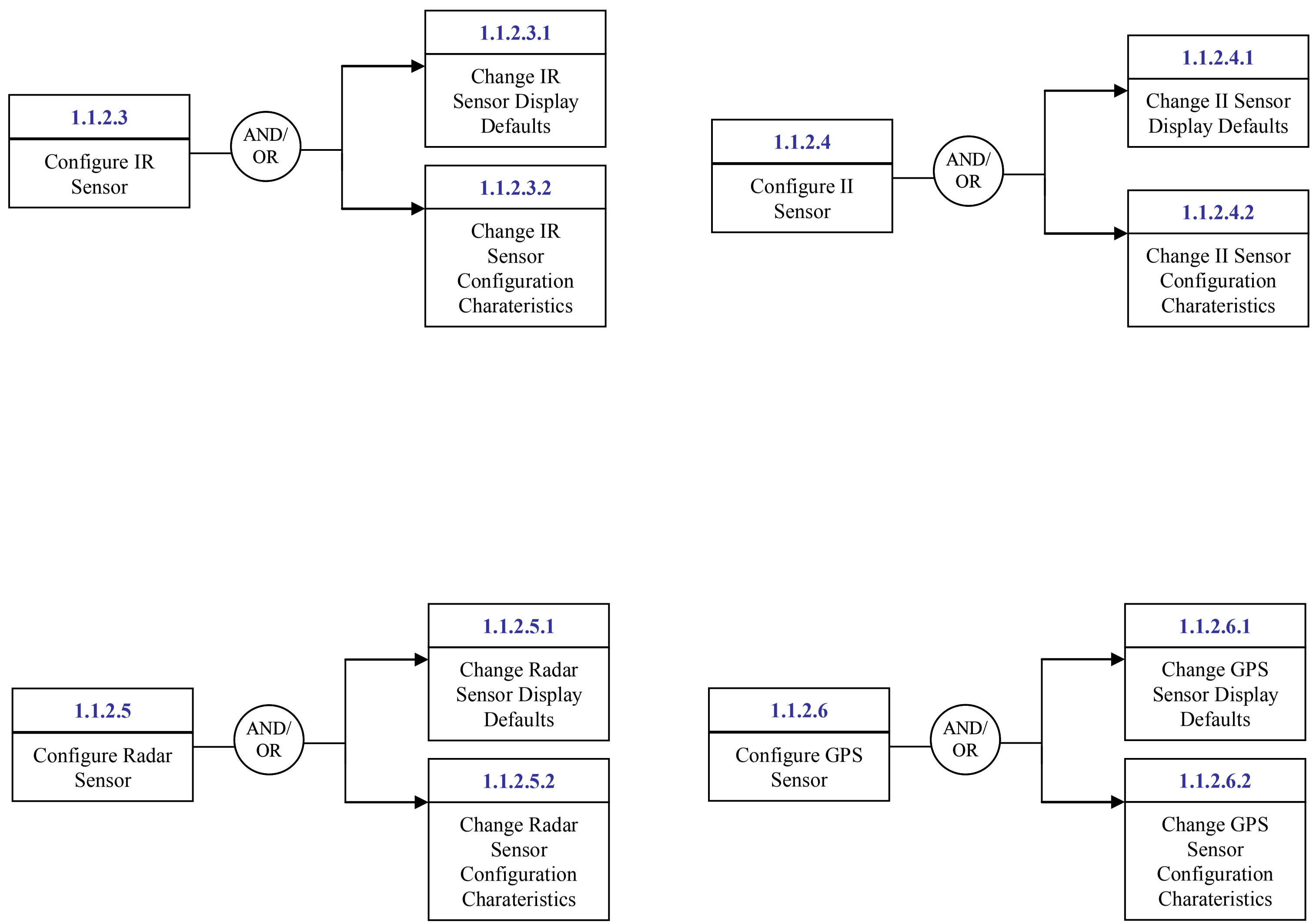






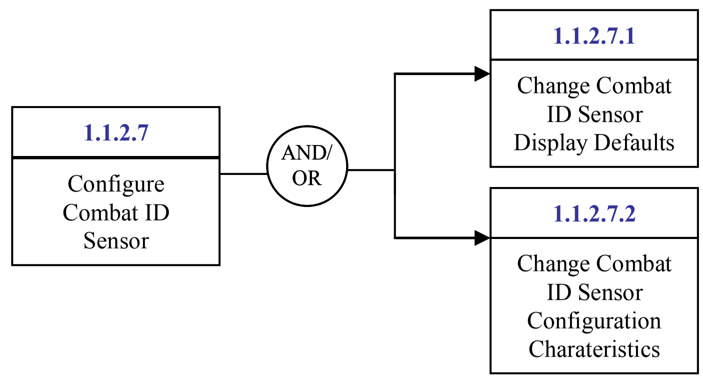
1 Systems Management

1.1 Own Vehicle Systems Configuration; 1.1.2 Configure External Sensors (Continued)



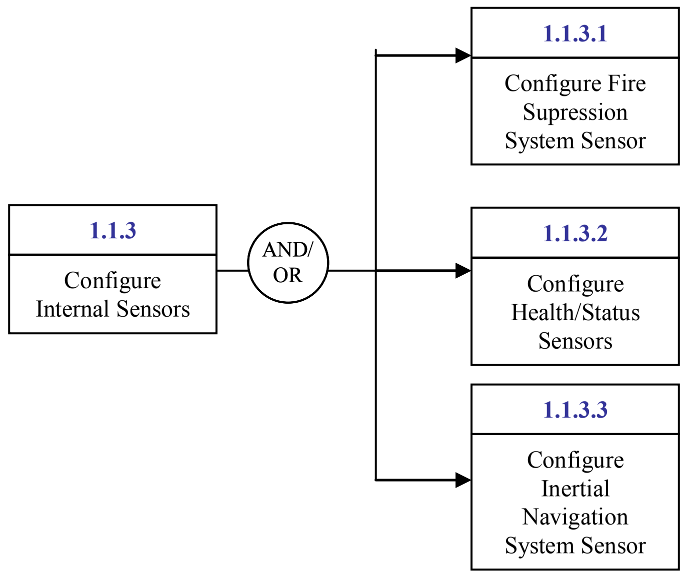
1 Systems Management

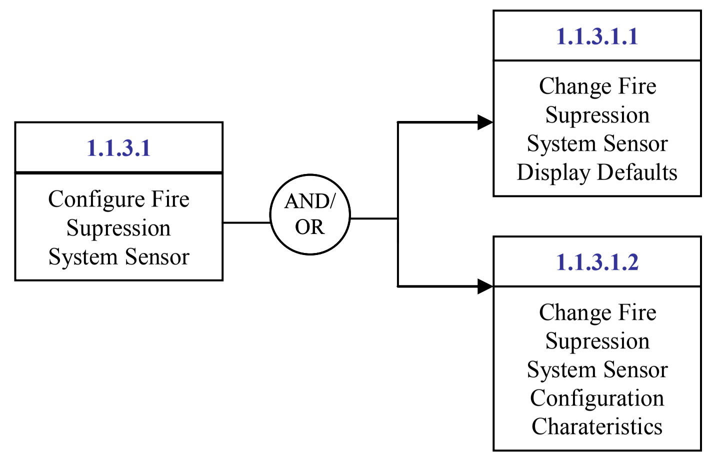
1.1 Own Vehicle Systems Configuration; 1.1.2 Configure External Sensors (Continued)

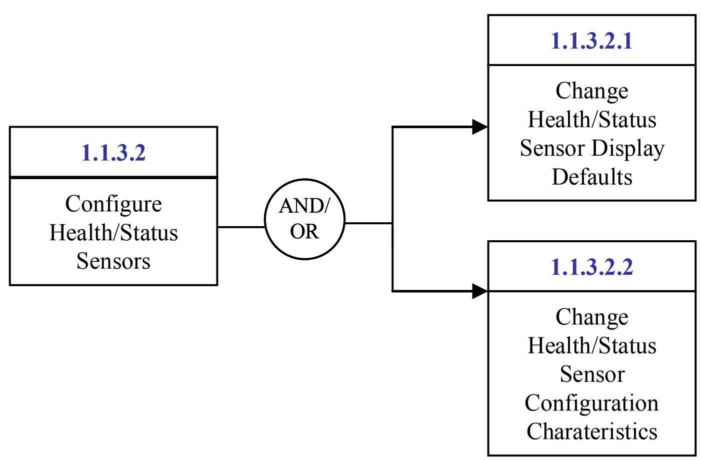


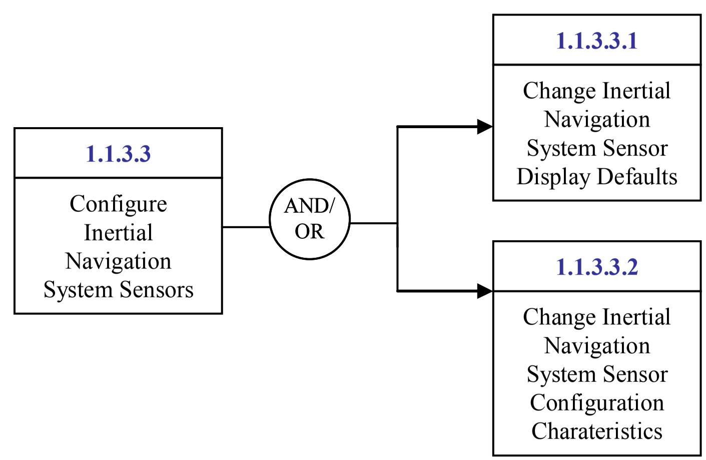
1 Systems Management

1.1 Own Vehicle Systems Configuration; 1.1.3 Configure Internal Sensors



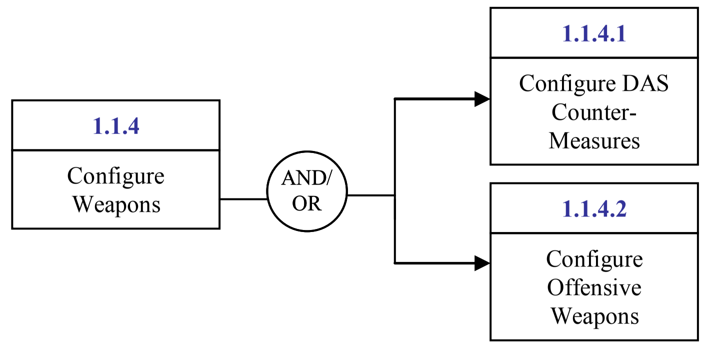


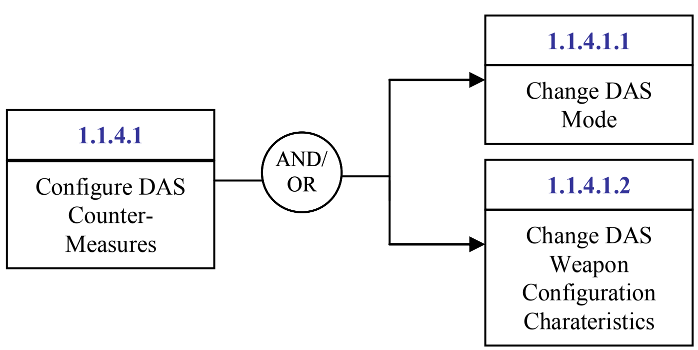


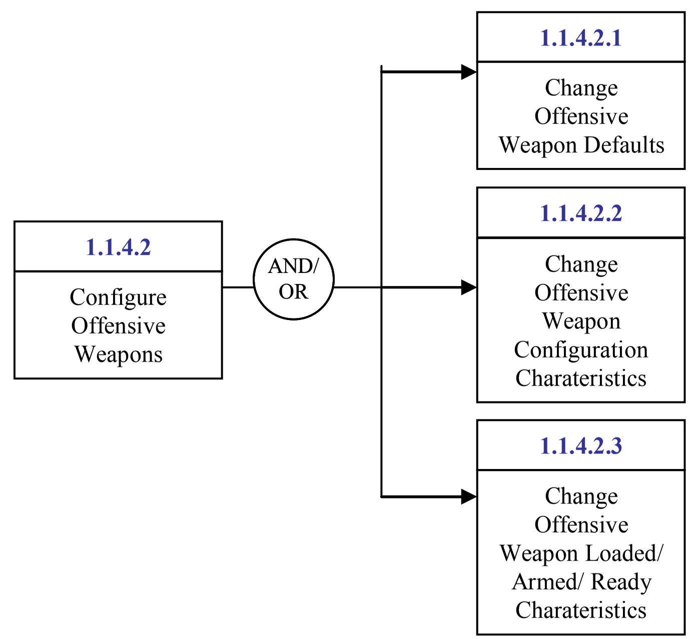


1 Systems Management

1.1 Own Vehicle Systems Configuration; 1.1.4 Configure Weapons

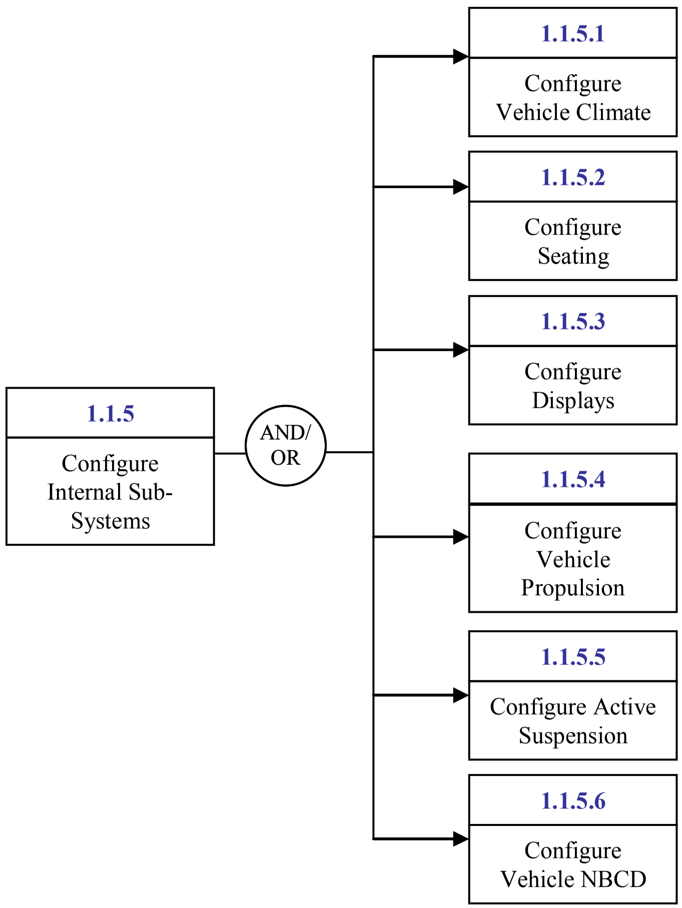


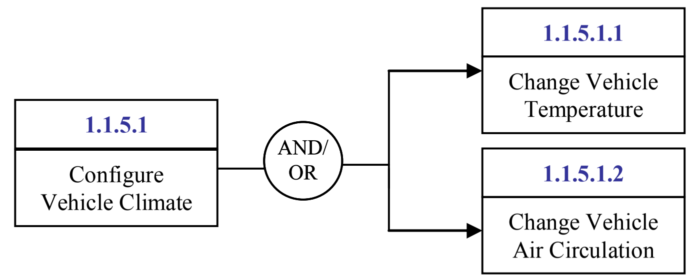


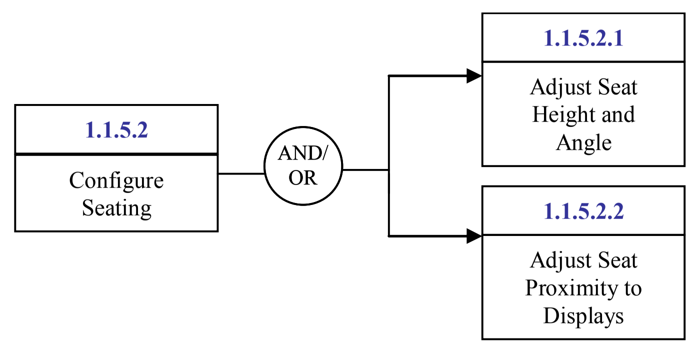


1 Systems Management

1.1 Own Vehicle Systems Configuration; 1.1.5 Configure Internal Sub-Systems

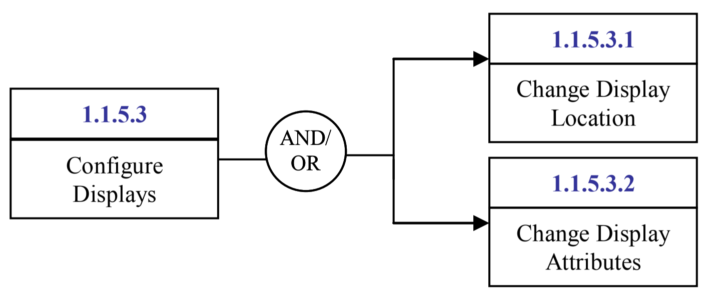


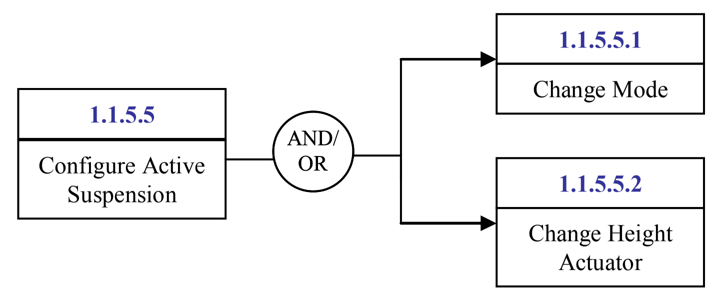




1 Systems Management

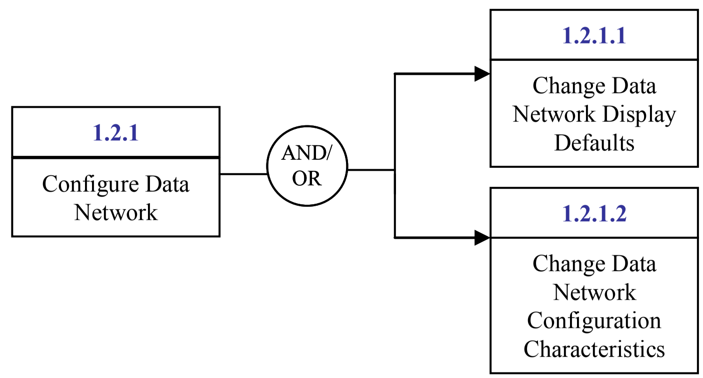
1.1 Own Vehicle Systems Configuration; 1.1.5 Configure Internal Sub-Systems (Continued)





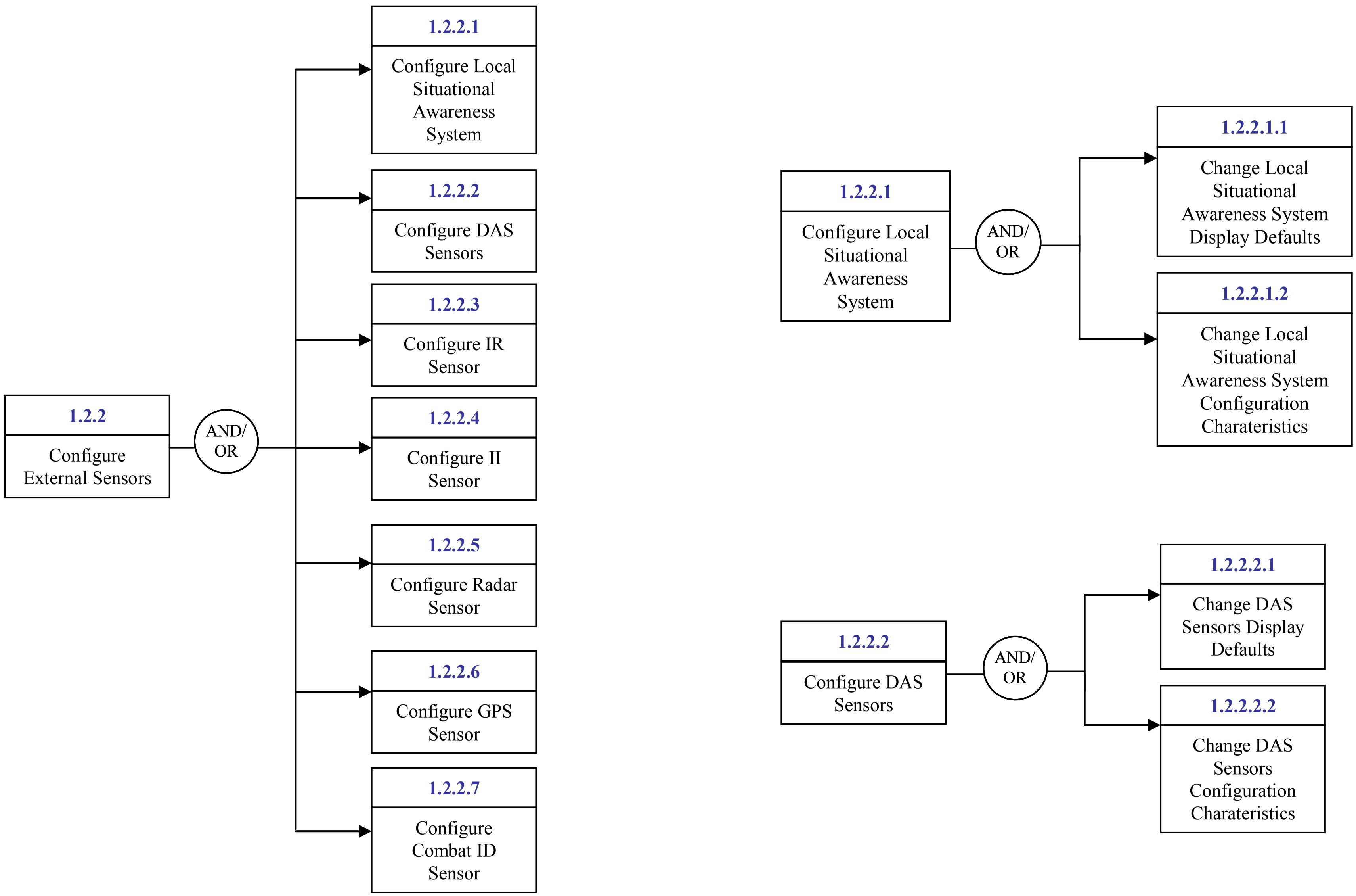
1 Systems Management

1.2 Other Vehicle Systems Configuration; 1.2.1 Configure Data Network



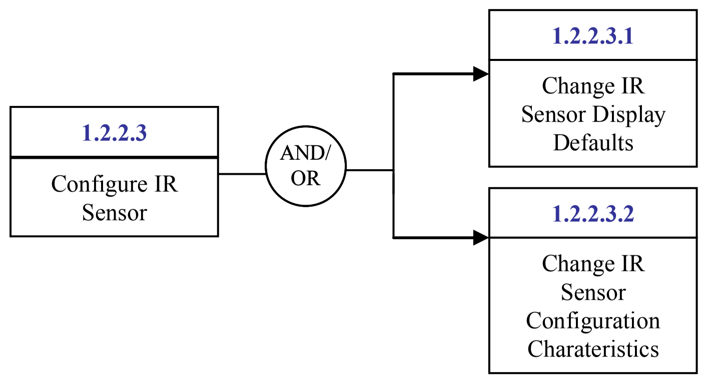
1 Systems Management

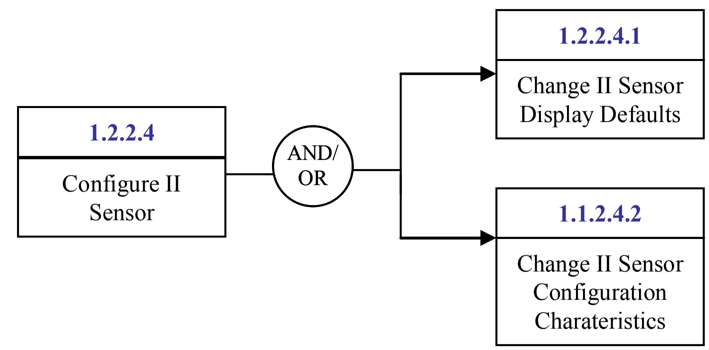
1.2 Other Vehicle Systems Configuration; 1.2.2 Configure External Sensors

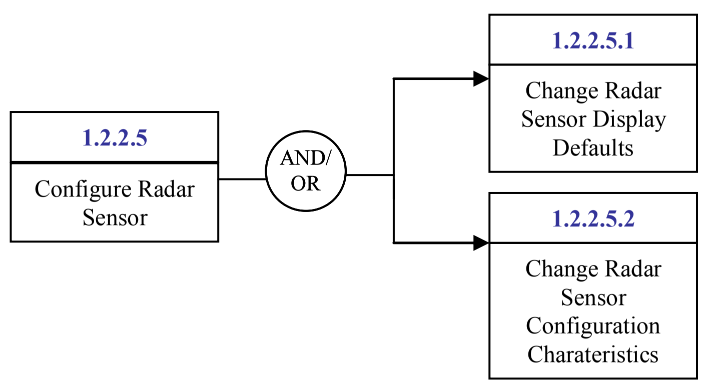


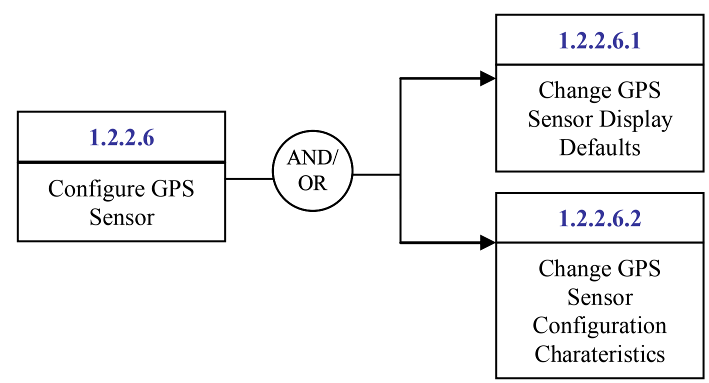
1 Systems Management

1.2 Other Vehicle Systems Configuration; 1.2.2 Configure External Sensors (Continued)



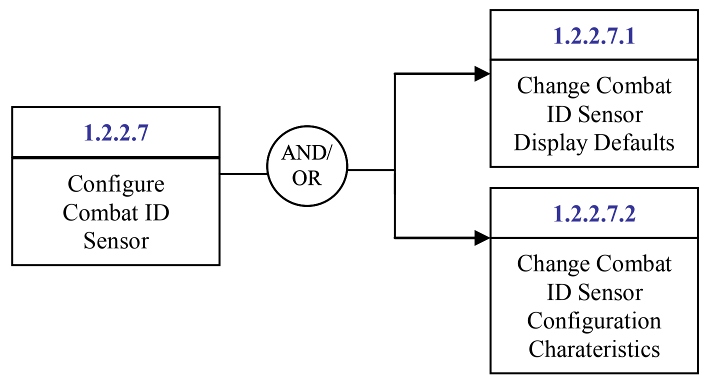






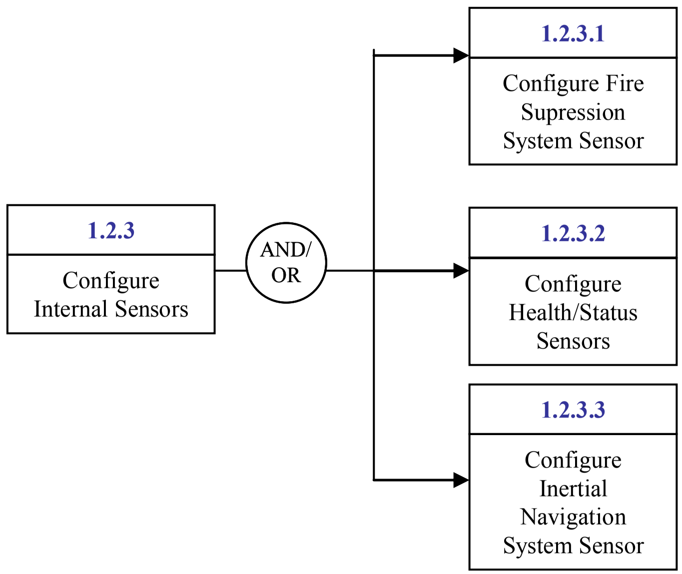
1 Systems Management

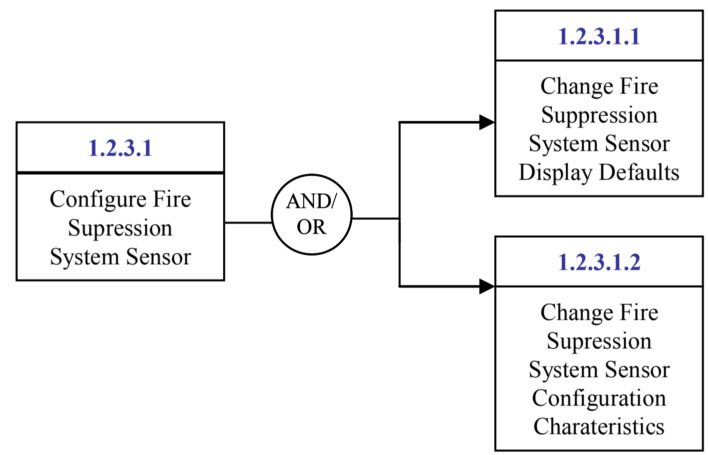
1.2 Other Vehicle Systems Configuration; 1.2.2 Configure External Sensors (Continued)

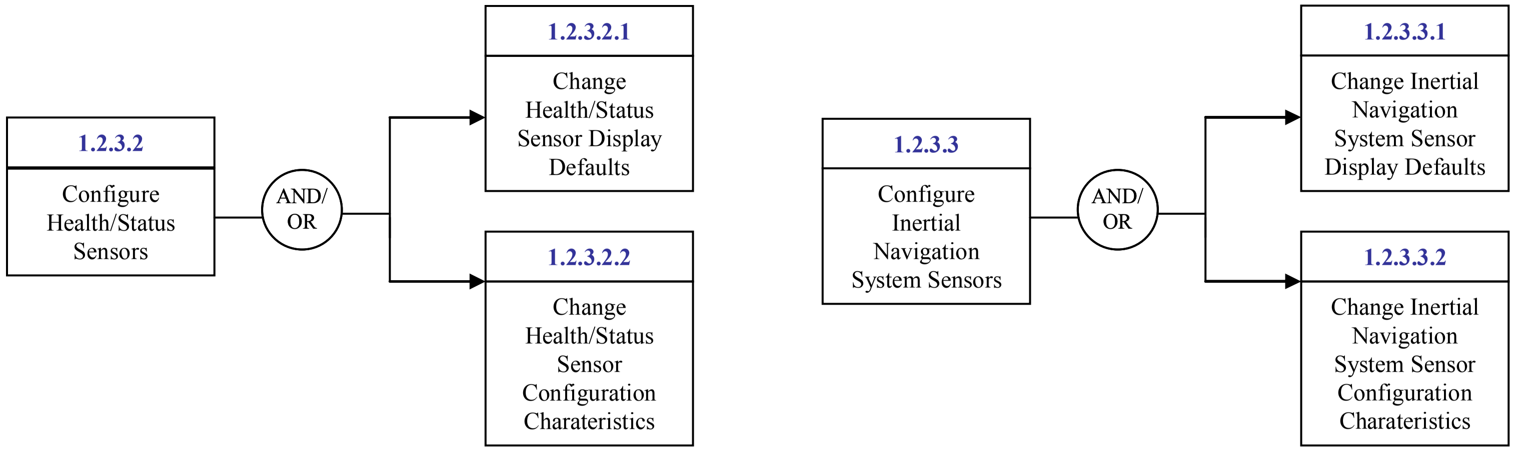


1 Systems Management

1.2 Other Vehicle Systems Configuration; 1.2.3 Configure Internal Sensors

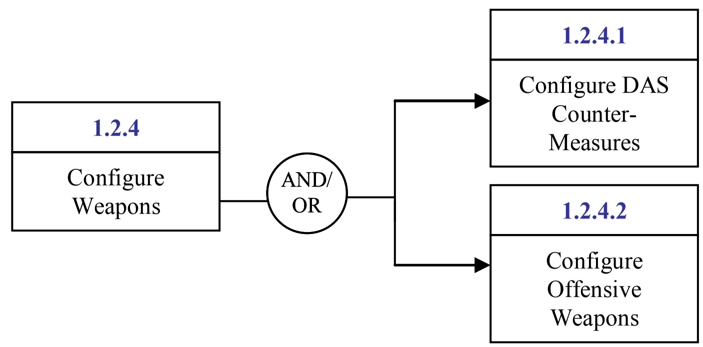


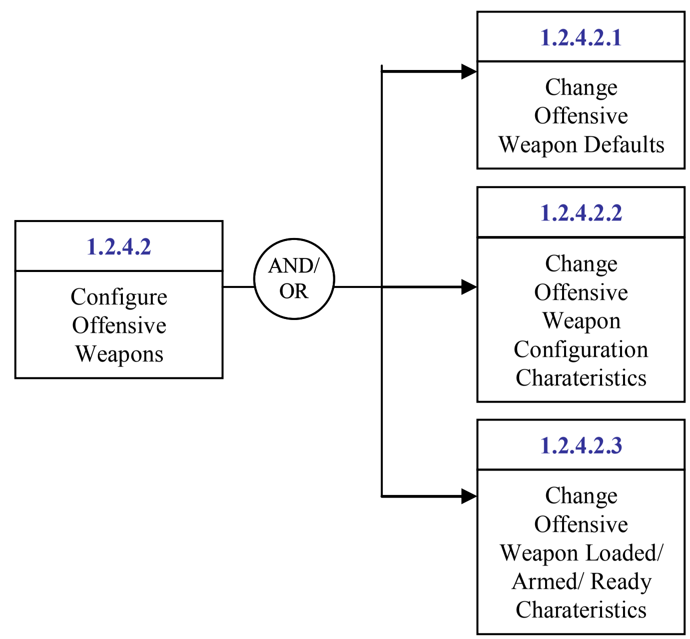


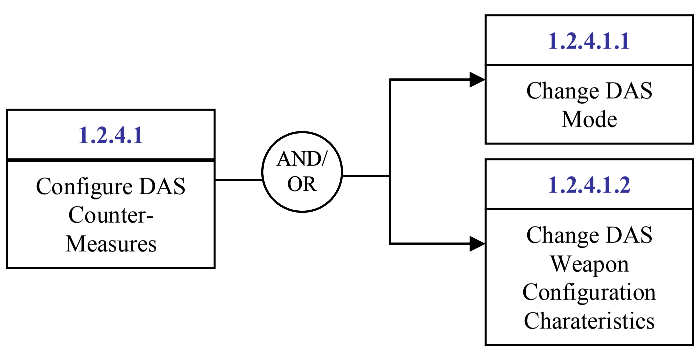

1.2.3.2
Configure Health/Status Sensors
AND/ OR
1.2.3.2.1
Change Health/Status Sensor Display Defaults
1.2.3.2.2
Change Health/Status Sensor Configuration Charateristics
1.2.3.3
Configure Inertial Navigation System Sensors
AND/ OR
1.2.3.3.1
Change Inertial Navigation System Sensor Display Defaults
1.2.3.3.2
Change Inertial Navigation System Sensor Configuration Charateristics

1 Systems Management

1.2 Other Vehicle Systems Configuration; 1.2.4 Configure Internal Sensors



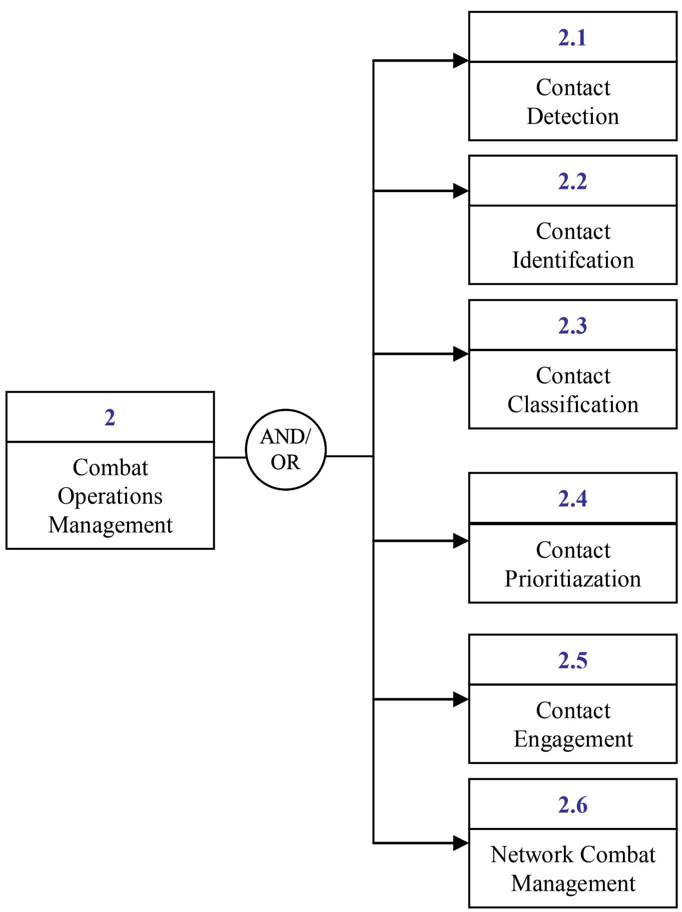


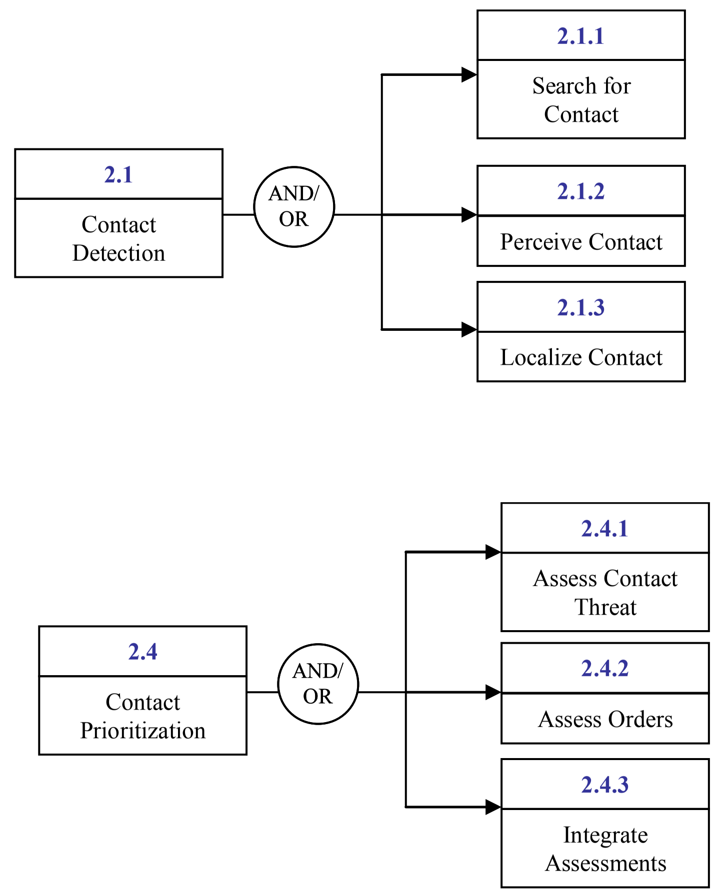


2 Combat Operations Management

2.1 Contact Detection; 2.2 Contact Identification; 2.3 Contact Classification; 2.4 Contact Prioritization;

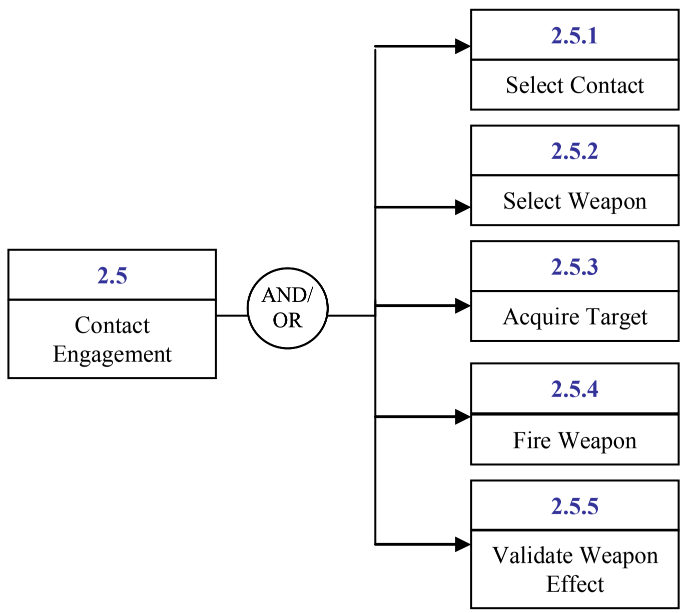
2.5 Contact Engagement; 2.6 Network Combat Management

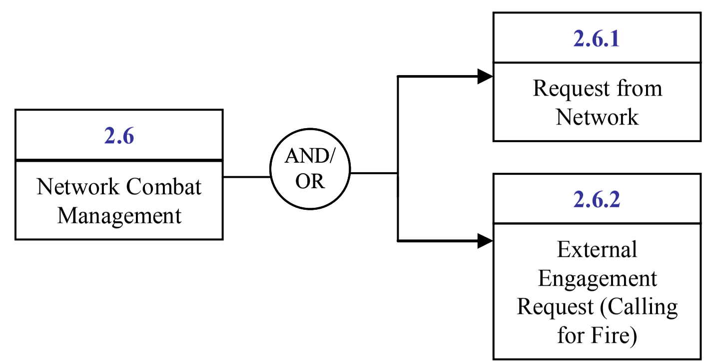




2 Combat Operations Management

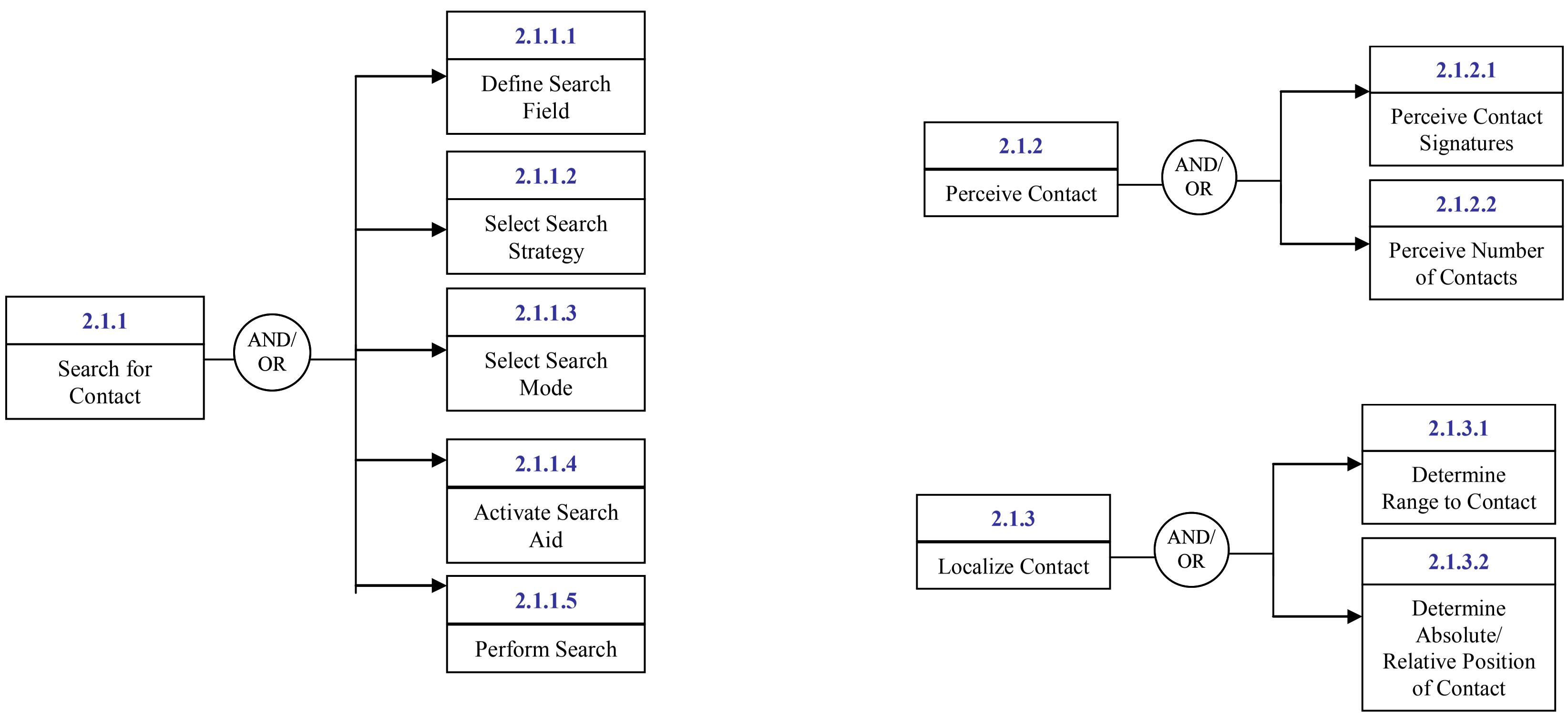
2.1 Contact Detection; 2.2 Contact Identification; 2.3 Contact Classification; 2.4 Contact Prioritization; 2.5 Contact Engagement; 2.6 Network Combat Management (Continued)





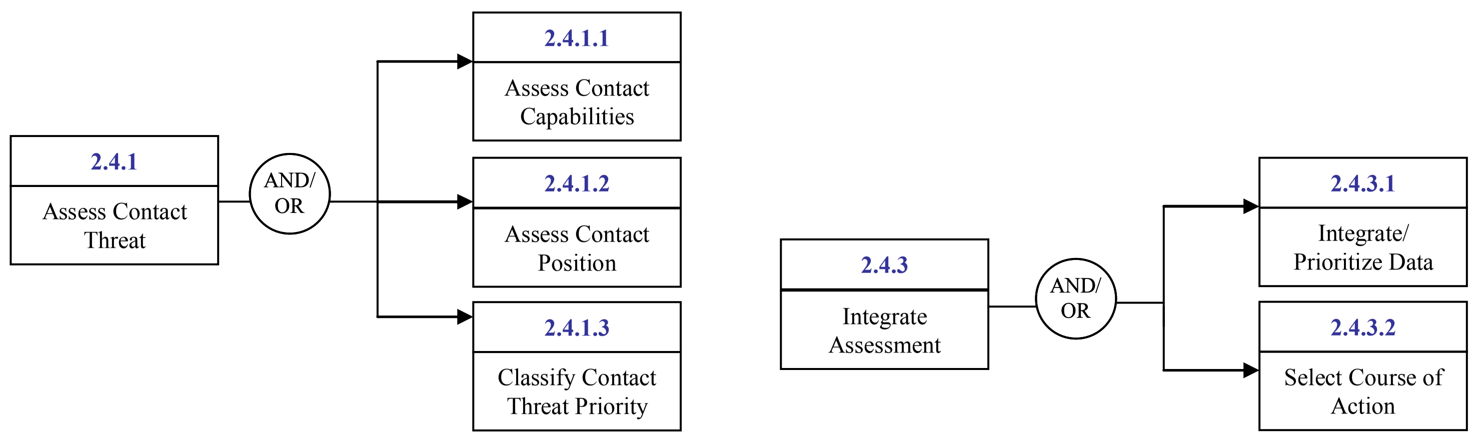
2 Combat Operations Management

2.1 Contact Detection; 2.1.1 Search for Contact; 2.1.2 Perceive Contact; 2.1.3 Localize Contact



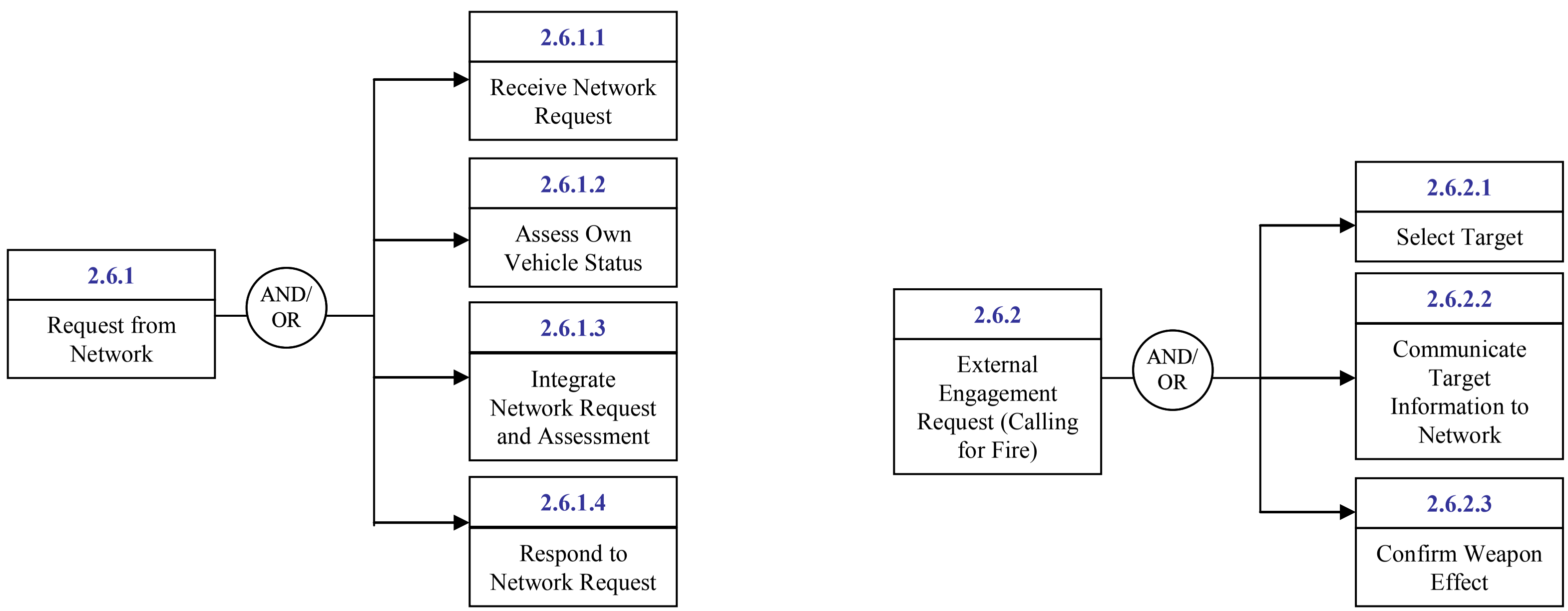
2 Combat Operations Management

2.4 Contact Prioritization; 2.4.1 Assess Contact Threat; 2.4.3 Integrate Assessment



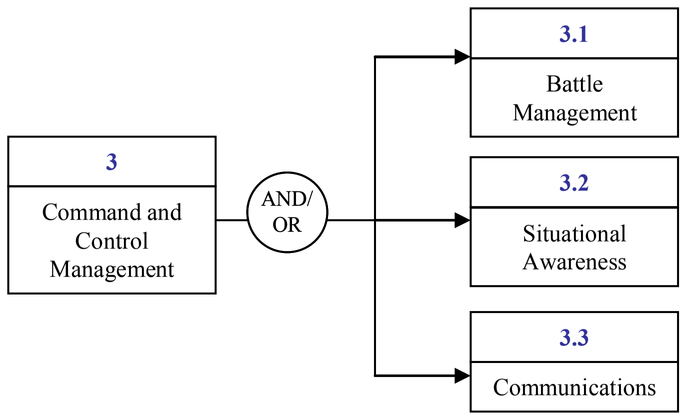
2 Combat Operations Management

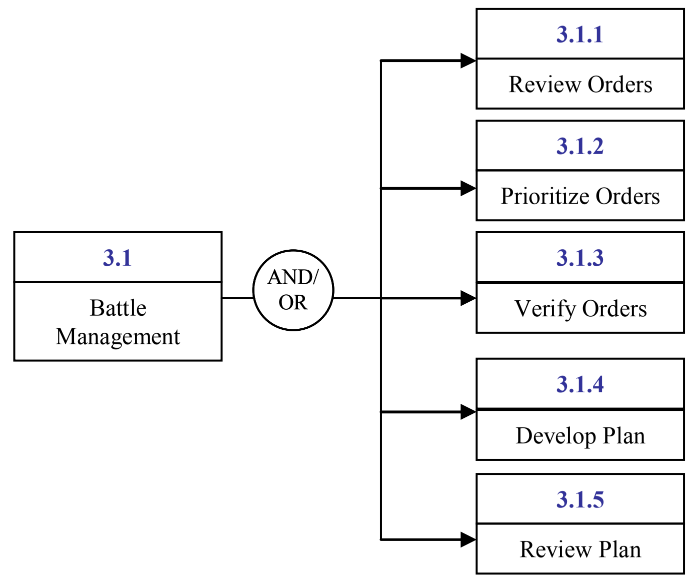
2.6 Network Combat Management; 2.6.1 Request from Network; 2.6.2 External Engagement Request (Calling for Fire)

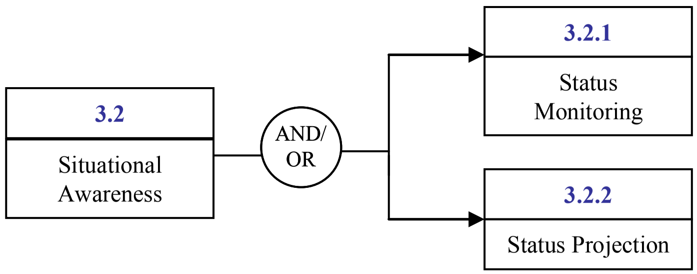


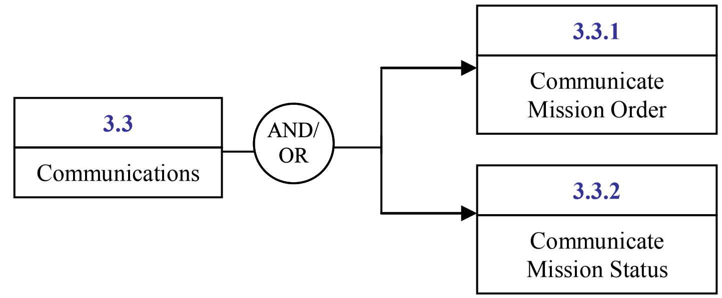
3 Command and Control Management

3.1 Battle Management; 3.2 Situational Awareness; 3.3 Communications



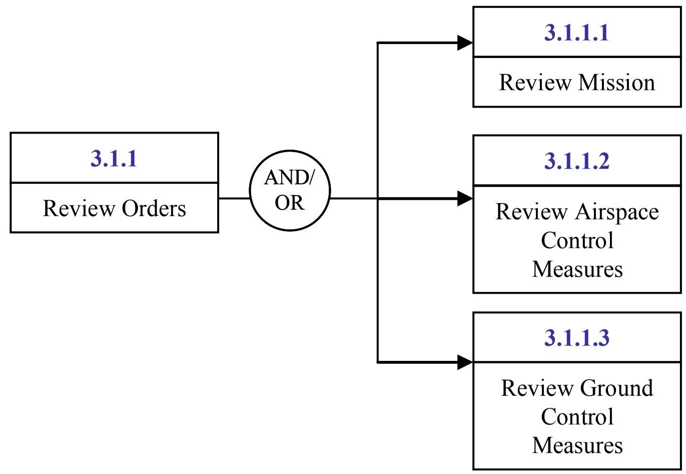



3.2
Situational Awareness
AND/ OR
3.2.1
Status Monitoring
3.2.2
Status Projection


3.3
Communications
AND/ OR
3.3.1
Communicate Mission Order
3.3.2
Communicate Mission Status

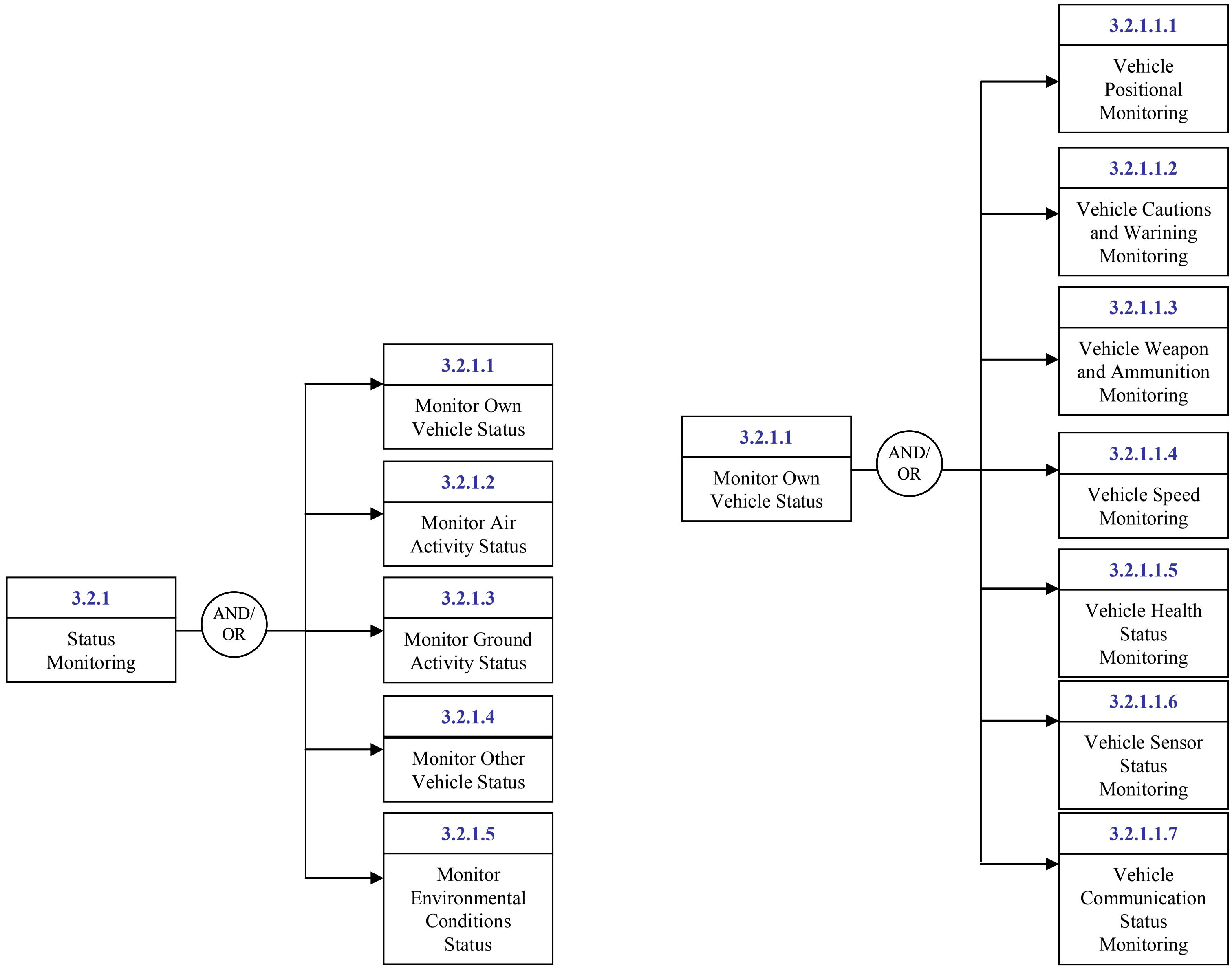
3 Command and Control Management

3.1 Battle Management; 3.1.1 Review Orders



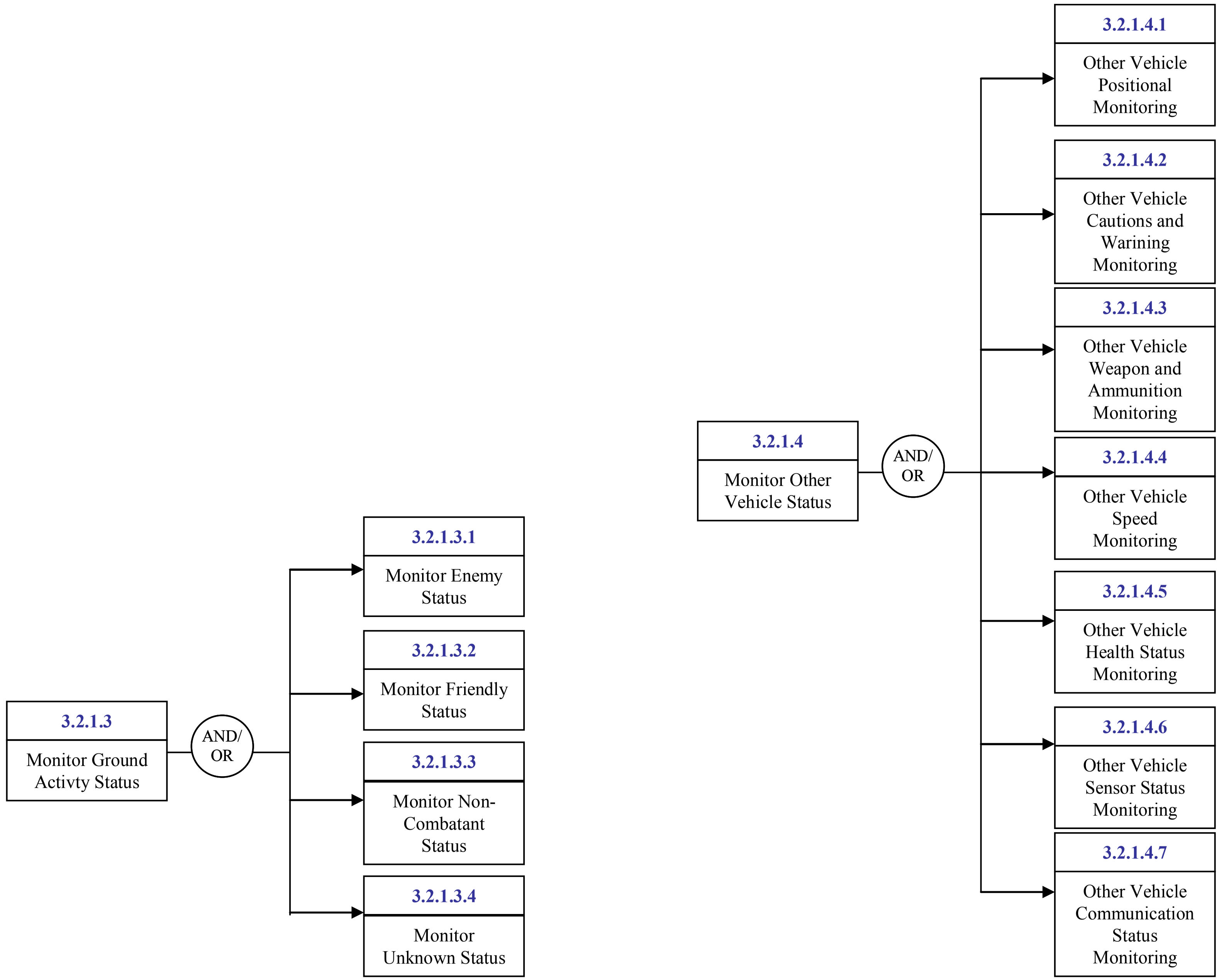
3 Command and Control Management

3.2 Situational Awareness; 3.2.1 Status Monitoring



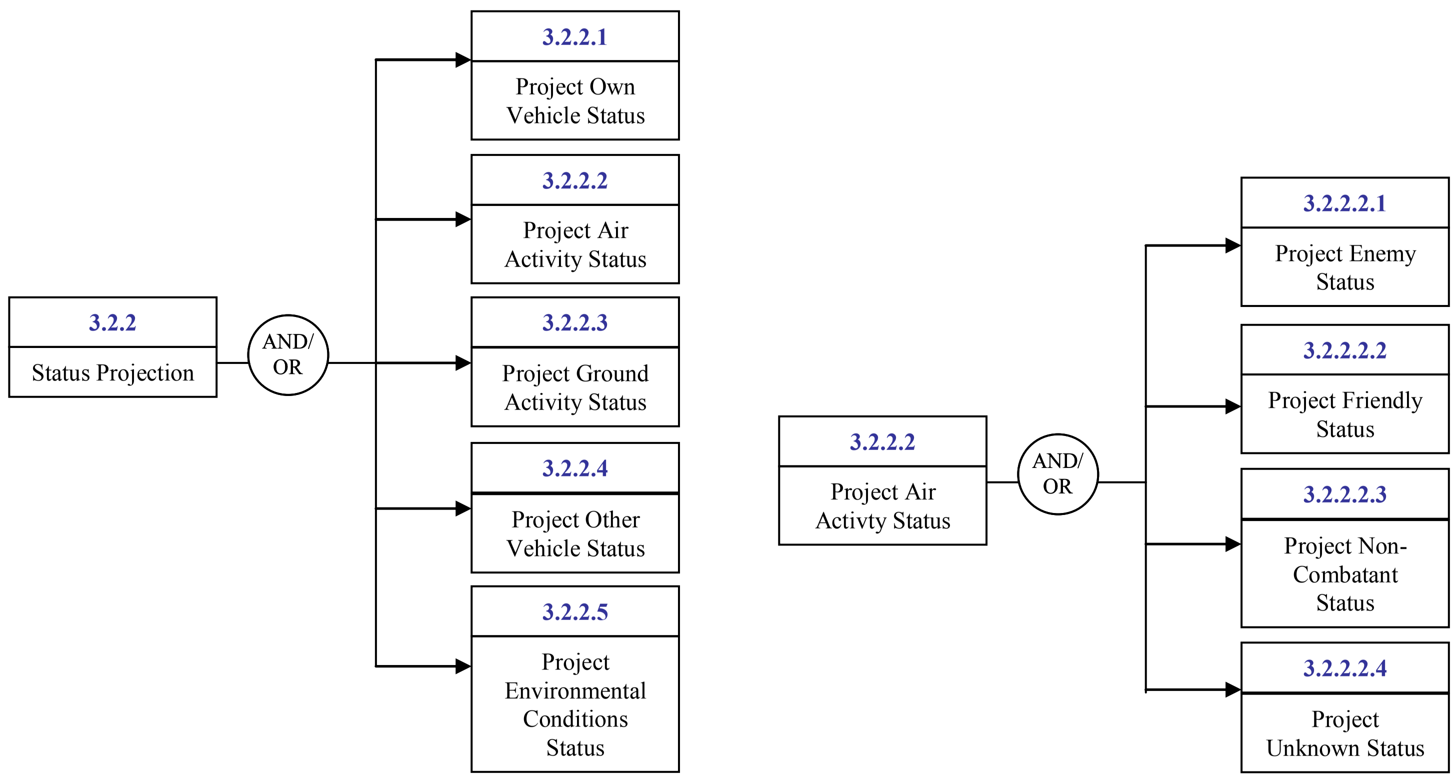
3 Command and Control Management

3.2 Situational Awareness; 3.2.1 Status Monitoring (Continued)



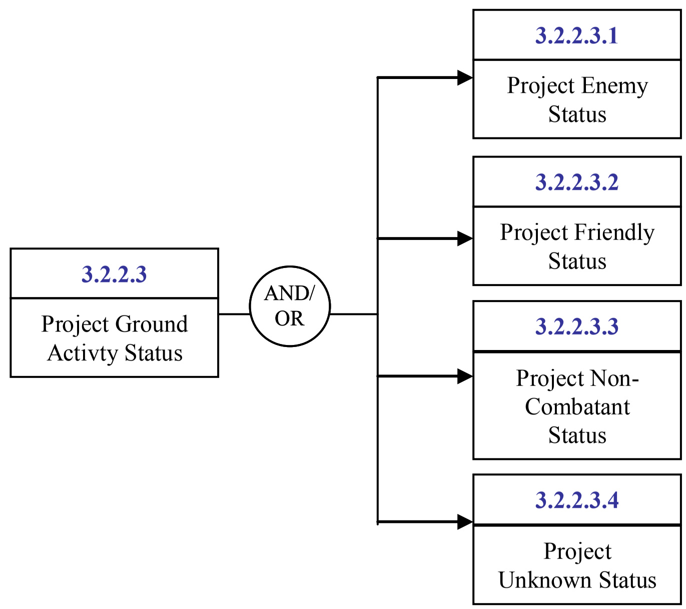
3 Command and Control Management

3.2 Situational Awareness; 3.2.2 Status Projection



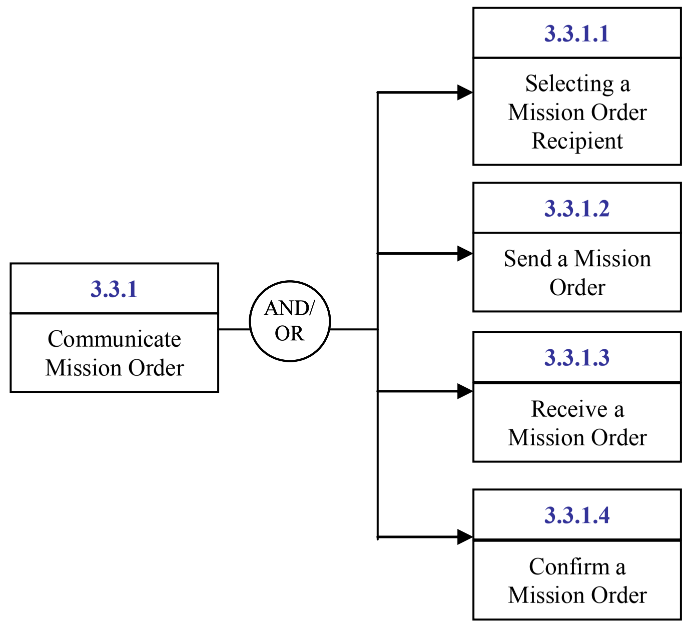
3 Command and Control Management

3.2 Situational Awareness; 3.2.2 Status Projection



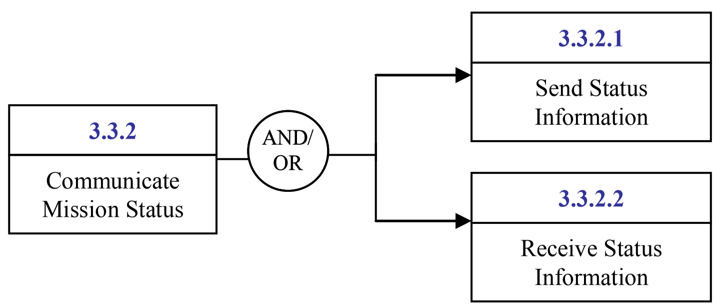
3 Command and Control Management

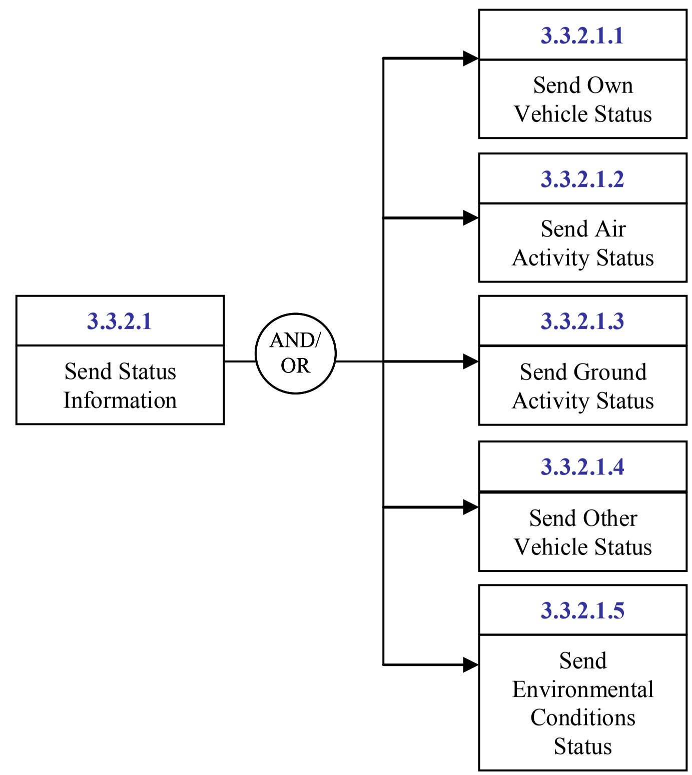
3.3 Communications; 3.3.1 Communicate Mission Order



3 Command and Control Management

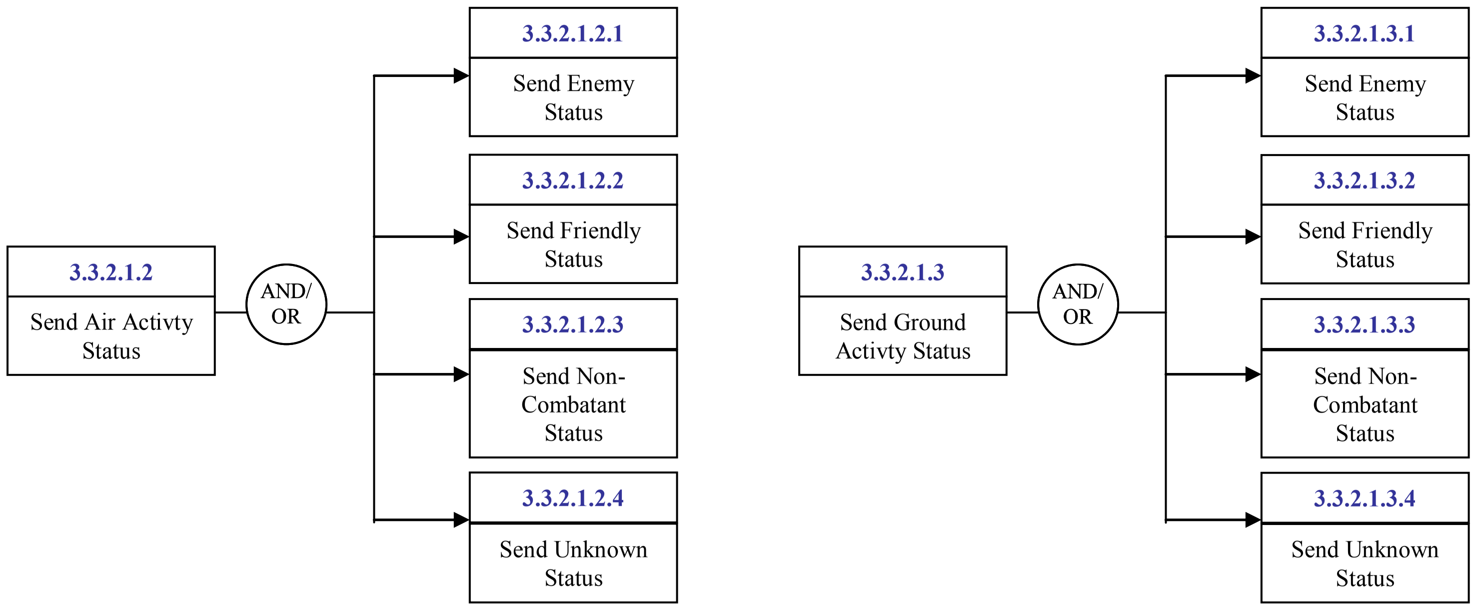
3.3 Communications; 3.3.2 Communicate Mission Status





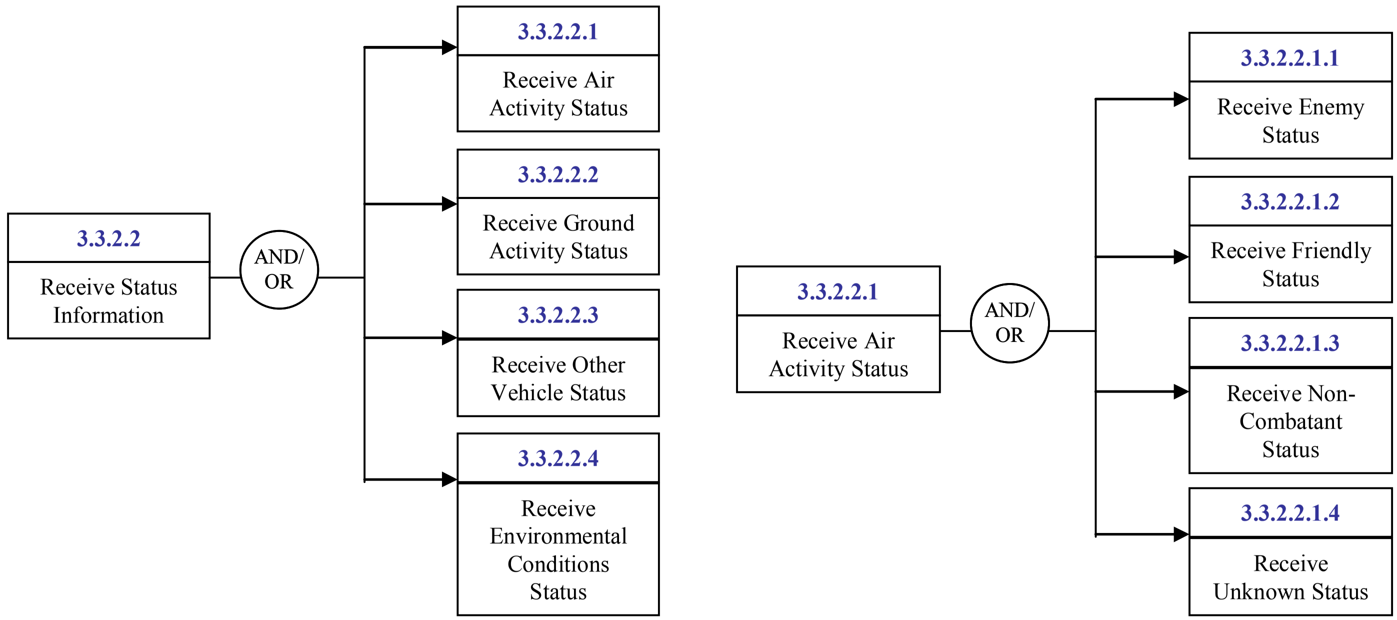
3 Command and Control Management

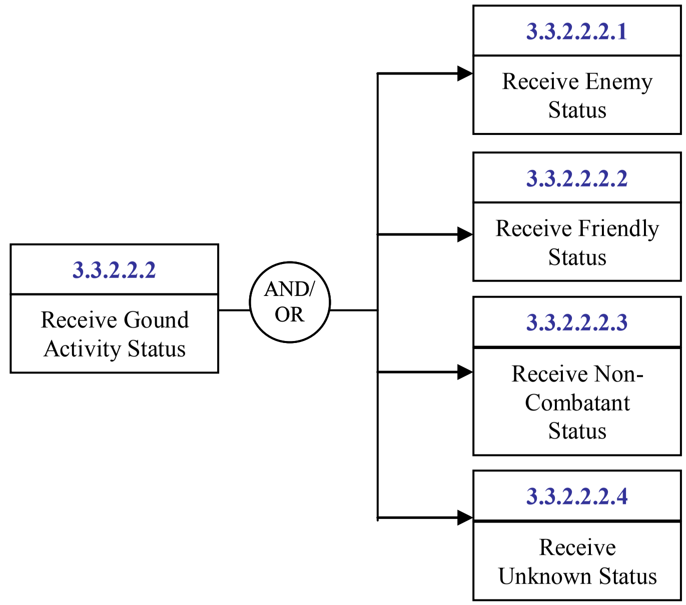
3.3 Communications; 3.3.2 Communicate Mission Status (Continued)



3 Command and Control Management

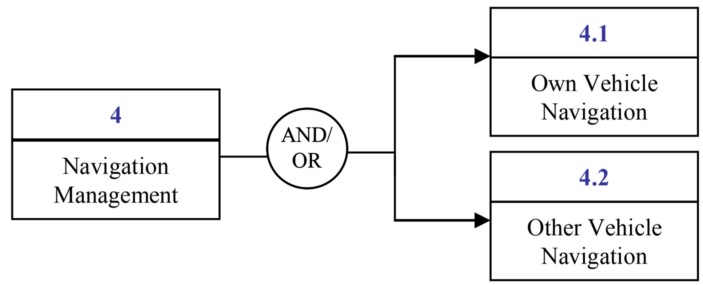
3.3 Communications; 3.3.2 Communicate Mission Status (Continued)

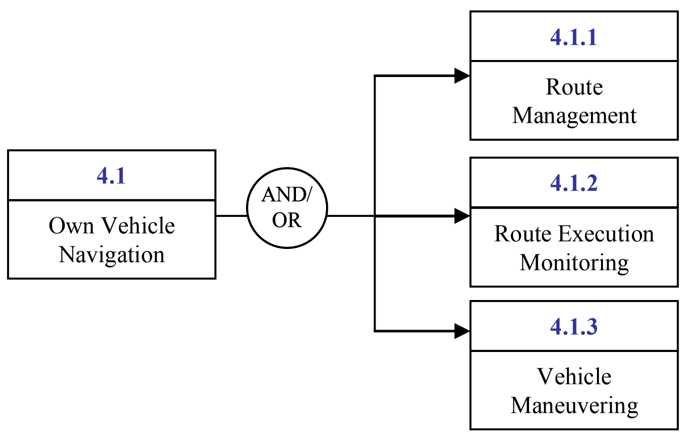


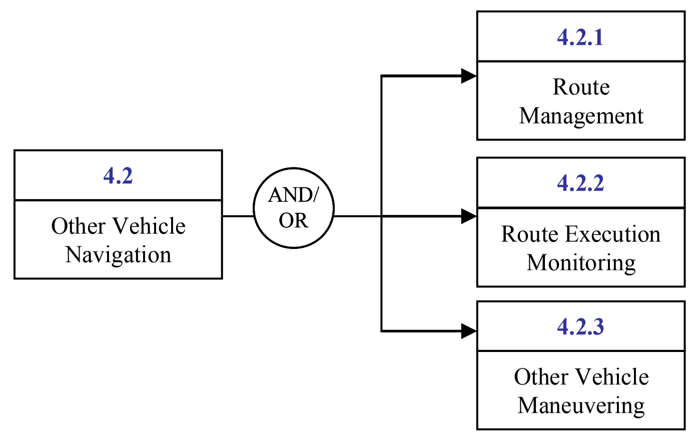

3.3.2.2.2
Receive Gound Activity Status
AND/ OR
3.3.2.2.2.1
Receive Enemy Status
3.3.2.2.2.2
Receive Friendly Status
3.3.2.2.2.3
Receive Non-Combatant Status
3.3.2.2.2.4
Receive Unknown Status

4 Navigation Management

4.1 Own Vehicle Navigation; 4.2 Other Vehicle Navigation

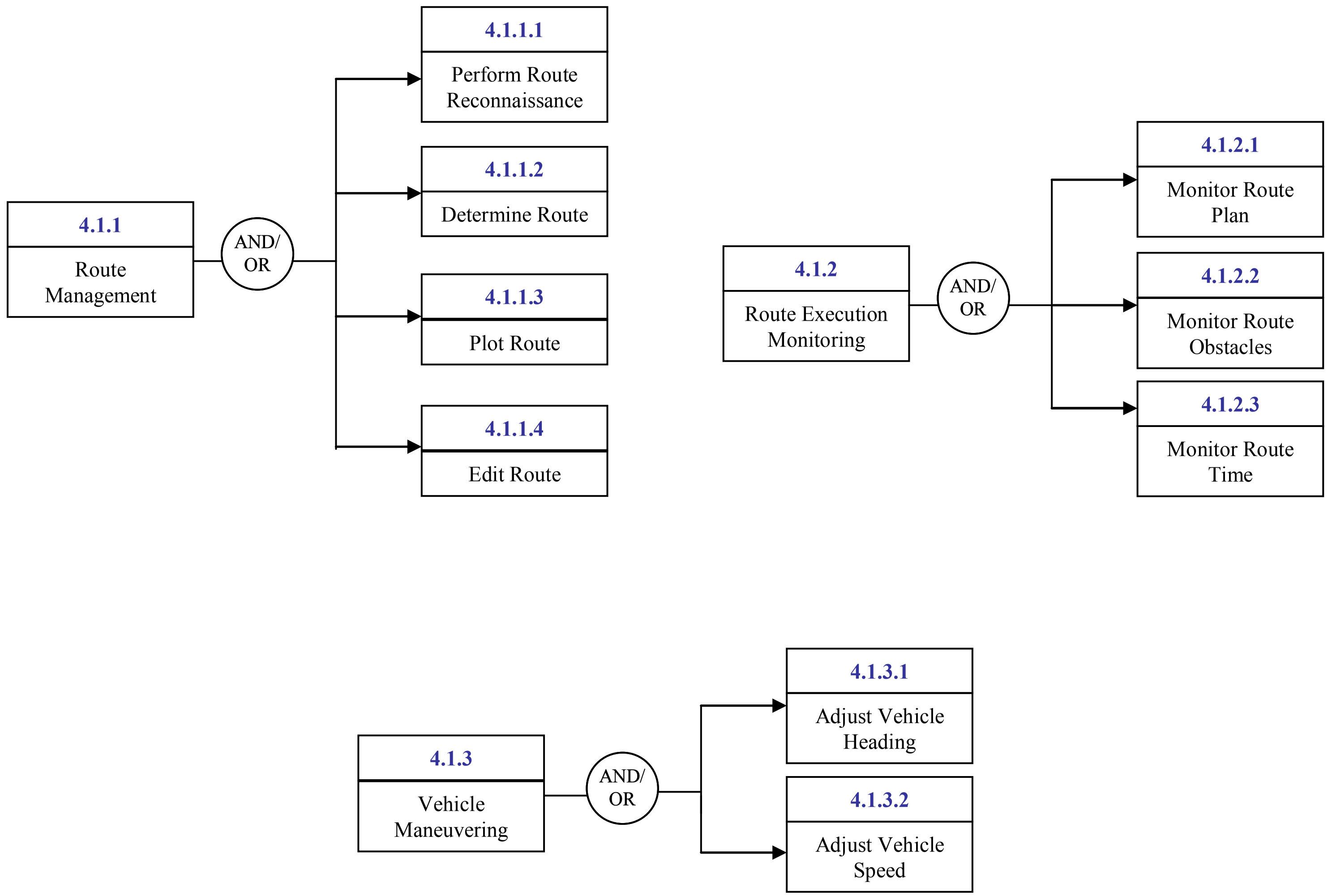






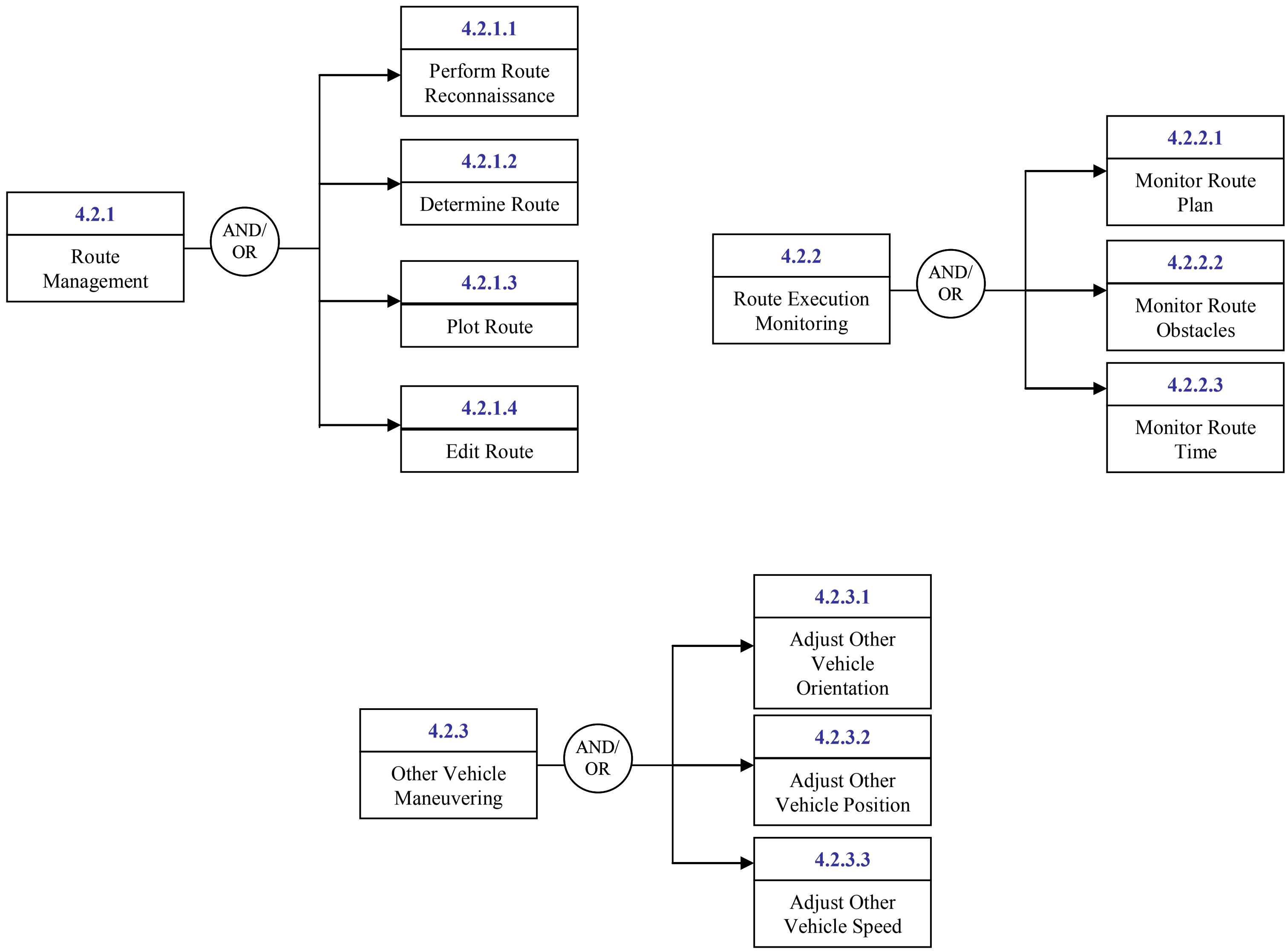
4 Navigation Management

4.1 Own Vehicle Navigation; 4.1.1 Route Management; 4.1.2 Route Execution Monitoring; 4.1.3 Vehicle Manoeuvring



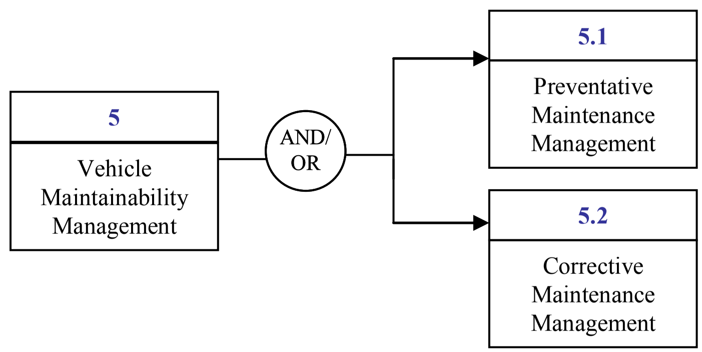
4 Navigation Management

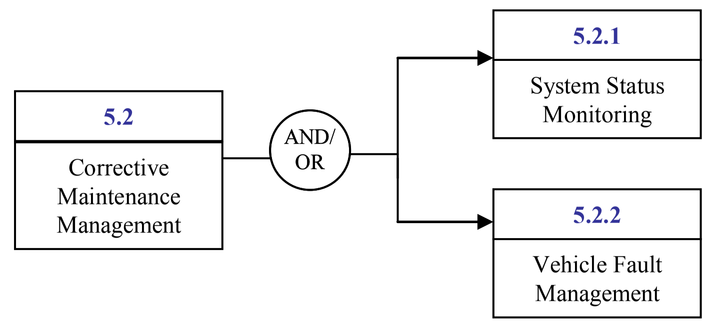
4.2 Own Vehicle Navigation; 4.1.1 Route Management; 4.1.2 Route Execution Monitoring; 4.1.3 Vehicle Manoeuvring



5 Vehicle Maintainability Management

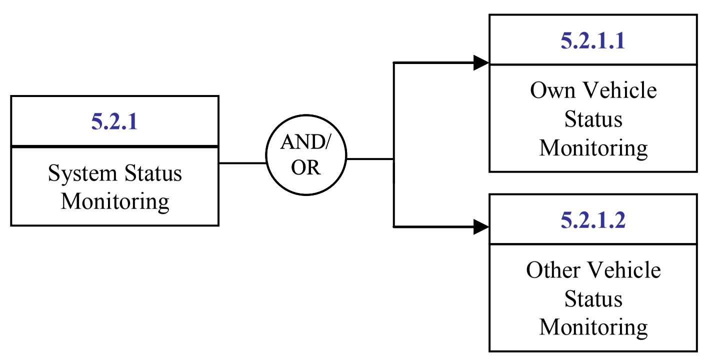
5.1 Preventative Maintenance Management; 5.2 Corrective Maintenance Management

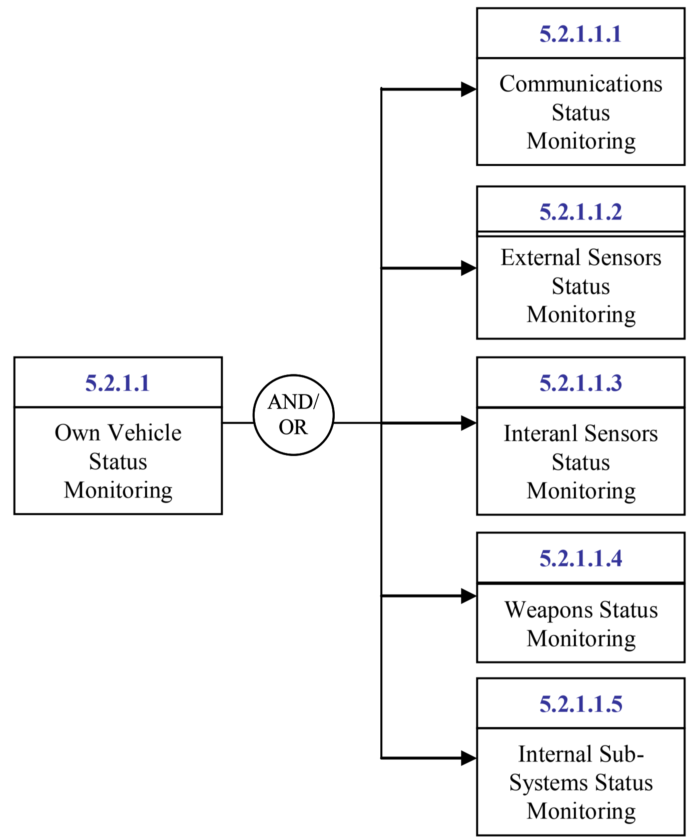




5 Vehicle Maintainability Management

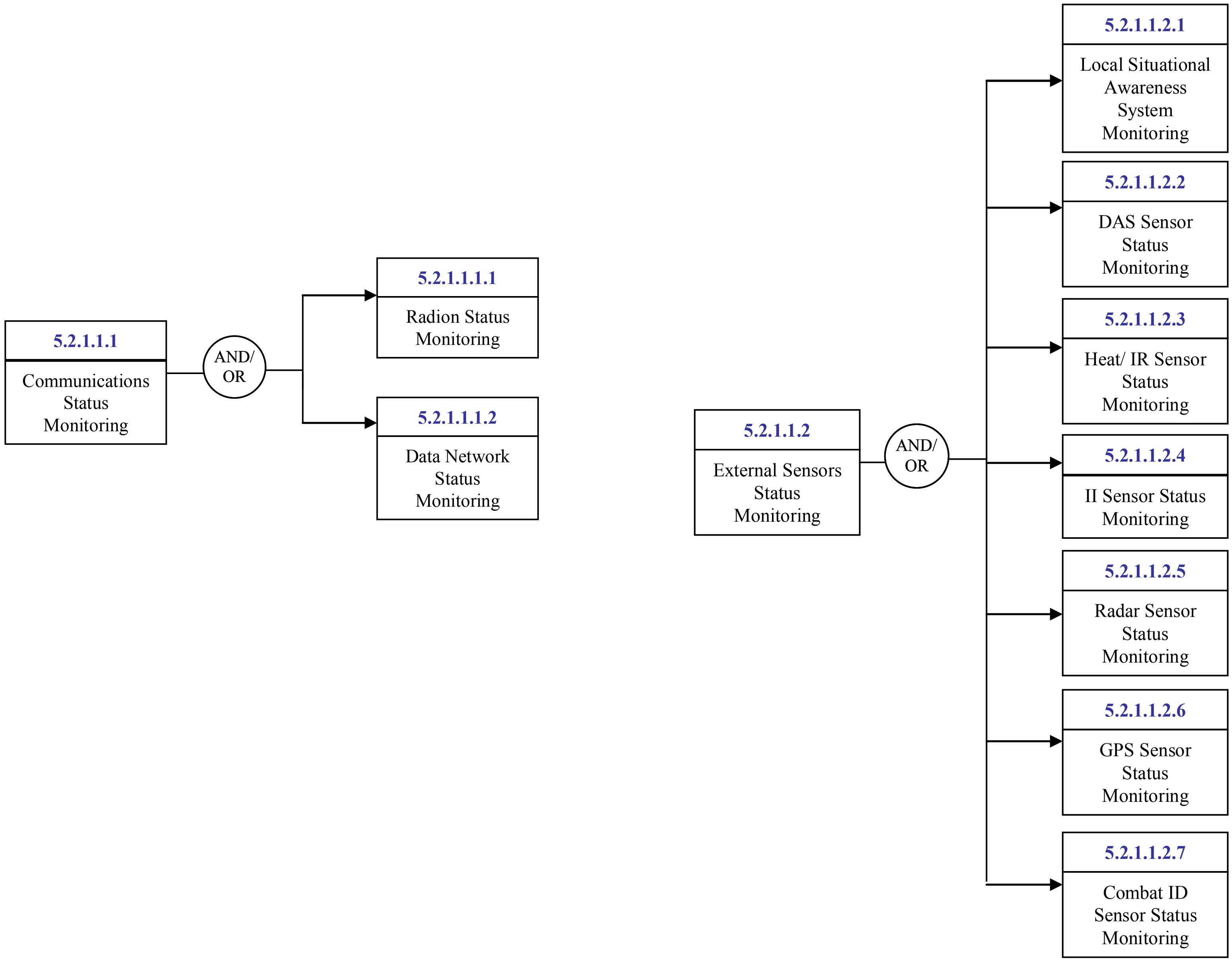
5.2 Corrective Maintenance Management; 5.2.1 System Status Monitoring





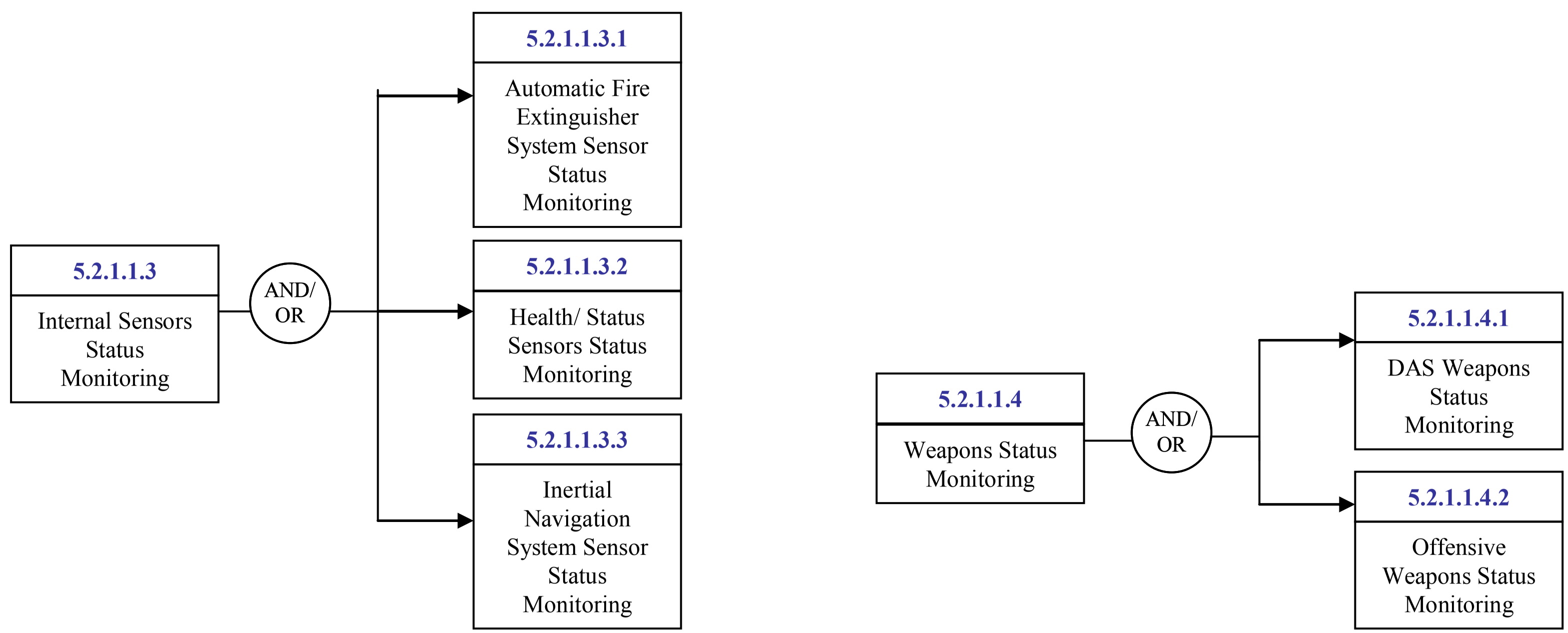
5 Vehicle Maintainability Management

5.2 Corrective Maintenance Management; 5.2.1 System Status Monitoring


5.2.1.1.1
Communications Status Monitoring
AND/ OR
5.2.1.1.1.1
Radion Status Monitoring
5.2.1.1.1.2
Data Network Status Monitoring
5.2.1.1.2
External Sensors Status Monitoring
AND/ OR
5.2.1.1.2.1
Local Situational Awareness System Monitoring
5.2.1.1.2.2
DAS Sensor Status Monitoring
5.2.1.1.2.3
Heat/ IR Sensor Status Monitoring
5.2.1.1.2.4
II Sensor Status Monitoring
5.2.1.1.2.5
Radar Sensor Status Monitoring
5.2.1.1.2.6
GPS Sensor Status Monitoring
5.2.1.1.2.7
Combat ID Sensor Status Monitoring

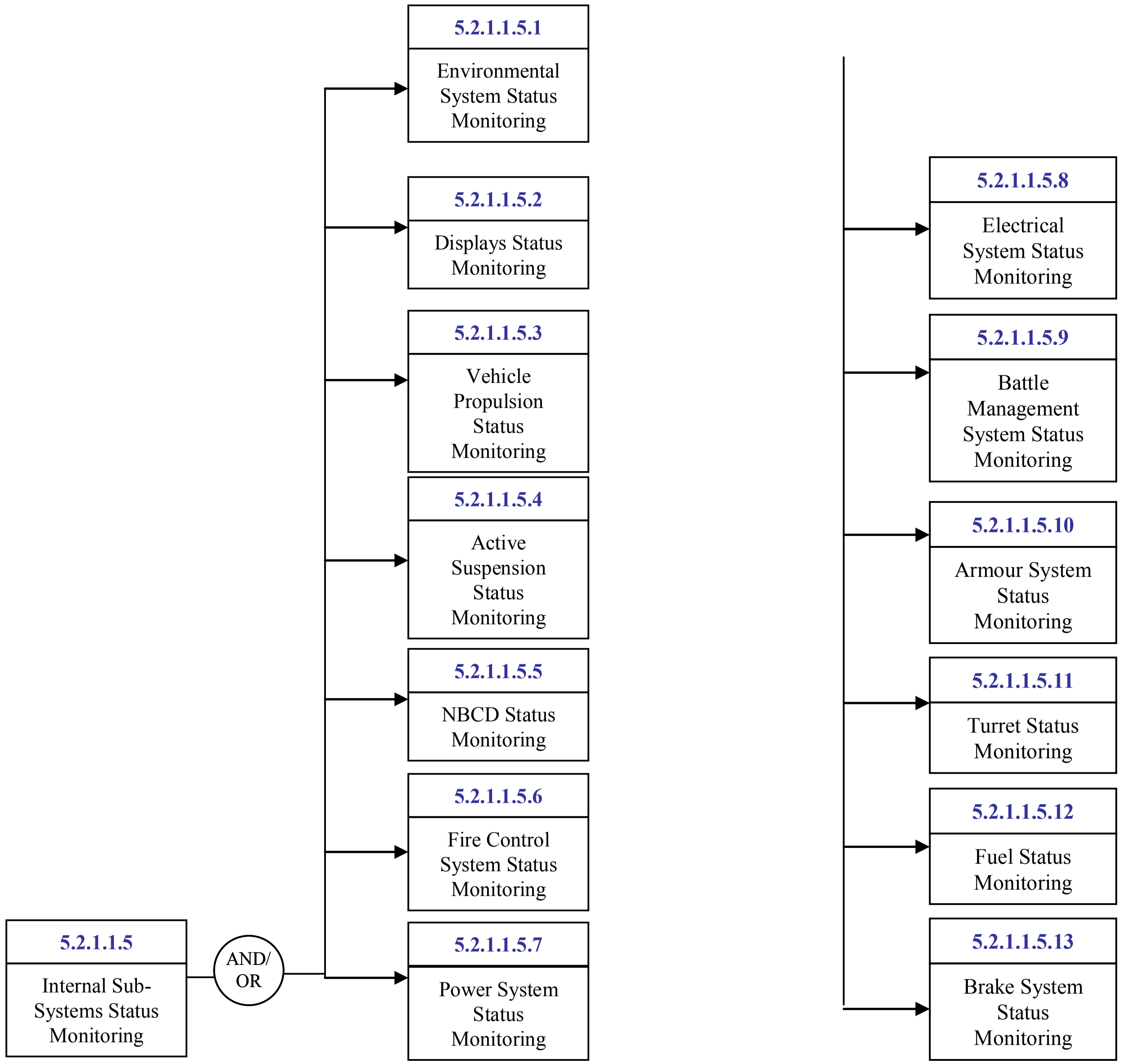
5 Vehicle Maintainability Management

5.2 Corrective Maintenance Management; 5.2.1 System Status Monitoring



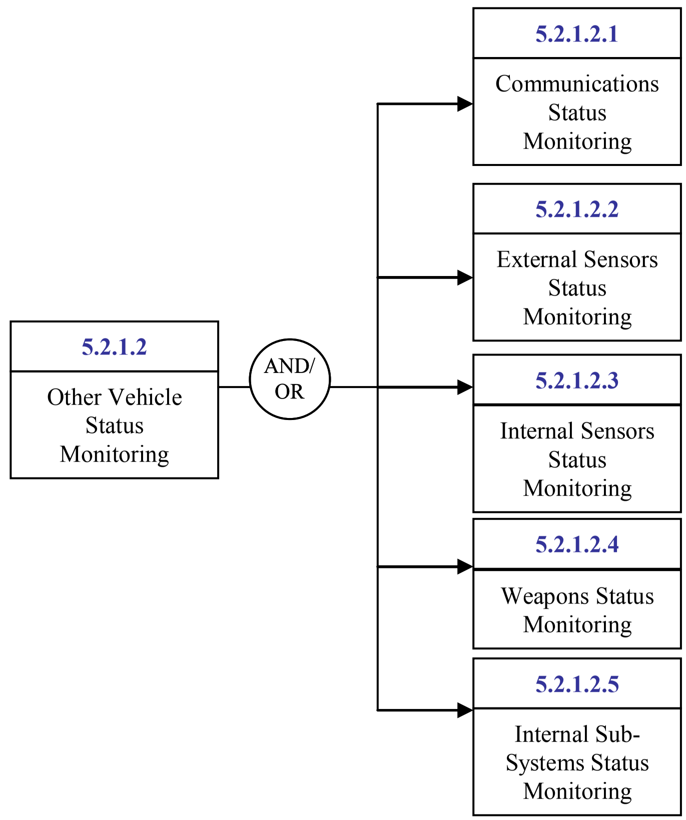
5 Vehicle Maintainability Management

5.2 Corrective Maintenance Management; 5.2.1 System Status Monitoring


5.2.1.1.5
Internal Sub-Systems Status Monitoring
AND/ OR
5.2.1.1.5.1
Environmental System Status Monitoring
5.2.1.1.5.2
Displays Status Monitoring
5.2.1.1.5.3
Vehicle Propulsion Status Monitoring
5.2.1.1.5.4
Active Suspension Status Monitoring
5.2.1.1.5.5
NBCD Status Monitoring
5.2.1.1.5.6
Fire Control System Status Monitoring
5.2.1.1.5.7
Power System Status Monitoring
5.2.1.1.5.8
Electrical System Status Monitoring
5.2.1.1.5.9
Battle Management System Status Monitoring
5.2.1.1.5.10
Armour System Status Monitoring
5.2.1.1.5.11
Turret Status Monitoring
5.2.1.1.5.12
Fuel Status Monitoring
5.2.1.1.5.13
Brake System Status Monitoring

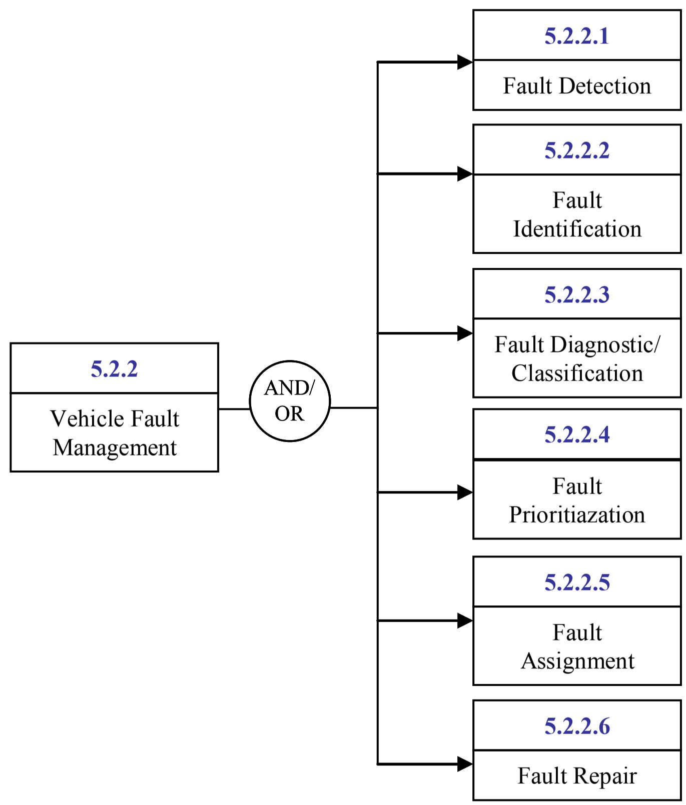
5 Vehicle Maintainability Management

5.2 Corrective Maintenance Management; 5.2.1 System Status Monitoring



5 Vehicle Maintainability Management

5.2 Corrective Maintenance Management; 5.2.2 Vehicle Fault Management



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