Overview of Operational Concepts and Autonomous Tactical Task and Behavior Analysis in Support of Robotic Combat Vehicle (RCV) Development

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Agenda

- Introduction- What are we doing?
- Background- Developing Operational Autonomy for Unmanned Systems
- Concept of Operations (CONOPs) Development
- Developing the Master List of Tactical Tasks and Tactical Behaviors
- Way Ahead

JHNA is helping the Army better articulate how future Robotic Combat Vehicles will maneuver and fight via CONOPs depicting operational autonomy and Autonomous Tactical Behavior decomposition

- We see the following benefits:
  - Dramatic improvement of Engineer to Warfighter communication
  - Ability to accelerate and insert autonomy earlier into relevant warfighting tasks
  - Ability to expand autonomy into component areas of different warfighting functions
  - Ability to inform industry what capabilities are needed
  - Ability to do outreach to second tier suppliers in ways that accelerate capability

- This benefits
  - NGCV-CFT
  - PM-Maneuver Combat Systems
  - MCoE RDD
  - GVSC-GVR
  - Academia and Industry

Operational Concepts- The JHNA Way

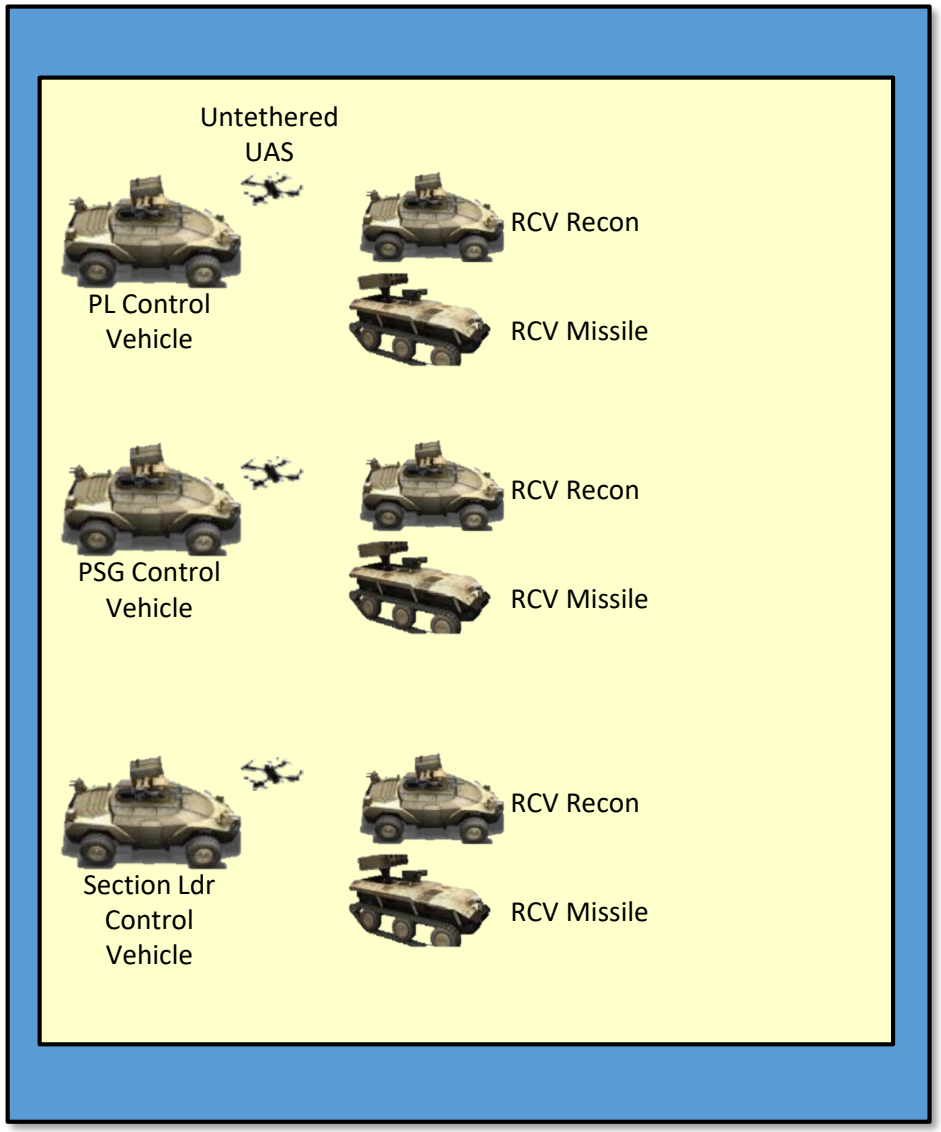
Assumptions for CONOPS (1 of 2)

- Assume a robust, future near-peer threat environment
- Assume this is Combined Arms Maneuver is in support of Joint Multi-Domain Operations in a GPS-Denied, Communications-Degraded Environment
- Assume that Assured Position, Navigation, and Timing (A-PNT) capability is available provided by some capability (Manned A/C, UAS, or ground vehicle)
- Assume that our close air support of Army aircraft will be from the FVL ecosystem – FARA, FLRAA, AUAS, NGTUAS, ALE (providing Decoy/EW/Lethal/Recon capabilities)
- All NGCV/RCV have full Situational Awareness and multiple Communications capabilities
- All RCV have scalable autonomy (from ALFUS 0-10) for navigation, reconnaissance/surveillance [inquisitive and investigate] and maneuver
- All RCV have scalable autonomy levels for operator sensor/lethal package and platform control
- All RCV have full Survivability Equipment suites, including hostile fire indicator, slew-to-cue, counterfire, smoke, emergency movement, blinding lights, loudspeaker, and active protection system (APS)

Assumptions for CONOPS (2 of 2)

- All RCV may have remotely deployable drones (UAS) and potentially ground launched effects (Air Launched Effects equivalent including Detect, Identify, Locate, Report [DILR], Decoy, Disruptor [EW], and Lethal capabilities)
- All RCV will have robust Aided Target Recognition/Automated Target Recognition (AiTR/ATR is available to manned and unmanned systems including attached/appended UAS/ALE)
- All RCV will be able to receive and understand digital operational updates (FRAGOs with mission changes, graphics [e.g. boundaries, phase lines, no-fire/restricted-fire lines, NAI/TAI, etc.] commander's guidance changes [CCIR, etc])
- All RCV have a self sacrifice capability based on SA (HFI, pyrotechnic, hostile group/intent, etc.) or operator signal that allows physical interposition or action to save manned vehicles/Soldiers (e.g. react to ambush by driving at enemy with lights/sirens/smoke/pyro/final protective fire, potentially with a VBIED capability?)
- Lethal engagement by autonomous systems only on individual targets or specific target groups that have been validated by an authorized human operator

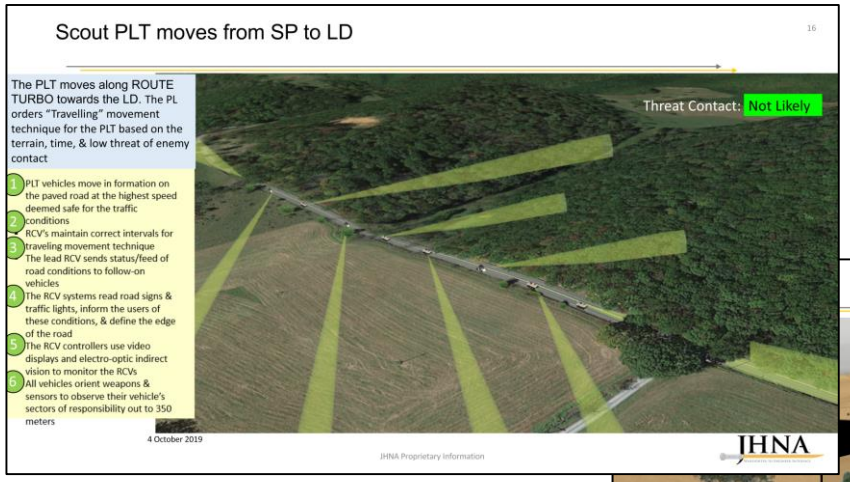
We project the content of a Reconnaissance Platoon based on what's contained in current RCV(L) draft documents. Vehicle depictions are notional

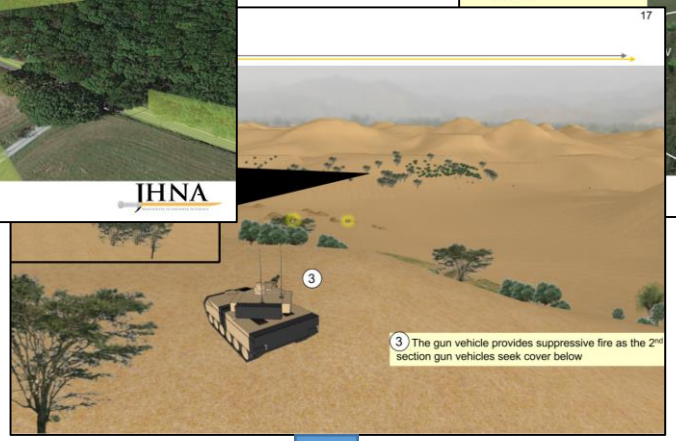


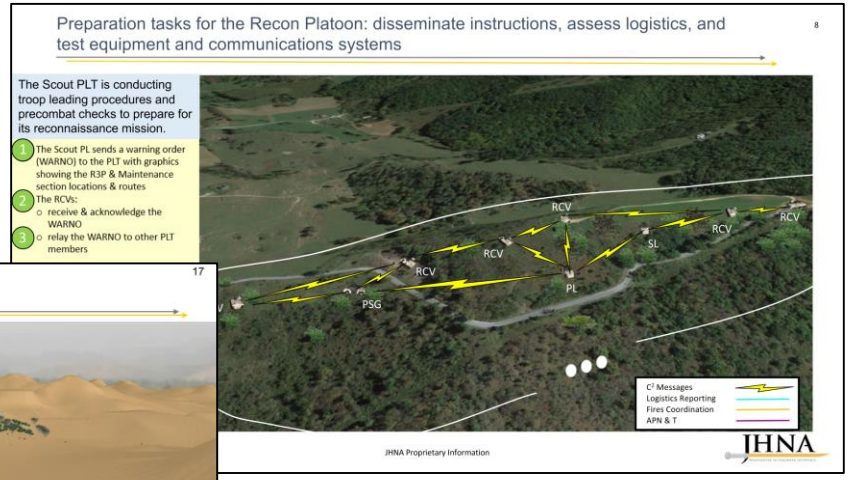
Direct Support (DS) UAS

Medium UAS

CONOPs animations will depict capabilities and behaviors prioritized by GVSC and the NGCV CFT. All PowerPoint products will have accompanying write-ups







Each accompanying writeup explains the CONOP's mission, its stages, objectives, standards, and prioritized discrete behaviors

*Slide excerpts are notional

PPT Depictions will be relevant to Army challenges

- European type terrain (mixed wooded, some open rolling)
- Friendly: Recon Plt equipped with RCV
- Threat: BMP, BTR, UAV…
- Go through all 9 stages of the operation as GVSC and JHNA have determined
- Presume 2028 “full” autonomy capability per platform in movement (navigation), tactical behaviors during movement and at danger areas, obstacle avoidance, RSTA, etc.

- Post Kick-off: shift to 6 missions that support GVSC STX "events"
  - 1: Route reconnaissance (METL Task 17-PLT-4000)
  - 2: Reconnoiter an obstacle (METL Task 17-PLT-4012)
  - 3: Area reconnaissance (METL Task 17-PLT-4011)
  - 4: Establish an observation post (METL Task 07-PLT-9016)
  - 5: Conduct a screen (METL Task 17-PLT-9225)
  - 6: Displace to subsequent screen (METL Task 17-PLT-2625)

Each CONOP breaks down into “stages” or “events”

The next two slides are a draft template for CONOPs to encompass events 1-6 of GVSC’s guidance in accordance with the

CoVeR program's STX schedule

JHNA Stage 2-3-4 template (meets missions 1-4 of GVSC CoVeR program: Route Recon, Recon Obstacle, Area Recon, Emplace OP)

- PLT crosses LD in formation/technique based on low threat of contact (traveling overwatch)
- Execute recon tasks enroute to templated OPs overlooking NAI Boat
- Feed from UAS reports obstacle (wire/mine?) along route.
- Transition to bounding overwatch a terrain feature before obstacle since it's likely covered by observation/fires.
- Avoid observation, recon obstacle, confirm earlier report, report higher...
- find and execute bypass around obstacle
- Continue to bound to establish OPs IOT overwatch NAI Boat
- Send reports on activity at NAI Boat

Red = specific CoVeR event

JHNA Stages 5-6 (Events 5 and 6 Screen and displace missions from CoVeR program)

- Plt receives FRAGO to screen movement of sapper platoon and security element that are sent to reduce obstacle
- (need discussion here of the threat RCVs are screening against)
- Completion of obstacle reduction = trigger to displace (by bounds) to screen the flank of Battalion's lead effort (rifle company) which has crossed the LD (RCV scout platoon occupies high ground positions along the boundary of graphics)
- RCVs report log status and possibly receive follow-on mission

Red = specific CoVeR event

Challenge #1: doctrinal recon subtasks must be prioritized; we must choose how far to take this

- Find, report, and clear within capabilities all enemy forces that can influence movement along the route.
- Determine the trafficability of the route; can it support the friendly force?
- Reconnoiter all terrain that the enemy can use to dominate movement along the route, such as choke points, ambush sites, and pickup zones, landing zones, and drop zones.
- Reconnoiter all built-up areas, contaminated areas, and lateral routes along the route.
- Evaluate and classify all bridges, defiles, overpasses and underpasses, and culverts along the route.
- Locate any fords, crossing sites, or bypasses for existing and reinforcing obstacles (including built-up areas) along the route.
- Locate all obstacles and create lanes as specified in execution orders.
- Report the above route information to the headquarters initiating the route reconnaissance mission, to include providing a sketch map or a route overlay.

*These subtasks are doctrinal. Our mission is to help sort out what's relevant to RCV.

Challenge #2: CONOPs must depict capabilities the government desires for RCV(L) platforms

- Need for ability to drop static unmanned ground sensors?
- Teamed UAS? Tethered/untethered UAS?
- Will one or more RCV have a mast sensor?
- When operators dismount, does the PL/PSG/SL continue to supervise the RCVs?
- RCV(L) has direct fire weapons. Most likely method of engagement of certain threats during a recon mission? (How lethal of an operation should we show?)

We are composing a concise Route Recon task list as we go

- Two filters:
  - 1) Movement/maneuver task from CONOP
  - 2) Identified unmet needs from the "Needs of a Scout Platoon" study

Unmet Needs from Scout Platoon Study (Move/Maneuver focused)

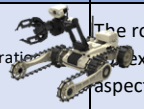
1. Determine how enemy forces will impact a reconnaissance mission, e.g., alter route based on location/capabilities, influence course of action given expected contact
2. Avoid being surprised by an unknown situation when conducting a reconnaissance mission, e.g., presence of an enemy, impassable terrain, civilian activity
3. Ensure the presence of an enemy is detected during a reconnaissance mission, e.g., from a distance, at night, around hills/curves, in buildings
4. Avoid inadvertently being detected by an enemy while conducting reconnaissance, e.g., making too much noise, being seen, being identified through an electronic/heat signature
5. Ensure communication/coordination with adjacent/supporting units is maintained while moving to conduct reconnaissance, e.g., if using different systems, when geographically separated, if “comms” are down
6. Ensure scouts are able to execute a reconnaissance mission in the event technology/equipment fails, e.g., GPS goes down, electronic maps are offline
7. Avoid losing track of an enemy’s location/activities after making contact on a reconnaissance mission, i.e., maintain visual contact through surveillance, gain insight through maneuver

Decomposing Relevant Autonomous Tactical Behaviors

JHNA proposed Operational Autonomous Levels for Unmanned Systems (O-ALFUS) as a governing rubric for open discussions on autonomy. Our Autonomous Tactical Behavior (ATB) analysis governs how a robot qualifies for an O-ALFUS level. It is derived from this analytical product

O-ALFUS Levels	LORA Levels of Robot Autonomy	Description	Independent Autonomous Tactical Behavior Maturity 1. Move / Manuever 2. Observe / Engage 3. Communicate / Control 4. Evaluate / Adapt 5. Survive 6. Sustain
0 Human Manual Operation	Manual	The human performs all aspects of the task including sensing the environment, generating plans/options/goals, and implementing processes	None
1 Human Tele-Operation of a RAS Platform	Tele-Operation	The robot assists the human with action implementation. However, sensing and planning is allocated to the human. For example, a human may teleoperate a robot, but the human may choose to prompt the robot to assist with some aspects of a task (e.g., gripping objects).	Least Mature → Very Limited
2 RAS Provided Operator Assist	Assisted Tele-Operation	The human assists with all aspects of the task. However, the robot senses the environment and chooses to intervene with task. For example, if the user navigates the robot too close to an obstacle, the robot will ***automatically steer*** to avoid collision.	Limited
3 RAS Surbordinated Control	Batch Processing	Both the human and robot monitor and sense the environment. The ***human*** , however, ***determines*** the goals and plans of the task. The robot t…nts the task.	
	Decision Support	Both the human and r…ironment and generate a task plan. However, the ***human chooses*** the task plan and commands the robot to implement actions.	Functional
4 RAS Led Shared Control	Shared Control with Human Initiative	The robot autonomously senses the environment, develops plans and goals, and implements actions. However, the human monitors the robot's progress and may intervene and influence the robot with new goals and plans if the robot is having difficulty.	
	Shared Control with Robot Initiative	The robot performs all aspects of the task (sense, plan, act). If the robot encounters difficulty, it can prompt the human for assistance in setting new goals…ns.	Proficient
5 Human Executive/ Supervisory Control	Executive Control	The human may give an abstract high… navigate in environment to a specified location). The robot autonomously senses environment, sets t…	
	Supervisory Control	The robot performs all aspects of task, but the hu… human has override capability and may set a new ***control, shared control*** , or ***decision support.***	Advanced
6 Full RAS Autonomy	Full Autonomy	The robot performs all aspects of a task autonomo… implementing action.	
7 Cooperative Full Autonomy	Full Autonomy-Cooperative	Fully autonomous robotic system teams with a hu… to problem solving through shared sensing, planni… feel like it was all his idea.	Expert
8 Collaborative Full Autonomy	Full Autonomy-Collaborative	Human-Robot Teaming. A group of fully autonom… to solve simple or complex problems. The missio… instantly adapt, change roles, and take over contr… function that requires more cognitive intelligence	Most Mature


Soldier controls everything on his weapon



Autonomous Tactical Behaviors (ATBs) are actions and behaviors associated with a RAS's role in a mission and the expectations of its co-combatants

- ATBs are not Warfighting Functions (WfFs). ATBs reflect where autonomy can contribute to accomplishing the subtasks associated with a mission. ATBs can be organized by WfFs as part of a task decomposition into subtasks
- ATBs are the actions and capabilities of a RAS associated with the execution of specific subtask components of a WfF
- ATBs can be associated with individual and collective actions of a team when the RAS is a co-combatant
- We see three categories, ATBs as:
  - Related to itself
  - Related to the mission/others
  - Related to safety – external
- Multiple ATBs may be associated with a single subtask – and a single ATB may be associated with various subtasks
- ATBs descriptions facilitate communication between users and engineers
- A RAS may execute numerous ATBs, some several times, including all six WfFs, in the execution of a single mission

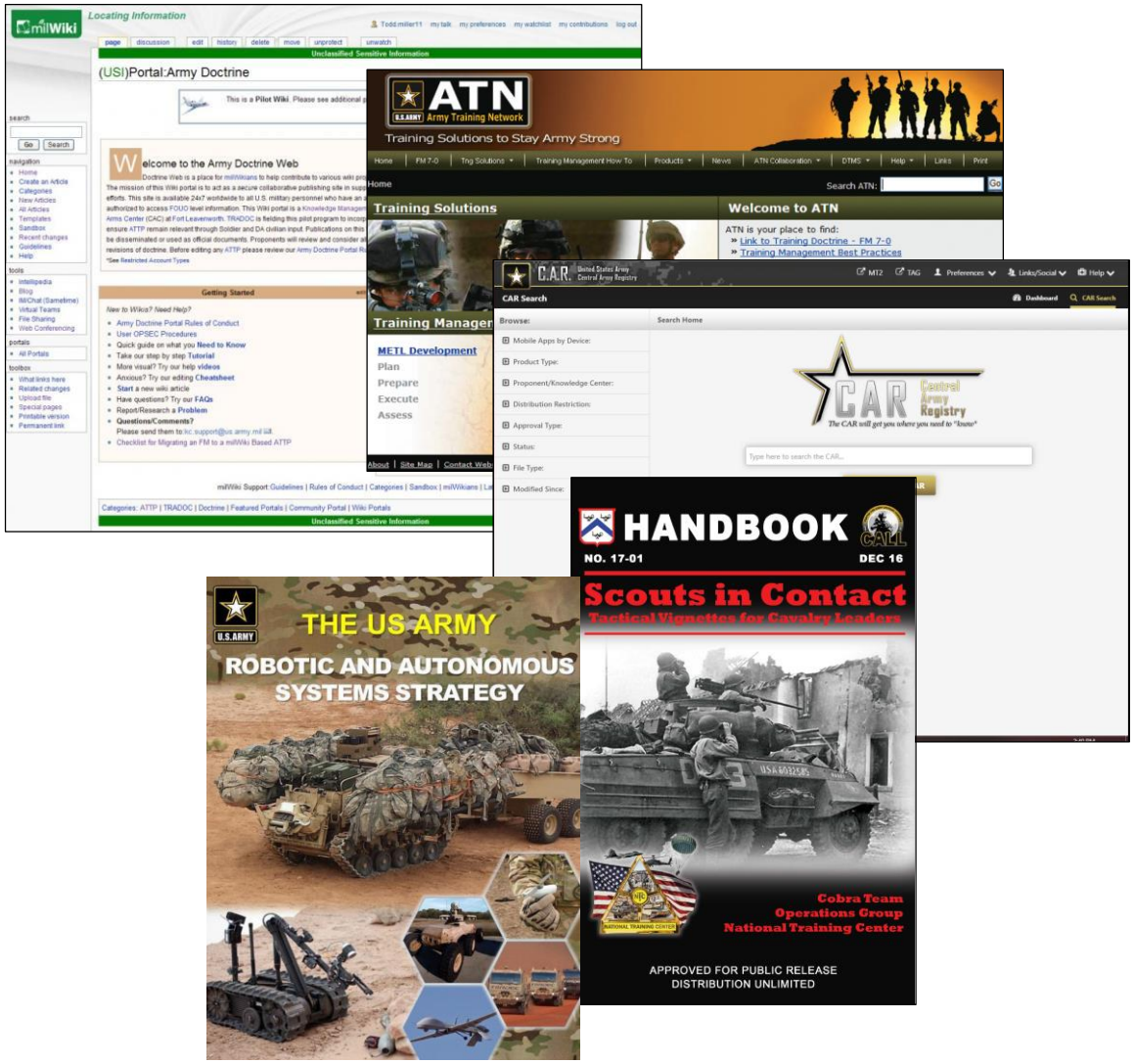
When we define all the tactical behaviors of a mission, we can begin to understand where and to what degree autonomy can contribute from an operational perspective

JHNA's ATBs begin with a focus on Army tactical doctrine as a guide to decompose each mission's tasks and subtasks from established standards

- **References Common to all Tasks**
  - ADP 1-02 Terms and Military Symbols
  - ADRP 1-03 Army Universal Task List
  - STP 21-1-SMCT Soldiers Manual of Common Tasks, Warrior Skills Level 1
  - STP 21-24-SMCT Soldiers Manual of Common Tasks, Warrior Leader Skills Level 2, 3, and 4
  - WBD 2015 Warrior Task and Battle Drill Critical Individual Supporting Tasks 2015
- **References Used as Appropriate for Specific Tasks**
  - ADPs Army Doctrinal Publications
  - ADRPs Army Doctrinal Reference Publications
  - ARTs Army Tactical Tasks
  - ATPs Army Techniques Publications
  - FMs Field Manuals (that are still current)
  - ICTLs Individual Critical Task Lists
  - STPs Soldiers Manual and Training Guide (Levels 1-4)
  - TCs TRADOC Circulars

JHNA also complements the doctrinal references with current practices, lessons learned, and strategic goals to ensure we produce a robust product.

- User Community sources (i.e. recent TTPs)
  - Army Doctrine milWiki
  - Army Training Network
  - Central Army Registry
- Center for Army Lessons Learned
  - Handbooks
  - Newsletters
  - Combat Training Center Bulletins
- Strategy
  - The U.S. Army Robotic and Autonomous Systems Strategy (2015-2040)



Our Initial Task Decomposition is already underway. Mission: “Route Reconnaissance”

- With all relevant Army tactical doctrine resources as a guide, we started our Task Decomposition focusing on the “Plan” and “Prepare” stages of 17-PLT-4000 – Conduct Route Reconnaissance (Scout Platoon)
- Analysis begins early. We split “Implied” tasks into “Inferred” and “Implied”
  - Inferred = Not listed in the T&EO as a specified task, but directly follows from the text of the performance step.
  - Implied = Not listed in the T&EO as a specified task, but logically follows from the text of the performance step.
- Current Status is evolving
  - Specified Tasks → Identified
  - Inferred Tasks → Verifying
  - Implied Tasks → Searching
  - “Divined” Tasks → Next step

Some performance steps do not have an existing supporting task in a doctrinal performance standard. In these cases, we have shown where to find the information

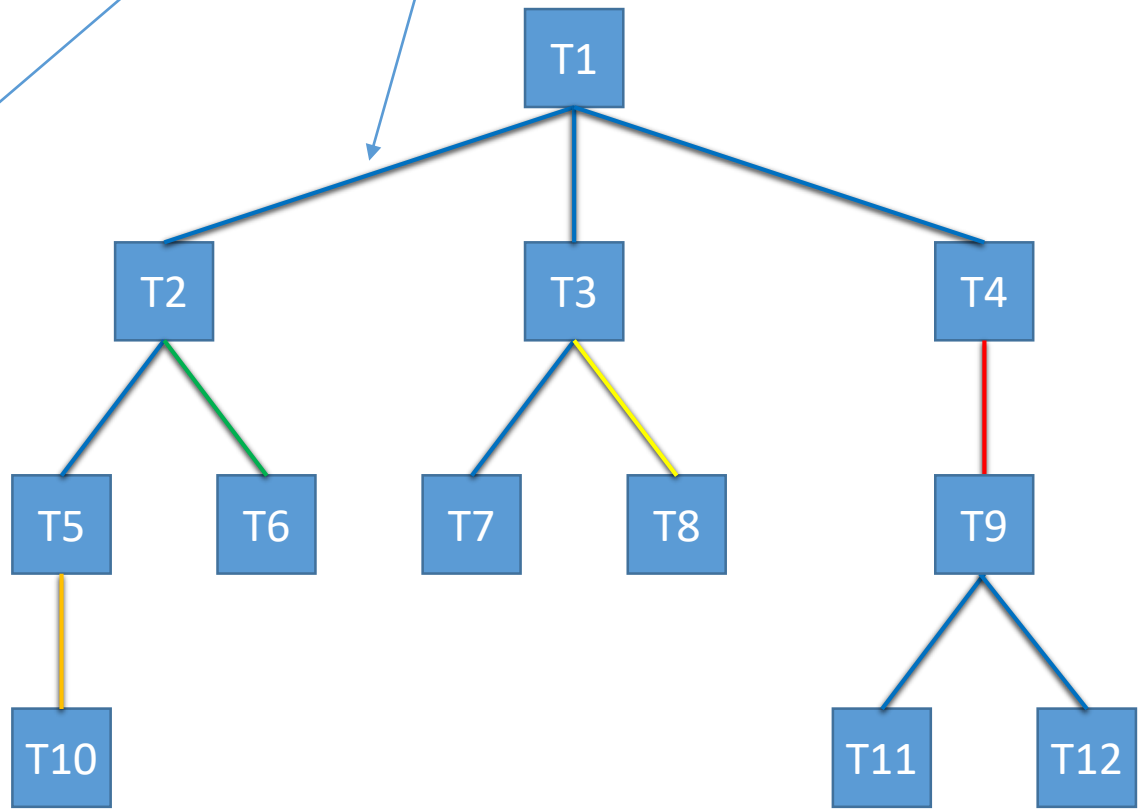
17-PLT-4000 – Conduct Route Reconnaissance

STEP NUMBER	PERFORMANCE STEP	SUPPORT-ING TASK NUMBER	SUPPORTING TASK TITLE	SUPPORT-ING TASK TYPE	NOTES
2.c.(2)	Integrates the fundamentals of reconnaissance by taking the following actions: (a) Ensures continuous reconnaissance. (b) Does not keep reconnaissance assets in reserve. (c) Orients on the reconnaissance objective. (d) Reports all information rapidly and accurately. (e) Retains freedom of maneuver. (f) Gains and maintains enemy contact. (g) Develops the situation rapidly.	FM 3-90.2	Reconnaissance, Security, and Tactical Enabling Tasks Volume 2	Reference	ATP 3-20.98 - Para 3-7 (pg 3-2) Lists the Fundamentals of Reconnaissance ATP 3-20.97 - Para 3-2 (pg 3-1) Lists the Fundamentals of Reconnaissance FM 3-90-1 - Bad reference, no mention of Fundamentals of Reconnaissance. FM 3-90.2 - Para 1-4 (pg 1-2) through Para 1-12 (pg 1-3) describes each of the fundamentals. FM 3-98 - Para 5-2 (pg 5-1) through Para 5-8 (pg 5-2) describes each of the fundamentals.

Each row of our Task Decomposition spreadsheet shows a task and a performance step for that task and identifies a sub-task that details the performance step

Parent Task Number	Parent Task Title	Perfor-mance Step	Supporting Task Number	Supporting Task Title	Supporting Task Type
T1	Task One	1	T2	Task Two	Specified
T1	Task One	2	T3	Task Three	Specified
T1	Task One	3	T4	Task Four	Specified
T2	Task Two	1	T5	Task Five	Specified
T2	Task Two	2	T6	Task Six	Inferred
T3	Task Three	1	T7	Task Seven	Specified
T3	Task Three	2	T8	Task Eight	Implied
T4	Task Four	1	T9	Task Nine	Replaced
T5	Task Five	1	T10	Task Ten	Superseded
T9	Task Nine	1	T11	Task Eleven	Specified
T9	Task Nine	1	T12	Task Twelve	Specified

Each Row = One Relationship

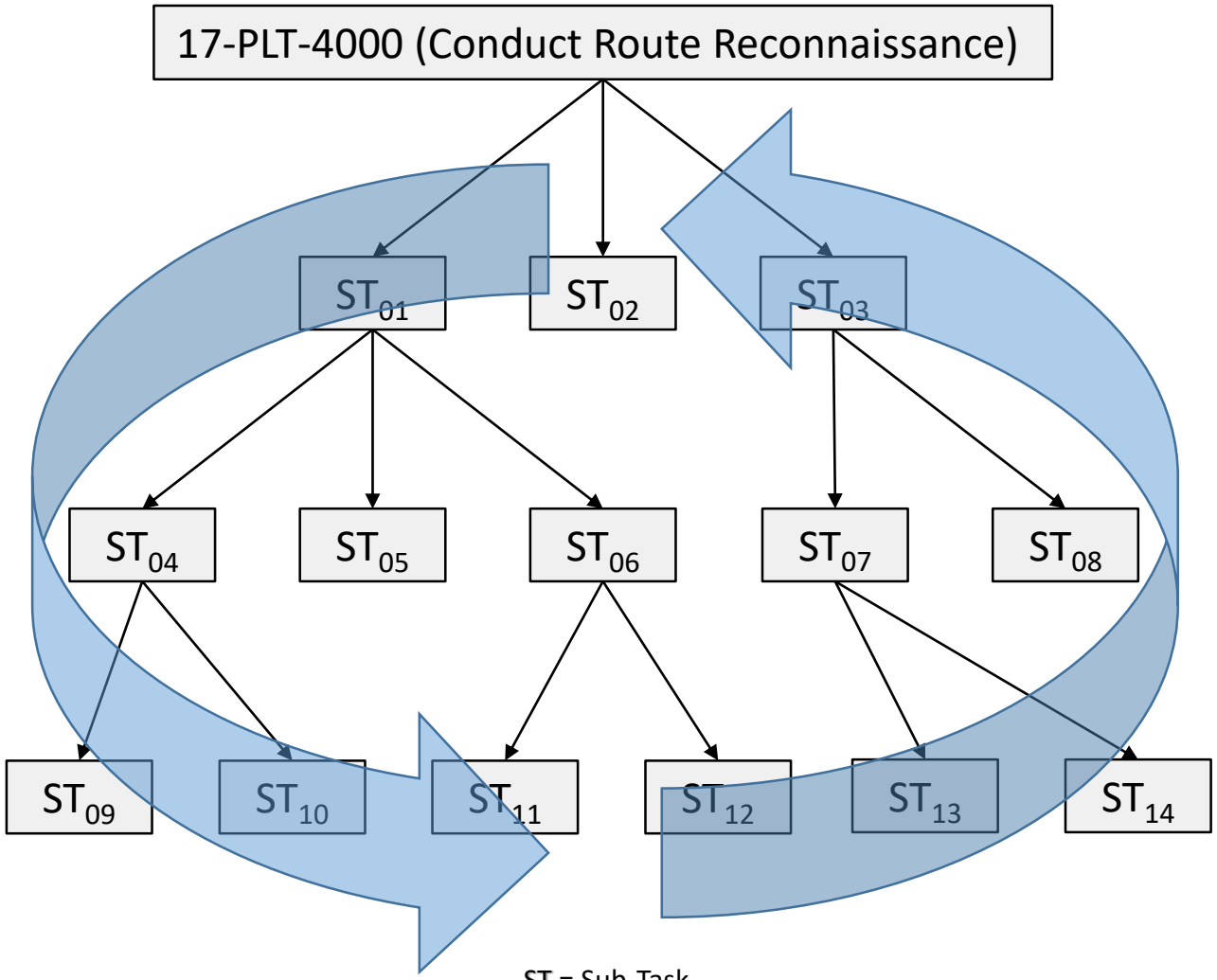


Specified – Listed in the T&EO as a Supporting Task
Inferred – Not listed in the T&EO, but directly supports the parent task
Implied – Not listed in the T&EO, but logically supports the parent task
Superseded – Task listed in the T&EO has been replaced by another task
Replaced – we have determined that another task is more appropriate.

Examples:
Task 1 has three specified tasks (T2, T3, and T4)
Task 2 has one specified task (T5) and one Inferred task (T6)
Task 5 has been superseded by Task 10.
Task 4 was replaced with Task 9 and Task 9 has two specified Tasks (T11 and T12)

Throughout the process the CONOPS team and the Task Decomposition Team work collaboratively to ensure that we include all key tasks down to the necessary level of detail

The process starts with the main doctrinal task for both teams.

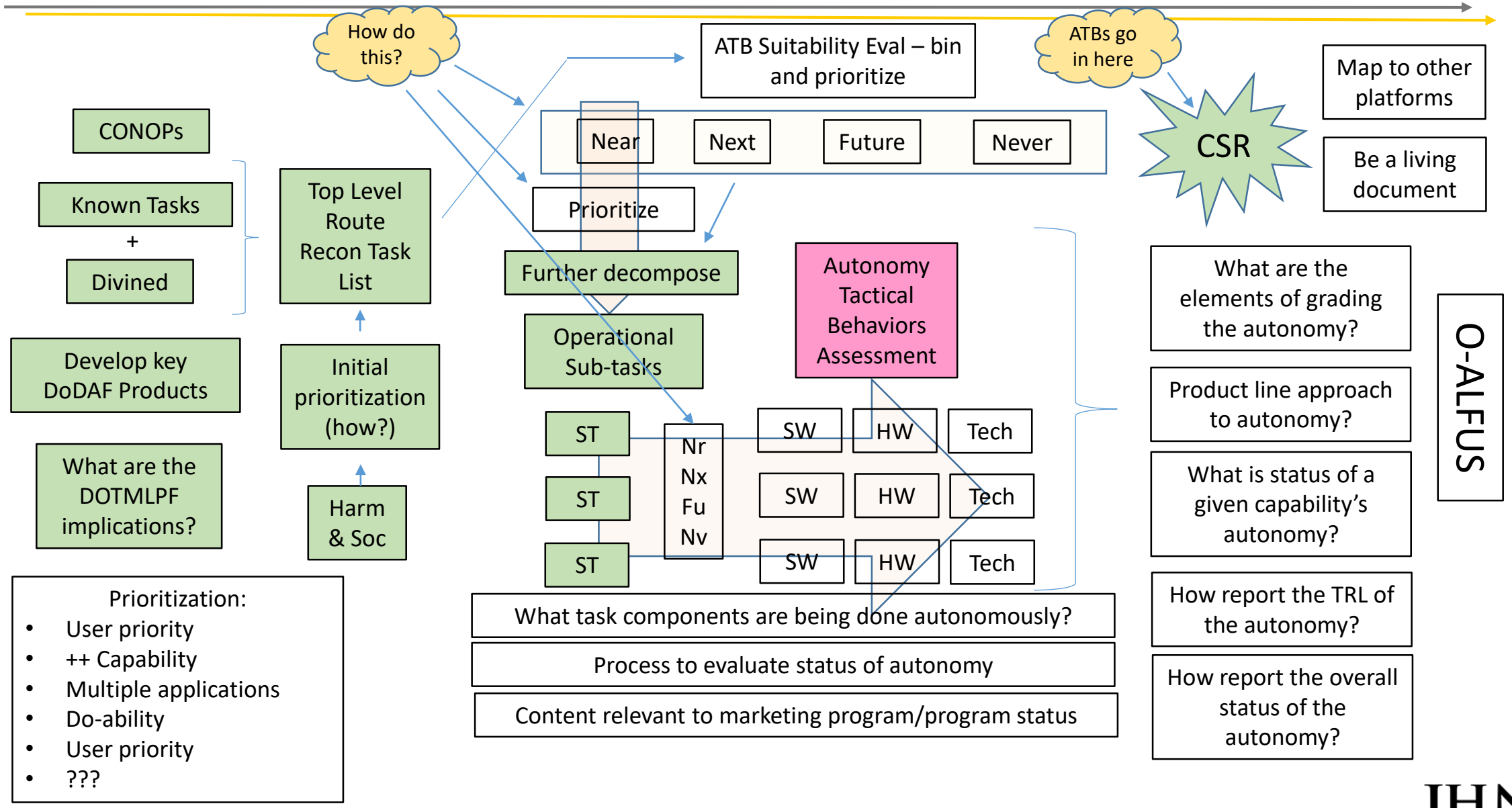


CONOPS Team
Develops the Concept
and
Identifies Key Tasks

Task Decomp Team
Incorporates Key Tasks
and
Details Relationships

ST = Sub-Task

This is a complex endeavor – here's how we think it all fits together



What we understand as project principles

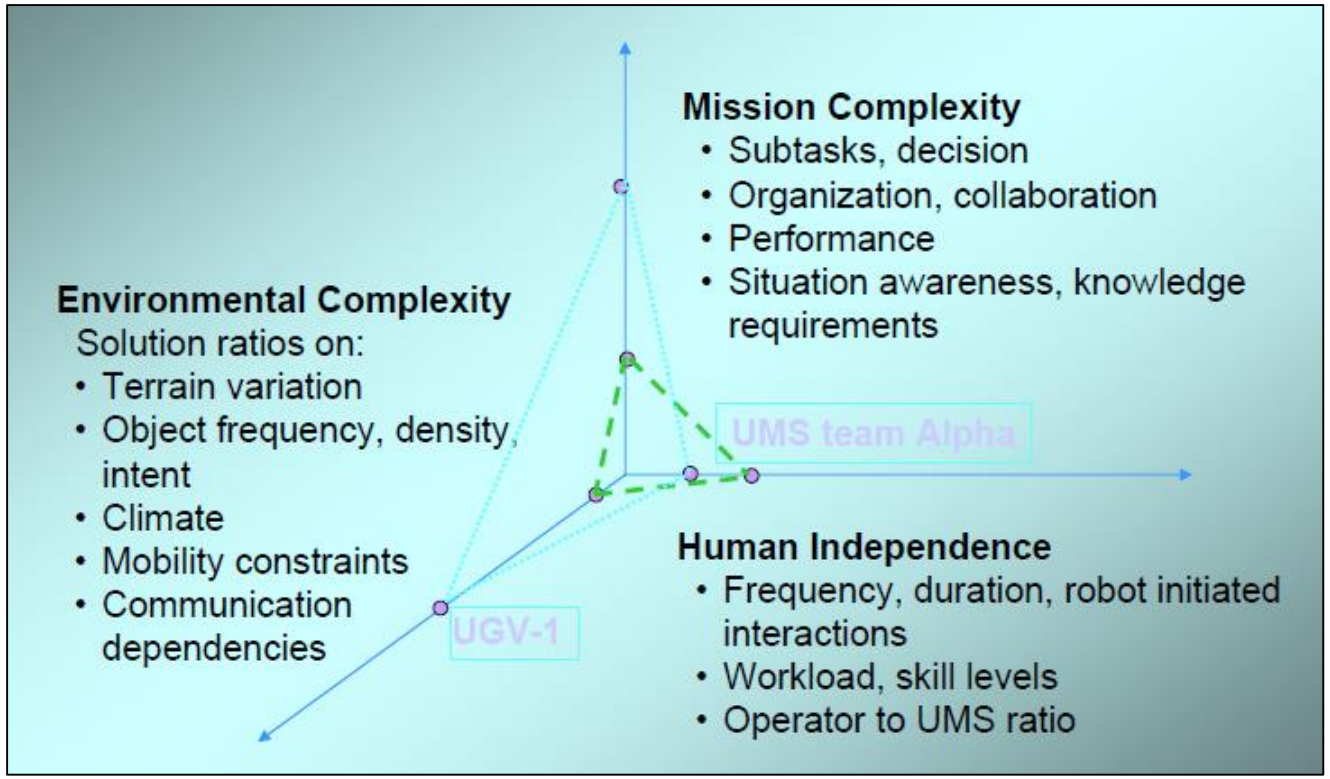
- This project is in support of GVSC's effort to accelerate progress in autonomy. We support an agile development process.
- With this project JHNA is attempting to identify and translate what human combatants do in military missions into understandable tactical tasks and behaviors for the RCV to perform autonomously
- All points of analytical departure in this process above begin with Army doctrine and User Community requirements
- Progress in this project will be iterative and interactive with our GVSC teammates
- Our work must be captured, harmonized, socialized, and documented in a format suitable for eventual access and use by approved academia, industry, and government interests
- Our deliverables will be suitable for use by Army testing agencies
- The primary deliverables include a compendium of tasks relevant to specific military operations, e.g. Route Recon; a Common Specification Reference document that captures ATBs judged as suitable for conversion to an autonomous capability; supporting operational concept of operations development

Back Up Slides

Where we are now: In 2008, NIST defined autonomy along a series of "Levels for Unmanned Systems" (ALFUS)

ALFUS Autonomy- Autonomy is defined as an Unmanned System's (UMS) own ability of integrated sensing, perceiving, analyzing, communicating, planning, decision-making, and acting/executing, to achieve its goals as assigned by its human operator(s) through designed Human-Robot Interface (HRI) or by another system that the UMS communicates with.

UMS autonomy in ALFUS is further characterized into levels from the perspective of Human Independence (HI), environmental complexity/difficulty (ED), and mission complexity (MC).



Source: Autonomy Levels for Unmanned Systems (ALFUS) Framework, Volume I: Terminology, Version 2.0 , 2008

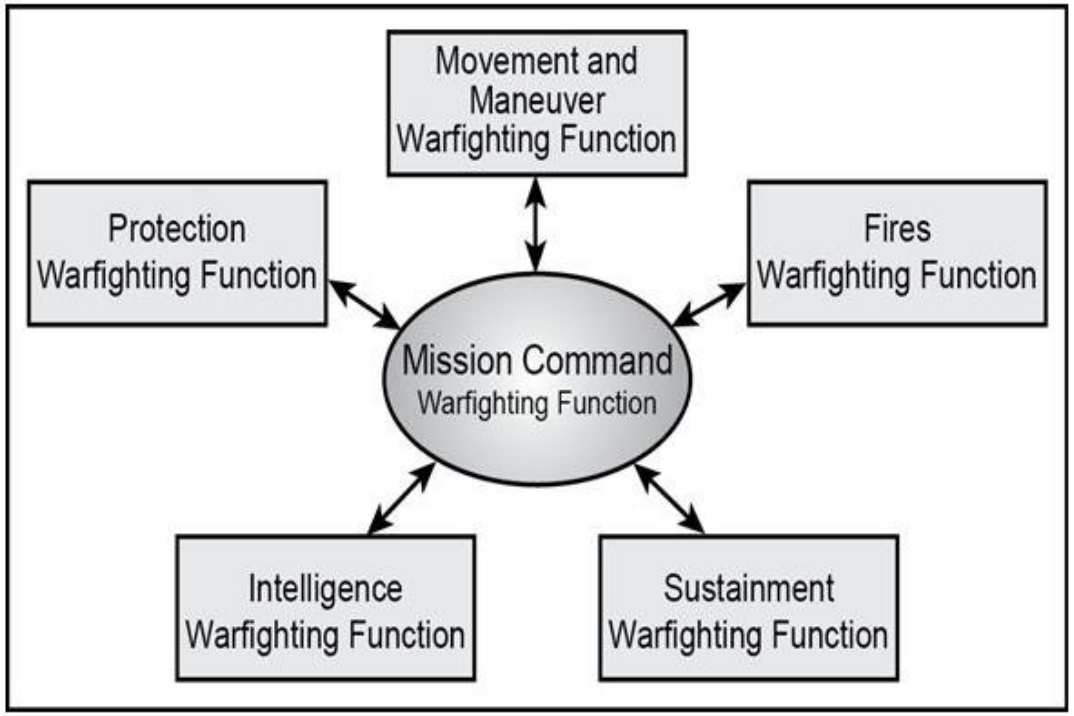
IHNA
WARFIGHTER TO ENGINEER INTERFACE

The original ALFUS matrix did not describe militarily useful levels of autonomy, nor did it permit detailed descriptions of discrete tactical behaviors military RAS require

SAE Level	Name	Narrative Definition	Execution of Steering and Acceleration / Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
***Human driver* monitors the driving environment**						
0	**No Automation**	The full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	The *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task.*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	The *driving mode*-specific execution by one or more driver assistance system so both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task.*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	The *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that that *human driver* will respond appropriately to a *request to intervene.*	System	**System**	Human driver	Some driving modes
4	**High Automation**	The *driving mode*-specific performance by an a*utomated driving system* of all aspects of the dynamic driving task, even if a *human driver* does not respond appropriately to a *request to intervene.*	System	System	**System**	Some driving modes
5	**Full Automation**	The full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway environmental conditions that can be managed by a *human driver.*	System	System	System	**All driving modes**

Source: ***Levels of Robot Autonomy from "Toward a Framework for Levels of Robot Autonomy in Human-Robot Interaction"; Beer,Fisk, and Rodgers; p.87. Journal of Human-Robot Interaction, Vol. 3, No. 2, 2014, Pages 74-99, DOI 10.5898/JHRI.3.2.Beer***

ALFUS doesn't account for Army Warfighting Functions (WfF), a militarily defined groups of Tasks and Systems working around a common purpose



A **warfighting function** is a group of *tasks* and *systems* (people, organizations, information, and processes) united by a *common purpose* that command use to accomplish missions and training objective (ADRP 3-0)

Commanders integrate and synchronize the other warfighting functions into a coherent whole to mass the effects of combat power at the decisive place and time through the mission command warfighting function.

WfF and AUTL tasks should be used as components of understanding operational autonomy