
[AISUM] - ARTIFICIAL INTELLIGENCE FOR SMALL UNIT MANEUVER

[AISUM]

Artificial Intelligence for Small Unit Maneuvers

CAPABILITY CONCEPT PACKAGE

"Remaining ahead of our adversaries in the ever changing global battlespace we face today involves innovating sustainable capabilities, capacity, and concepts for competitive advantage. We must think more creatively, beyond the physical domain, and redefine the "X." We must act with urgency as we continue the VEO fight while challenging great power competitors and countering rogue regimes. This is what the nation expects from Naval Special Warfare."

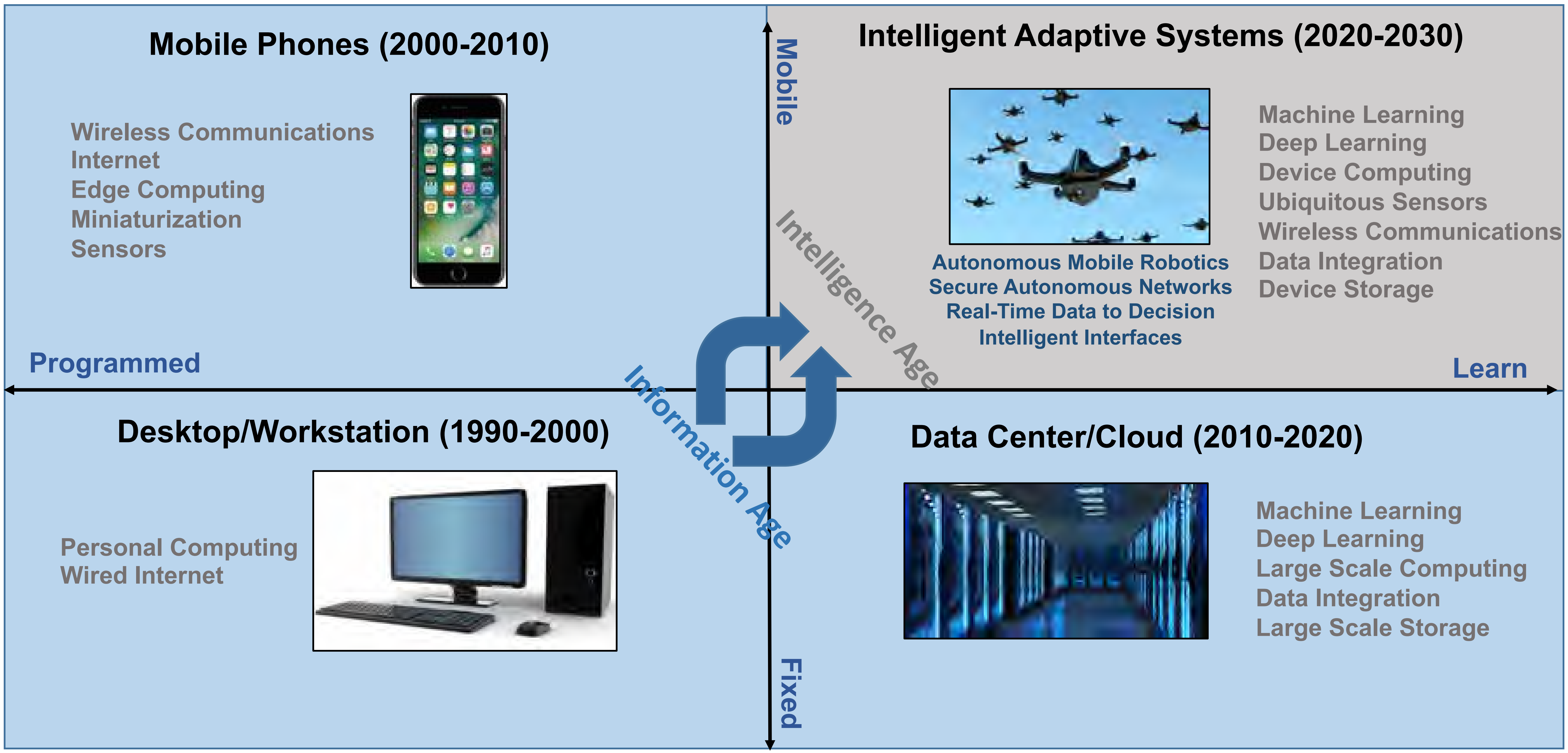
- RADM Green, Commander Naval Special Warfare 2018-2020

"Ten years from now... if the first thing going through the door of a breach isn't an unmanned system, then shame on us. And if there are not more unmanned systems than U.S. Army and Marine Corps ground units, shame on us."

- Robert Work, U.S. Deputy Secretary of Defense 2015-2017

Artist concept of AI Mobile Robots conducting Special Reconnaissance

[AISUM] BUILDING ON THE EVOLVING TECHNOLOGY ENVIRONMENT



THE (3) KEY TAKEAWAYS

1. Adversaries will attempt to contest all domains and utilize complex and congested terrain to mitigate current joint force capabilities and reduce effectiveness of SOF tactical maneuver elements.

2. Challenges exist to increase capacity of key SOF war fighting functions to both fight VEO and deter or defeat GPC.

3. Advances in artificial intelligence and robotic autonomous systems can be leveraged by SOF to create human machine teams capable of bringing greater mass, speed, range, precision, and certainty to SOF war fighting functions.

Artist concept of AI Mobile Robots in support of SOF operations

SECTION 1 - INTRODUCTION

1.1. Purpose - Artificial Intelligence for Small Unit Maneuver (AISUM) provides a vision of how future USSOCOM Special Operation Forces (SOF) tactical maneuver elements will team with intelligent adaptive systems to greatly enhance mission access, precision, speed, and mass in complex, contested and congested environments. AISUM enhances kinetic and non-kinetic effects, while reducing risk to missions, own force, populations and infrastructure.

1.2. Background - Battlefield movement has evolved throughout history; from melee, to mass, to the maneuver concepts documented in current military doctrine. Today's military scientists are examining swarming tactics as the next evolution of maneuver capable of addressing the emerging trends shaping competition and conflict. For the purposes of this concept package, the definitions of maneuver, swarming, artificial intelligence (AI) and robotic autonomous systems (RAS) includes, but is not limited to, the following skill sets required to conduct AISUM:

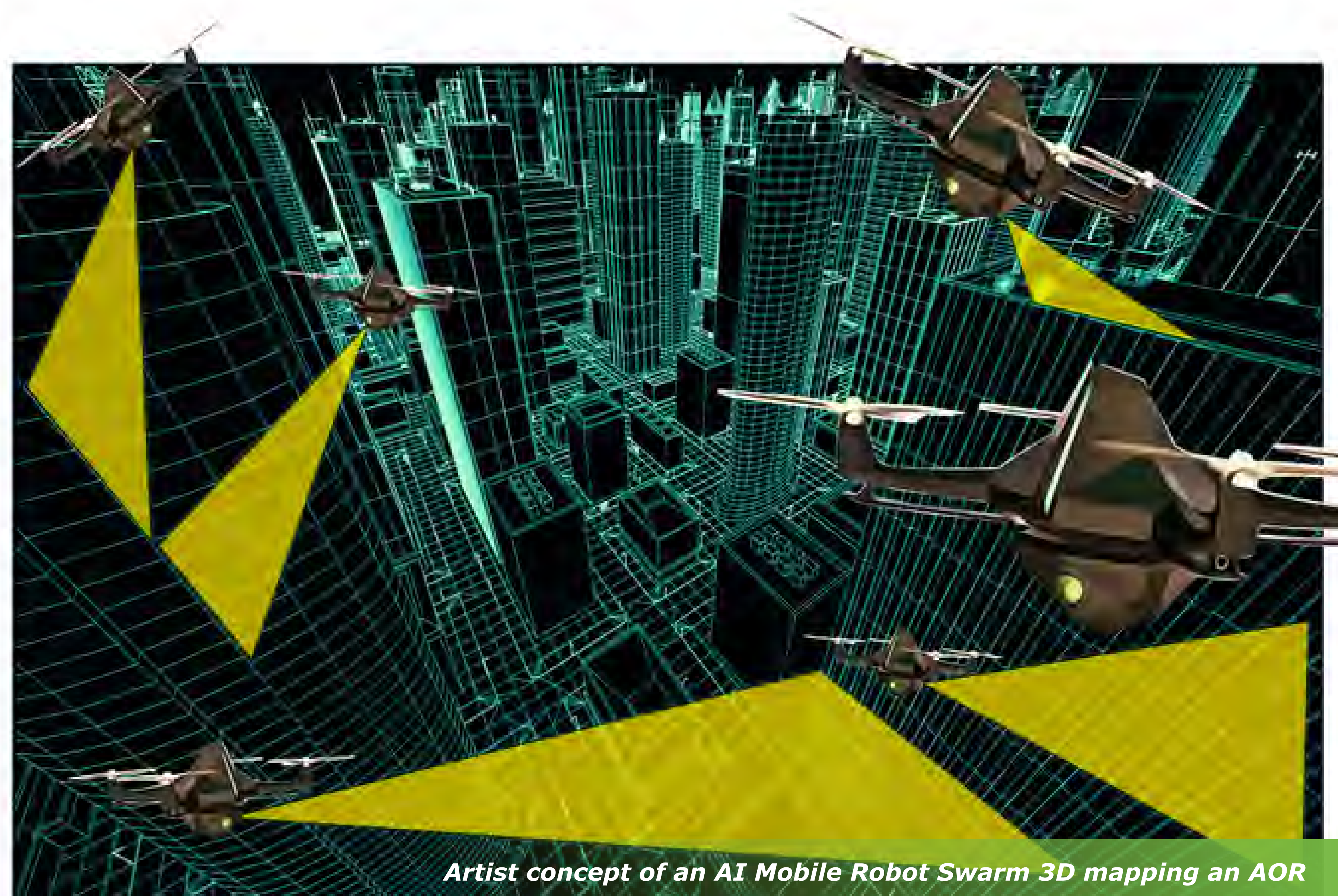
DIGITAL SCAN MAPPING

How does photogrammetry work?

In photogrammetry, a drone captures a large number of high-resolution photos of an area both exterior and interior. These images overlap such that the same point on the ground is visible in multiple photos and from different vantage points. In a similar way that the human brain uses information from both eyes to provide depth perception, photogrammetry uses these multiple vantage points in images to generate a 3D map.

Result: A high-resolution 3D reconstruction of a real world environment that contains not only elevation/height information, but also texture, shape, and color for every point on the map.

Uses
Simulation: High-fidelity simulation paired with 3D reconstruction of real world environments allows AI engineers to develop and validate drone autonomy capabilities quickly. Realistic environments enable rapid advancement and development of new autonomous capabilities. Via learning in simulation robots can learn how to adapt and solve new problems. Training, Planning and Rehearsals: 3D reconstruction of real world environments creates an inexpensive, highly realistic and immersive environment available in Virtual Reality to democratize training, test and validate SOF planning and rehearsals.



Artist concept of an AI Mobile Robot Swarm 3D mapping an AOR

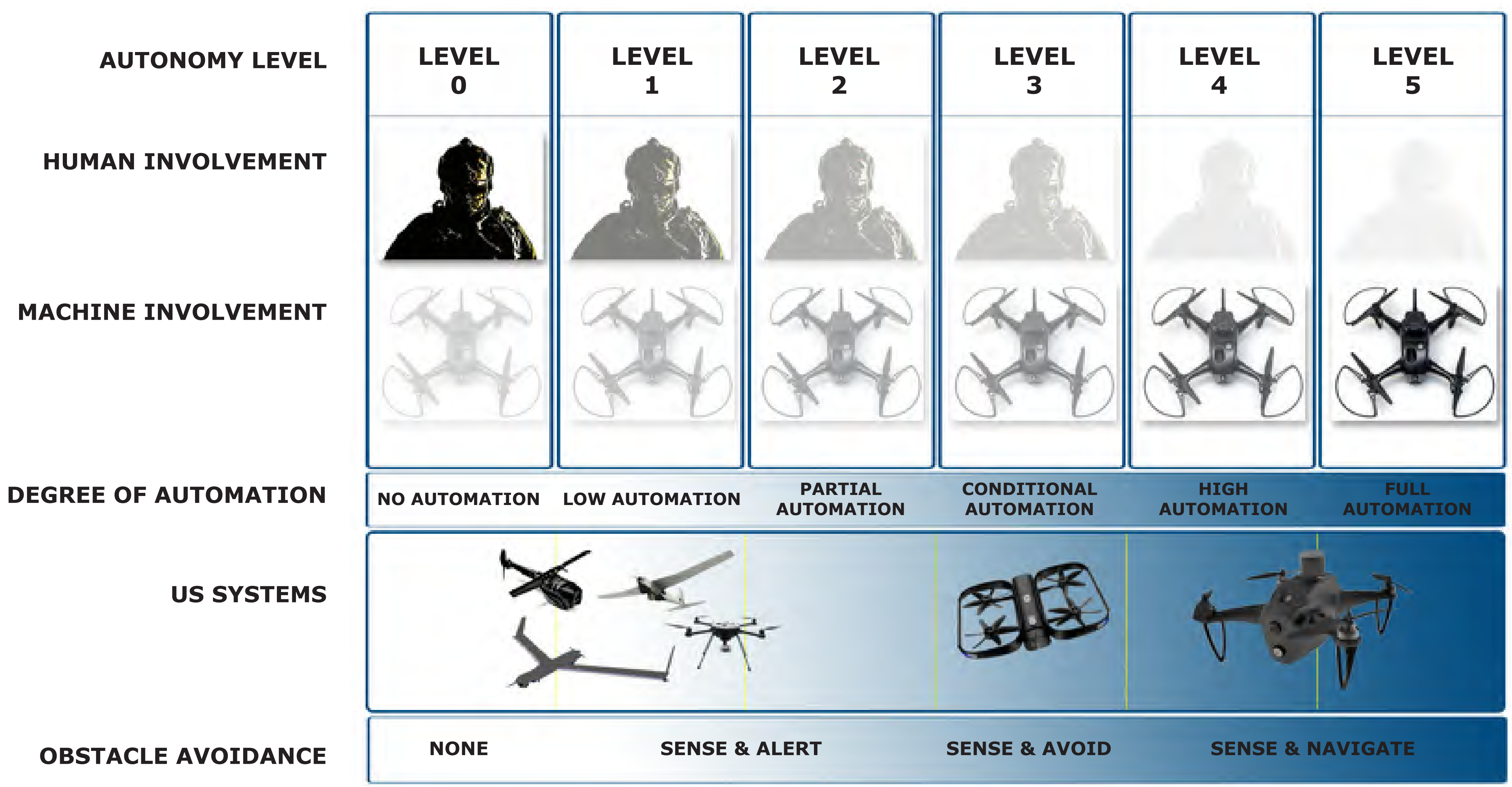
Maneuver is the cognitive and physical employment of mutually supporting lethal and non-lethal capabilities in multiple domains (sea, air, land, cyber). Maneuver generates overmatch, presents dilemmas to the enemy, and enables joint force freedom of movement and action. SOF currently employs small unit tactical maneuver to concentrate effects in decisive space across sea, air, land, and cyber domains to achieve advantage over enemy forces at the time and place of its choosing.

Swarming is the concept of engaging an adversary from all directions with concentrated, simultaneous precision effects. Swarming utilizes large numbers of dispersed elements (operators and RAS) that mass quickly to fight together as one cohesive unit then disperse before the adversary can react. (Note. This concept paper focuses on military swarms involving human-machine teams vice machine only swarms).

Artificial Intelligence (AI) is the ability of a computer system to solve problems and to perform tasks that would otherwise require human intelligence. Advances in AI are making it possible to cede to machines many tasks long regarded as impossible for machines to perform.

Robotic and Autonomous Systems (RAS) are physical systems (machines) capable of carrying out a set of complex tasks in an environment. Autonomy is the level of independence a system is capable of in an environment based on a combination of sensors and advanced computing (artificial intelligence).

5 LEVELS OF DRONE AUTONOMY



'ar·ti·fi·cial in·tel·li·gence'

In computer science, artificial intelligence (AI), sometimes called machine intelligence, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans.

Leading AI textbooks define the field as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals.

Colloquially, the term "artificial intelligence" is often used to describe machines (or computers) that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving".

Autonomous Mobile Robots
The extent to which a robot can sense its environment, plan based on that environment, and act upon that environment with the intent of reaching some task-specific goal (either given to, or created by the robot) without external control.

SECTION 2 - MANEUVER CONTEXT

2.1. Operational Context - The future operating environment will be increasingly more complex, congested and contested. After nearly two decades of sustained operations against violent extremist organizations (VEOs), SOF's operational context has expanded to include rapid dispersal of commercial technologies, new concepts of warfare, and great power competition (GPC) that spans a continuum from cooperation, to competition below armed conflict and lastly armed conflict.

In addition to conducting cooperative activities with our allies and partners, SOF must be prepared to support the Joint Force with competitive activities below the threshold of armed conflict, continuing the VEO fight and challenging great power competitors who are seeking to turn competition or conflict to their advantage – ***no easy task.***

2.2. Emerging Operational Environments (Contested, Complex, Congested)

2.2.1. Past Environments – In the past 20 years, Special Operations Forces (SOF) have perfected the combination of its tactical maneuver elements, small arms precision fires with overhead manned and remotely piloted airborne ISR and its aerial delivered precision firepower to precisely find, fix and finish networked threats with great precision. These non-state actors, operating in two dimensional (2D) battlespace, namely rural and urban sprawl, had little to no access to electronic warfare (EW) tools; in turn, permitting our airborne intelligence and fires platforms freedom of movement as well as the uncontested use of the electromagnetic spectrum. After nearly two decades of sustained operations against violent extremist organizations we have become masters of the close-in two-dimensional threat environment.

2.2.2. Emerging Environments – In today's emerging environments, adversaries will attempt to contest all domains with advanced technology and take advantage of complex and congested three dimensional (3D) battlespace to reduce effectiveness of SOF tactical maneuver elements, ISR and precision fires. The inability to maintain continuous airborne ISR feeds and key communications and navigation bands of the electromagnetic spectrum in these dense urban clutter and subterranean environments will leave our tactical maneuver elements challenged to conduct precision operations across the breadth and depth of the battlefield.

Therefore, SOF must re-imagine how to operate in an environment where adversaries possess the capability to degrade situational awareness, shared understanding, and common operating pictures.

SECTION 3 - MILITARY PROBLEM AND COMPONENTS OF THE SOLUTION

3-1. Military Problem - How do SOF forces scale the capacity of its precision capabilities from the existing VEO fight in semi-complex and congested land environments while posturing to deter or defeat peer threats in contested multi-domain environments?

3-2. Central Idea - Emerging robotic autonomy technologies and robust cloud to edge communications and processing will enable SOF to form dispersed man-machine tactical maneuver elements that drastically scale existing SOF precision capabilities to conduct independent activities as well as unite to conduct improvised, coordinated and precision manuever, intellkigence and effects-based operations.

3-3. Concept Synopsis - Artificial Intelligence for Small Unit Maneuver (AISUM) is the solution to maneuvering within contested, complex, and congested environments with existing SOF capacity.

AISUM is the convergence of artificial intelligence, robotic autonomous systems and SOF operational concepts to create tactical elements capable of conducting city scale direct action and special reconnaissance missions generating dilemmas, disruption, and overmatch for adversaries across the competition conflict continuum.

AISUM combines SOF tactical maneuver elements with RAS to create a human machine maneuver element that is optimized to gain, maintain and extend access in contested, complex and congested environments providing decision advantage and the precise application of effects. Elements of AISUM have proven in a limited wargame simulation to be very effective. AISUM revealed the ability of a smaller force reinforced with autonomous air and ground robots to create problems for a much larger and capable force. It validated the difficultly for an adversary to counter a distributed AISUM TME that is small, that is mobile, but has the capability to reach out and unleash pinpoint effects both interior and exterior at extended ranges.

Artist concept of AI Mobile Robot Swarm in support of SOF operations

3-3. Concept Synopsis (cont.)

AISUM applies advanced, edge-level intelligence to make rapid, on-site decisions as it responds to continually changing circumstances and environments. AISUM's autonomous, mobile robots strength is that they are capable of GPS denied movement and navigation in interior and exterior environments. The deployment of swarms over large geographic areas provides rapid mapping, navigation, searches, and exploitation of complex environments. These critical capabilities allow SOF to remove cover and concealment from the adversary. The challenge is integrating and synchronizing swarms across multiple domains, at a single point in time and space to create overmatch in support of a maneuver plan (tactical), a campaign plan (operational), or strategic objectives.

The Nova from Shield AI

Robotic systems can learn and share their experiences, from the real world and in simulation, to become smarter with each use. Leveraging virtual reality (VR), SOF tactical maneuver elements and their robotic teammates can rapidly rehearse across a multitude of operational environments. They can identify concept gaps, refine TTPs, and determine the statistical likelihood of mission success all before facing the demand of real-world operations. The iterative, aggregated learning of these integrated maneuver teams enables SOF to regenerate with less investment and sustain higher levels of readiness.

3-4. Components of AISUM - There are several technical capability components to increased autonomy in human-machine manuever teams.

Autonomy: Autonomy is broken into 3 components: perception, cognition, and action. These components enable robots and teams of robots to make intelligent decisions, navigate, explore, react to changes in the environment, and leverage the unique characteristics of different platforms within the robot formation.

Perception: Perception refers to the robot's ability to observe and generate data about the environment around it.

Cognition: Cognition is the thinking component of the robot. It is where the data the robot collects through perception is processed, interpreted, and used to draw conclusions and make decisions.

Action: The action component takes the decisions made with cognition and employs them to allow the robot to engage in the environment. In the case of multi-rotor drones it is the ability to conduct three-axis maneuverability, move along multiple axes, or remain stationary (hover or land and remain in place).

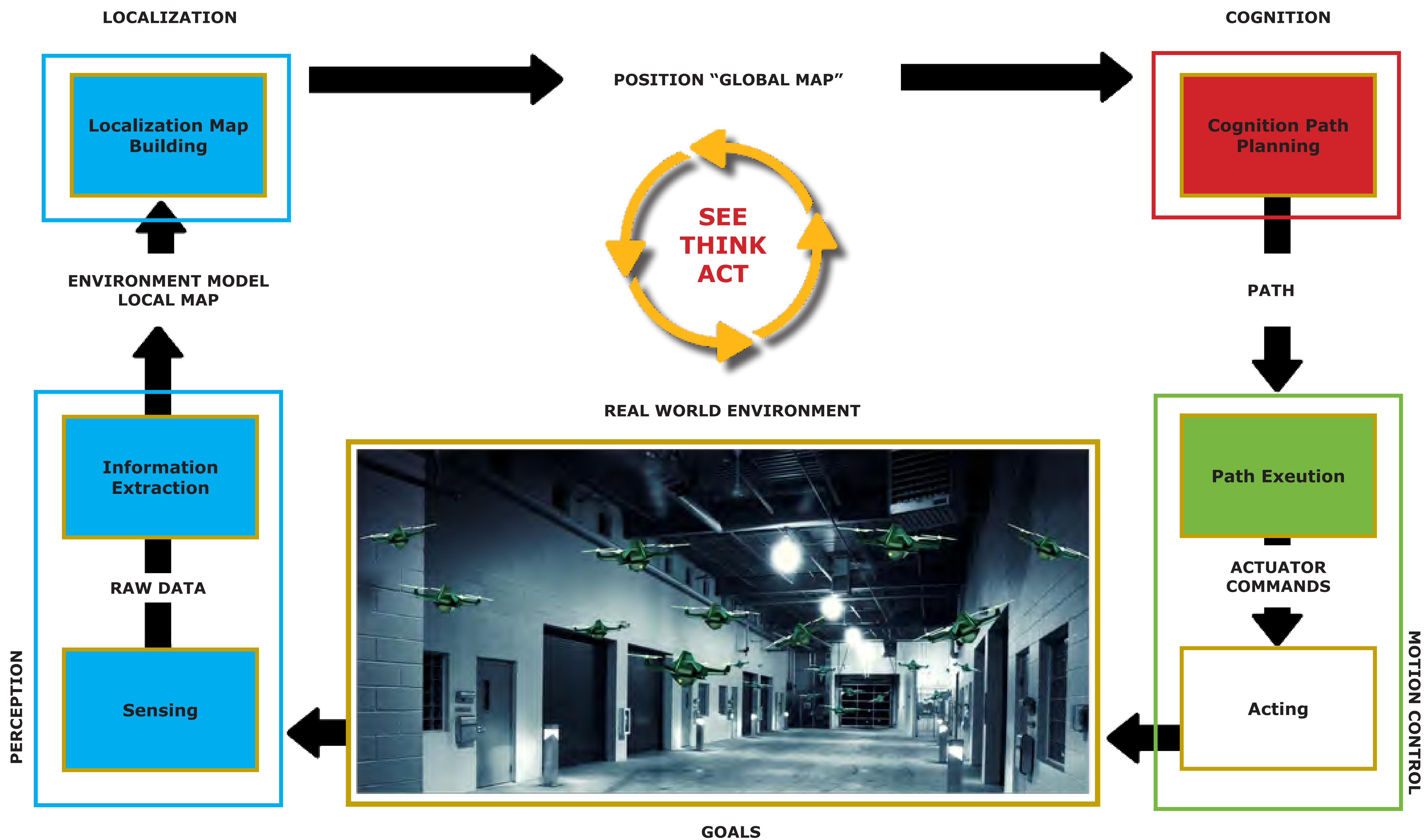
Small Size Platforms: Small enough to maneuver in both exterior and interior environments. This rules out tele-operation (human-piloted) of vehicles (Level 1 autonomy) and anything larger than Group 1 size platforms. Capable of carrying small kinetic and non-kinetic effects based payloads.

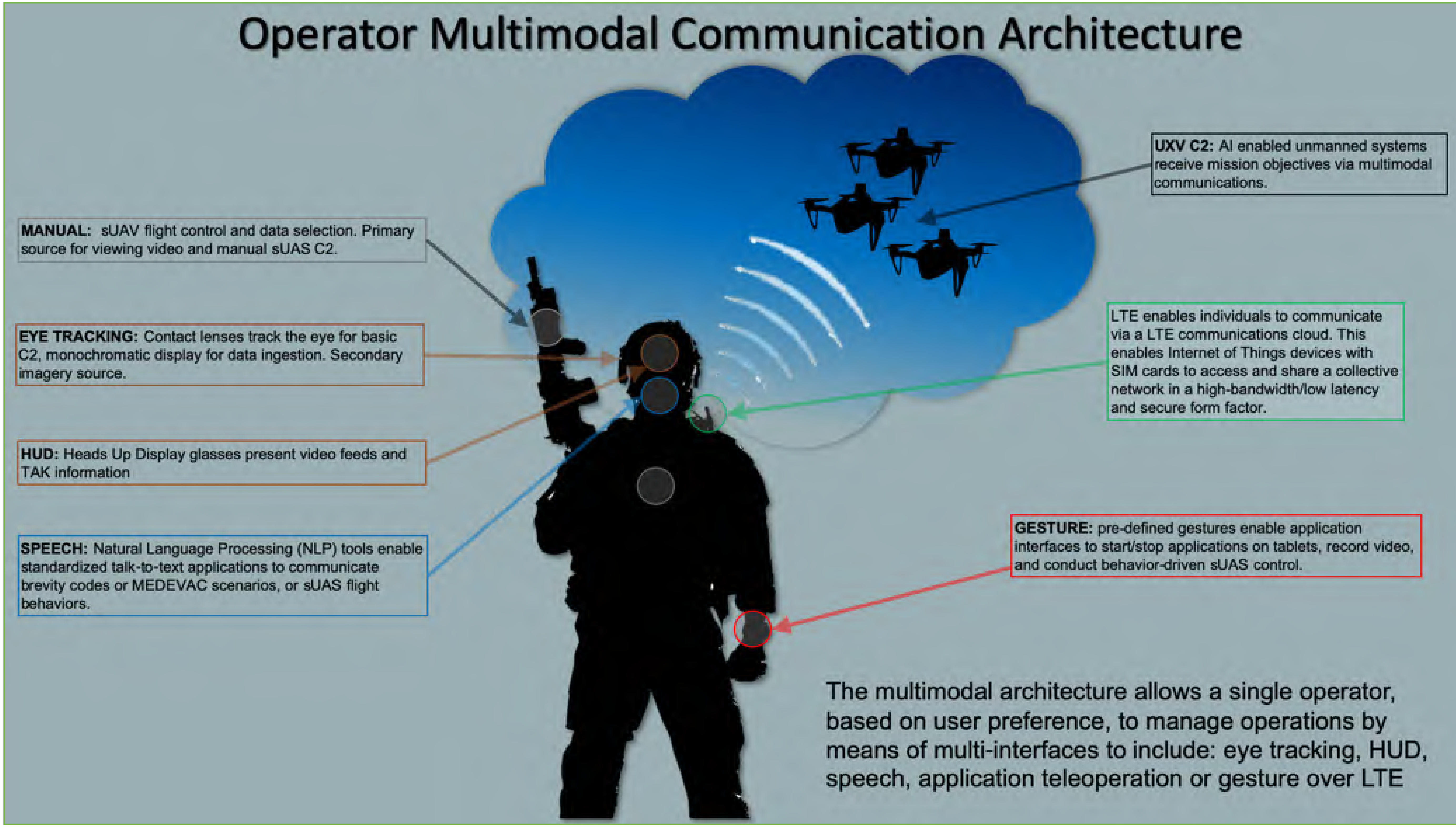
Interfaces: Capabilities that enable humans to effectively interact with, C2, validate and gain useful intelligence from the activities of an individual robot or teams of robots.

Integrated physical systems: In addition to autonomy and common control interfaces, SOF requires government-owned architecture, interoperability, common platforms, and modular payloads to ensure cost-savings and faster upgrades.

AUTONOMY METHODS	LEARNING METHODS	SOFTWARE AND INFRASTRUCTURE FOR AI SYSTEMS	HARDWARE FOR AI SYSTEMS	INTERFACE FOR AI SYSTEMS
Scene Understanding	Clasical Methods	Architecture	Sensing	Mobile
State Estimation	Reinforcement Learning	Build and Test	Computing	Desktop
Mapping	Supervised Learning	Cloud and Data	Communications (Transceivers)	AR
Motion Planning	Unsupervised Learning	Deployment	Interfaces	VR
Controls		Embedded	Vehicles	Gesture
		Middleware	Power	Speech
		Operating System		Manual
		Security		Tracking
		Simulation		

3-4. Components of AISUM (cont.)




Operator Multimodal Communication Architecture
MANUAL: sUAV flight control and data selection. Primary source for viewing video and manual sUAS C2.
EYE TRACKING: Contact lenses track the eye for basic C2, monochromatic display for data ingestion. Secondary imagery source.
HUD: Heads Up Display glasses present video feeds and TAK information
SPEECH: Natural Language Processing (NLP) tools enable standardized talk-to-text applications to communicate brevity codes or MEDEVAC scenarios, or sUAS flight behaviors.
UXV C2: AI enabled unmanned systems receive mission objectives via multimodal communications.
LTE enables individuals to communicate via a LTE communications cloud. This enables Internet of Things devices with SIM cards to access and share a collective network in a high-bandwidth/low latency and secure form factor.
GESTURE: pre-defined gestures enable application interfaces to start/stop applications on tablets, record video, and conduct behavior-driven sUAS control.
The multimodal architecture allows a single operator, based on user preference, to manage operations by means of multi-interfaces to include: eye tracking, HUD, speech, application teleoperation or gesture over LTE

3-5. Extending the Concept – The future operating environment requires SOF forces to operate dispersed with the ability to concentrate effects rapidly at decisive points to achieve tactical and operational objectives with strategic effects. Warfighting functions are the physical means that tactical commanders use to execute operations and accomplish missions. AISUM is the integration of movement, intelligence, and fires capabilities onto a single small platform. AISUM elements When swarmed and mission commanded by operators within a SOF tactical maneuver element these decentralized, geographically dispersed precision-strike and ISR networks achieve positions of advantage, understanding and overmatch while prevent the adversary from their ability to find, track and engage.

ISR: Conventional ISR is constrained to overhead two-dimensional imagery of exterior activities in permissive air environments. It offers little intelligence for activities conducted in complex and congested interior and subterranean environments. Its dependence upon resource intensive piloting and logistics means disproportionate personnel per fixed launch and recovery site and lengthy post-mission processing of critical targeting information. AI for ISR allows swarms of agents to operate in teams collecting a variety of sensor data not limited by the barriers present in complex environments. On platform data
processing means real time critical targeting confirmation such as facial recognition is reduced to seconds.

Maritime Mobility: SOF's fast, low-signature maritime mobility is capable of maneuver in highly contested and complex water space. Although AISUM focuses on maneuver of human-machine teams, fundamental to this concept is the development of mobility capabilities that are readily applicable and transferable to diverse systems, including other air, ground and water vehicles allowing for optionally piloted platforms.

Fires: AI for small unit fires envisions AI enabled small UAS providing a focused transfer of energy downrange sufficient to incapacitate the adversary across a broad spectrum of combat environments. A single-shot knockdown in interior and exterior confined close quarters as well as small UAS transiting long-range to targets across desert terrain. Increased understanding of the environment via AI for ISR will inevitably lead to greater levels of precision and certainty in effects-based action. It will reduce risk to operators, lessen collateral damage and ensure higher confidence targeting solutions, cueing a multitude of effects-based options. This enables massed synchronized fires in time and space, overwhelming adversaries' defenses by their sheer number. This construct provides an increase in area coverage of highly distributed and survivable networked maneuver elements capable of conducting both kinetic and non-kinetic effects.

Secure autonomous networks: Swarming requires self-healing decentralized networks that respond to dynamic events such as contested EMS or widely distributed man-machine tactical maneuver elements that cooperate for sensing, effects and edge computing. This will require on-device capabilities for processing low entropy data and transmitting only the relevant content back to the cloud. Considering the challenges in contested EMS's large volume time sensitive data needs to be edge processed at the collection platform while time insensitive tasks requiring large amount of compute resources, like AI model training, can be processed in the central cloud.

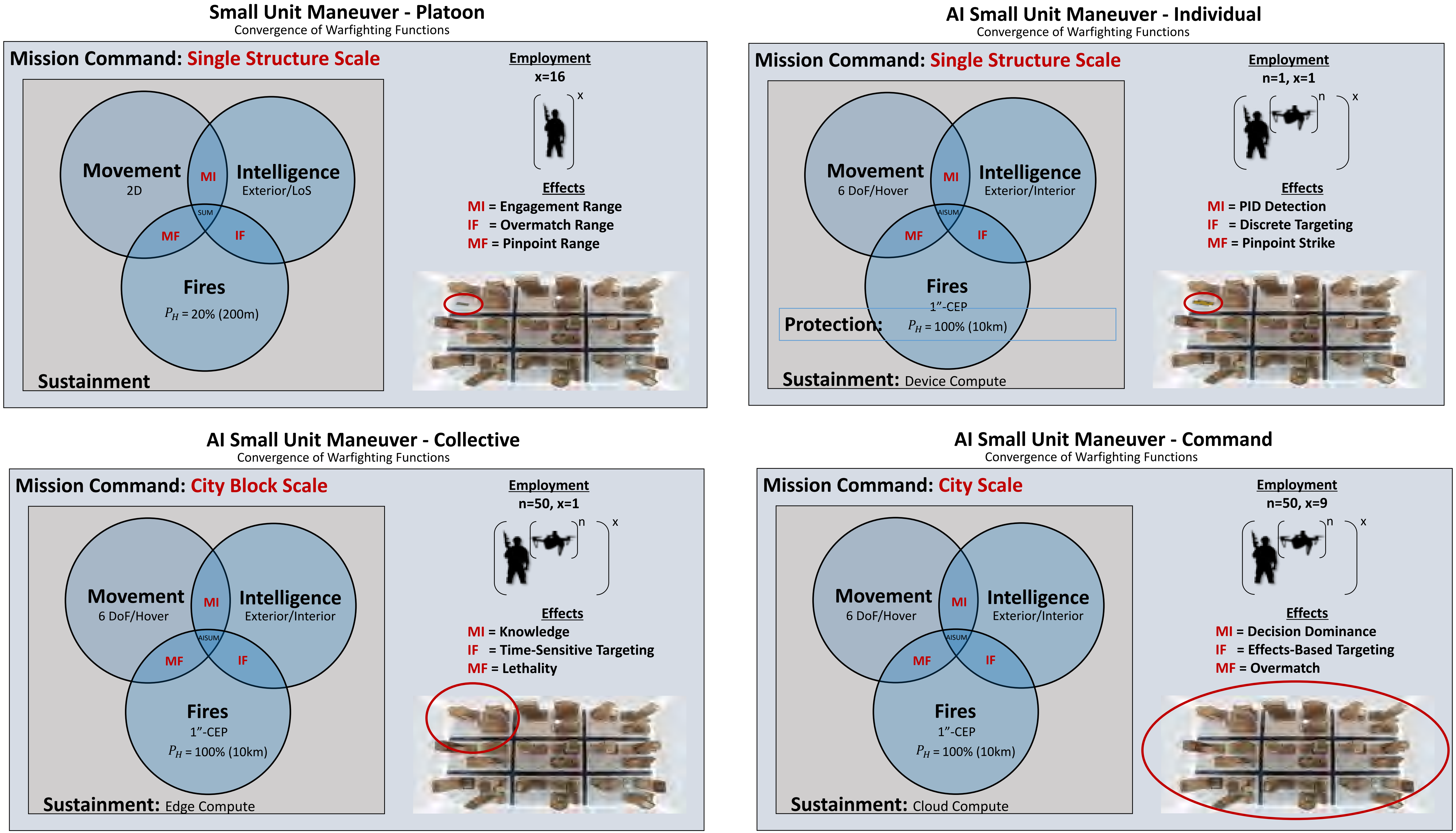


Figure #. Small Unit Maneuver versus Artificial Intelligence for Small Unit Maneuver (AISUM) where n represents the number of AI enabled robots and x the number of operators.

a. Traditional Tactical Maneuver Element employment (n=0, x=16): capable of single structure operations. **b.** Employed as AISUM Individual (n=10, x=1): capable of single building operations. **c.** AISUM Collective (n=50, x=1): capable of city block operations. **d.** AISUM Command level (n=50, x=9): capable of city scale operations.

SECTION 5 - ROI VIGNETTES

5.1. VIGNETTE 1: DRONE DEPLOYMENT OF FORWARD SENSORS TO INCREASE STAND OFF DISTANCE AND CONDENSE MISSION TIMELINES

Description -
A special reconnaissance team uses a drone with a sensor emplacement mechanism to deploy and embed a camera in a denied area to retrieve intelligence undetected. The drone covers 20 miles to the objective in 16 minutes and emplaces the sensor in 2 minutes; then, returns back to the standoff location. SOF operators at the standoff location use the gather sensor intelligence to conduct direct action operations the next day.

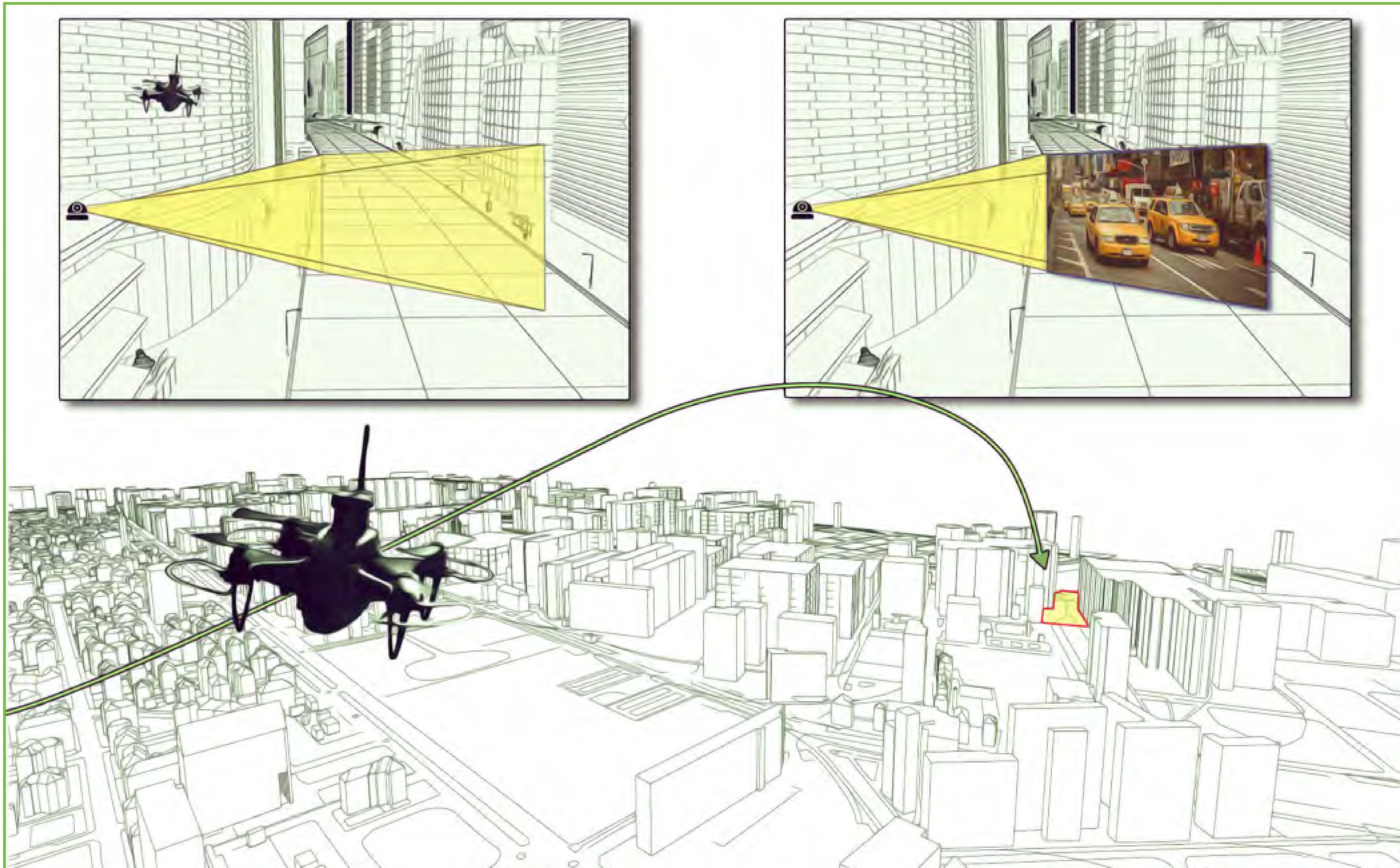
Key Takeaways -
A drone with an on-board sensor emplacement mechanism moves 90x faster than a reconnaissance team covering the same distance.

Drones that leverage efficiencies to condense mission timelines could re prioritizing SOF taskings and improve dwell times.

Ground emplaced sensors improve upon the current conventional, aerial ISR-dominance by extending reach into complex environments (e.g. dense canopy or denied) by enabling street level and/or interior intelligence.

Unmanned systems can carry loads up to 1000lbs. Such systems could be used to pre-deploy supplies ahead of an SR/DA element; to augment personnel recovery; or to supplement operator movement during a mission. The average SOF operator carries around 70lbs – meaning that an unmanned system could reduce the load burden and enable operators to move quicker. A special recon team can cover 20 miles/day; while a drone can travel 75 mph for up to 22 hours with an 8# payload.

There's currently a 25% reduction on global SOF taskings; and current SOCOM deployment-to-dwell ratio is 1:2 or greater.



SECTION 5 - ROI VIGNETTES (cont)

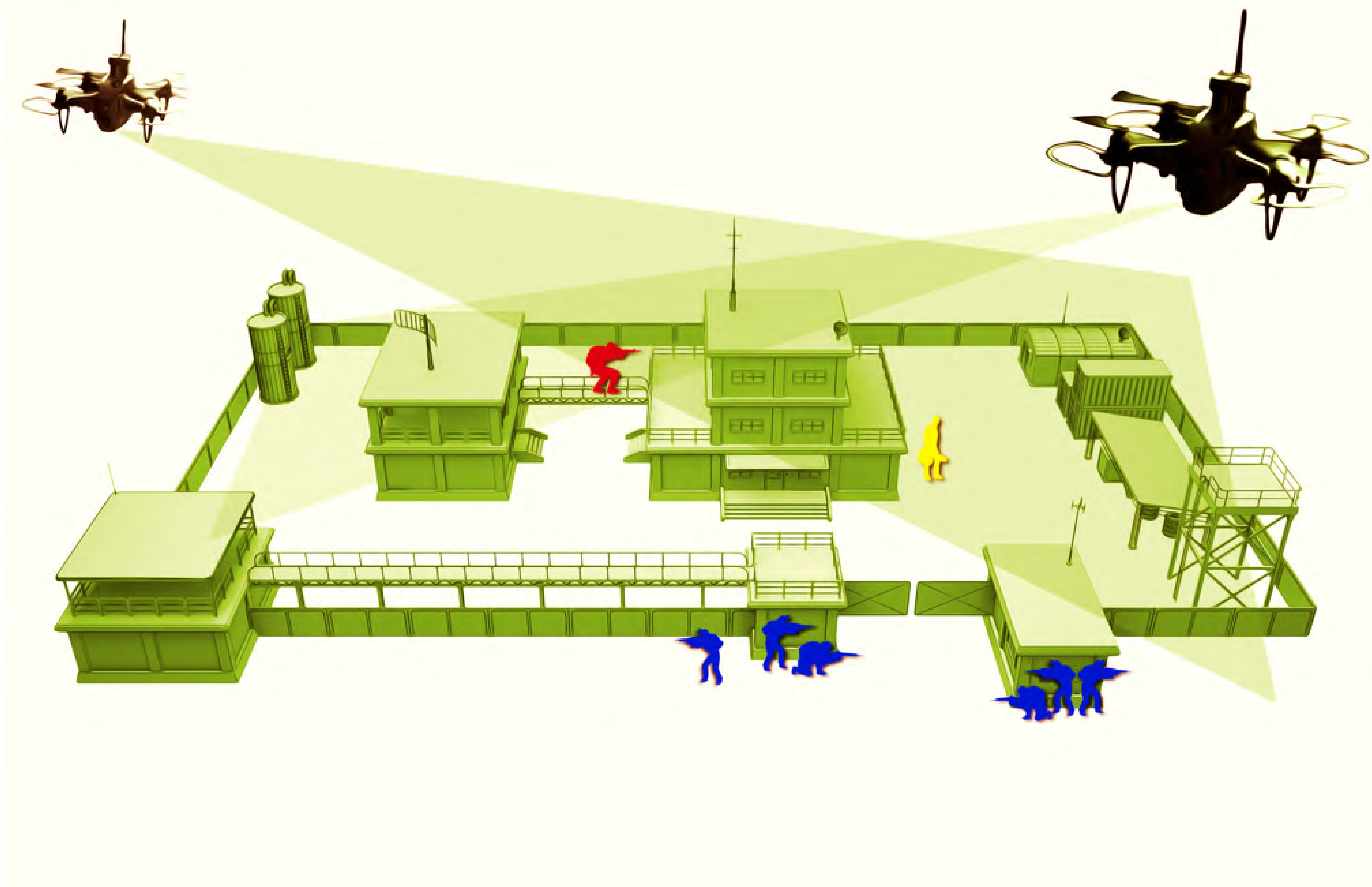
5.2. VIGNETTE 2: AI-ENABLED DIRECT ACTION TO DECREASE OPERATOR INJURY/LOSS

Description -
A SOFvteam on the objective is preparing to enter a building, however, there is a sniper entering a nearby warehouse to potentially engage. AI-enabled advanced threat detection warns the team of the sniper. Simultaneously, a non-combatant is approaching the team but has no hostile intent. The AI-enabled system notified the team of the non-combatants movements.

Key Takeaways -
67% of recent KIAs were SOF even though they only make up 5% of the force. Increasing standoff distance decreases risk of loss or injury.

Supervised autonomous systems have the ability to rapidly discriminating hostile intent and filtering out threats in complex urban environments.

A future-state remote biometric sensor watches the heart rates of potential adversaries and is able to detect an increase in heart rate for a combatant approaching the team with an SVEST.



5.4. VIGNETTE 4: DRONE USE FOR SPECIAL RECONNAISSANCE TO AVOID FACIAL RECOGNITION

Description -

A SOF mission requires soaking a target where overhead assets are ill-suited. The area of operation is considered denied and there is intelligence that the enemy has advanced facial recognition technology. In order to avoid detection, and in order to avoid adversarial capture of SOF operator identity, a street-level drone is deployed.

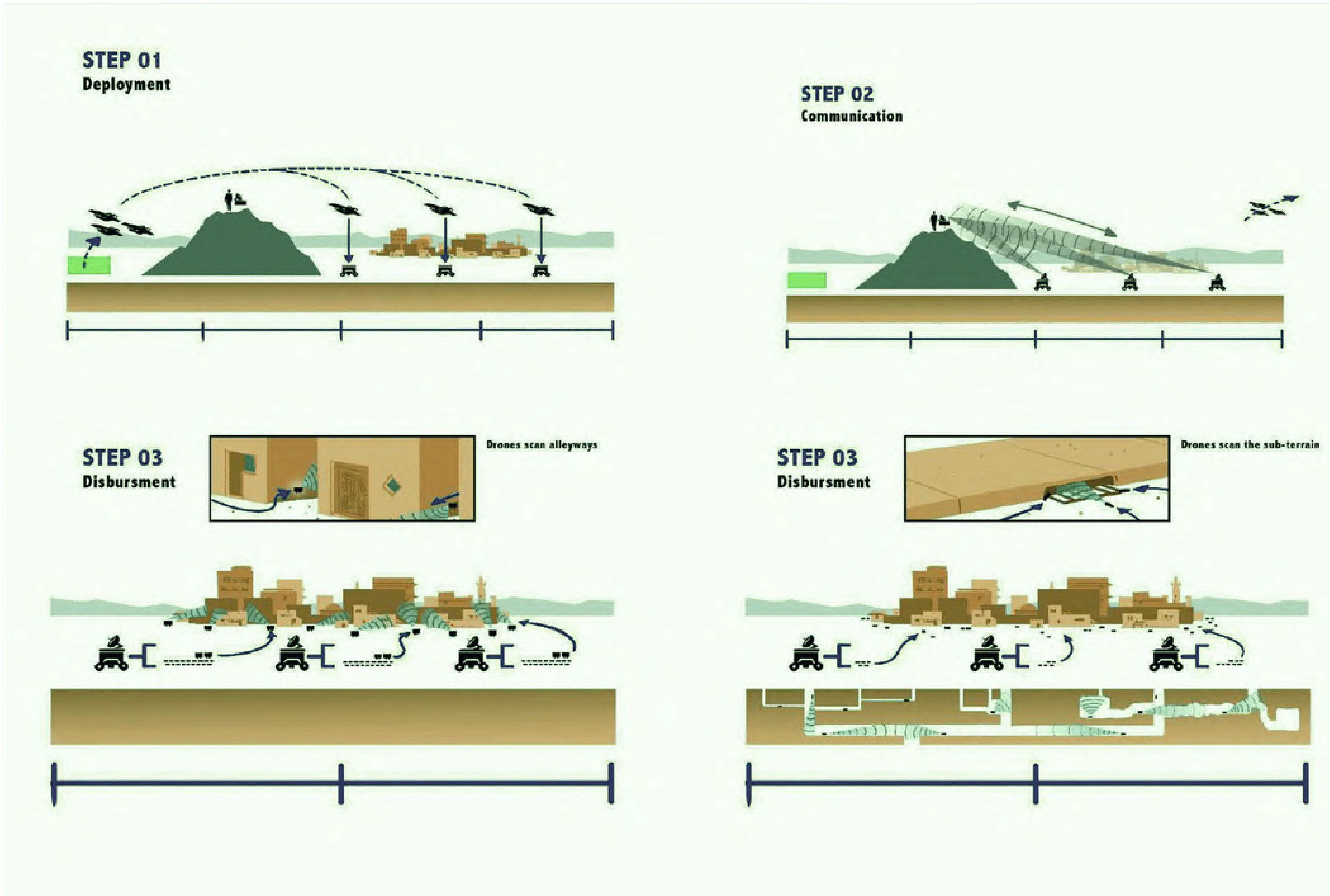
Key Takeaways -

Training a drone to conduct SR is cheaper than a SOF operator. The cost to maintain a SOF asset per year is $1.5M, while it costs well over $350,000 to train one Navy SEAL.

One near-peer adversary will have facial recognition technology in all 59 of the city's public housing sites by the end of 2019. In that same country, there are 200M cameras actively conducting surveillance. By 2021, that will be tripled. In cases where teams are dropping into denied areas, facial recognition technologies with greatly thwart clandestine operations.
By 2023, 97% of all airports will have facial recognition technology. Operators traveling clandestine or on diplomatic passports through commercial airports will be tracked by the host country.

Drones being used to avoid facial recognition technologies could also house on-board facial recognition systems for counterintelligence.

The South Koreans have developed the Samsung SGR-A1 robot sentry to defend South Korea against North Korean border intrusion.58 In 2007, it was revealed the SGR-A1 had a fully autonomous mode, and a number of press sources began referring to it as a fully autonomous weapons system, which resulted in a great deal of negative press, although Samsung and South Korean officials noted that a human was required to engage targets. Reportedly, the SGR-A1s, which cost $200,000 apiece, are remotely operated sentries that mount either a 5.5mm machine gun or a 40mm automatic grenade launcher, which work in conjunction with cameras and radar systems that can detect intruders with heat and motion sensors and can challenge them through audio or video communications.


STEP 01
Deployment
STEP 02
Communication
STEP 03
Disbursment
Drones scan alleyways
STEP 03
Disbursment
Drones scan the sub-terrain

SECTION 6 – OPERATIONAL STORYBOARDS

OPERATION CASSANDRA CROSSING

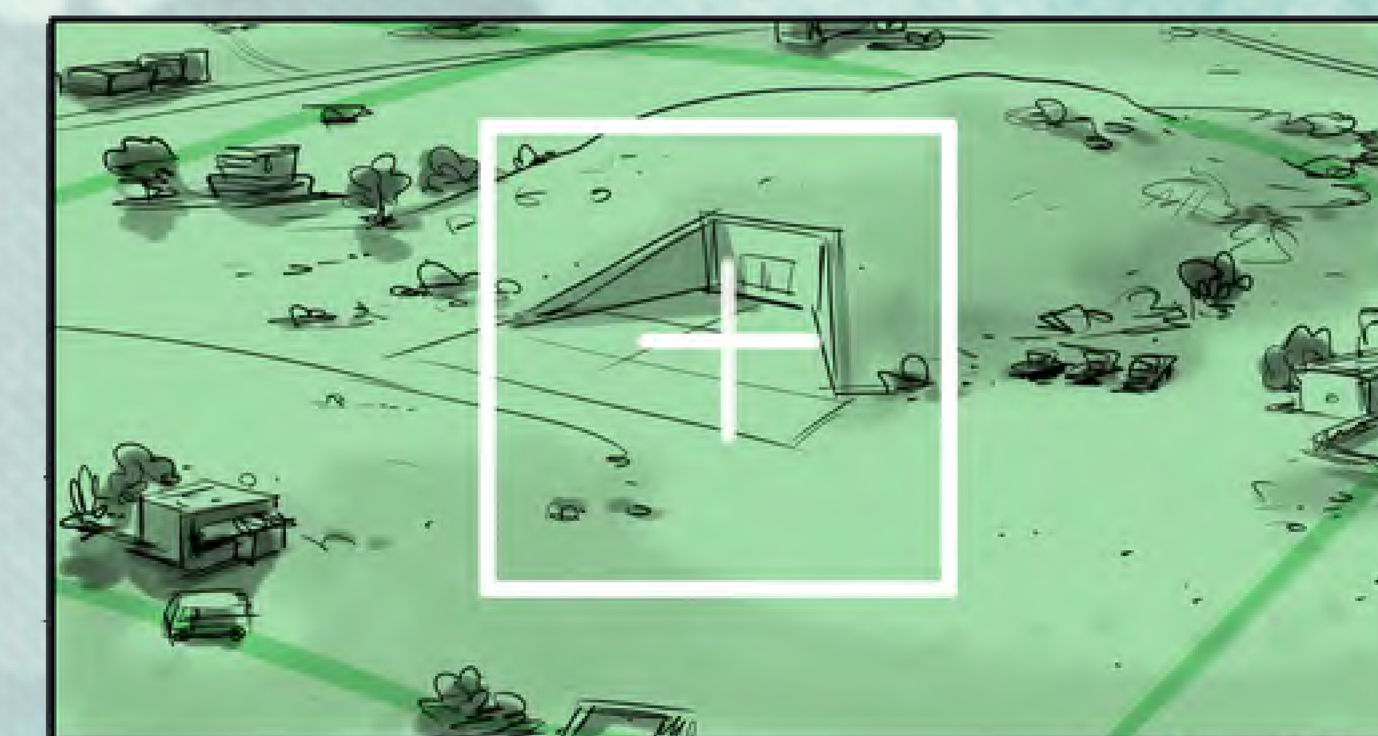
OBJECTIVE:
Confirm / defeat chemical warfare agent development in subterranean environment

MISSION:
Confirm chemical weapon manufacturing presence, and precise location
Determine personnel type and size
Determine security type and size
Conduct DA to defeat chemical weapon manufacturing

MISSION CONSTRAINTS:
No GPS
No Sat COMM
No telephone/WiFi

00:00::00

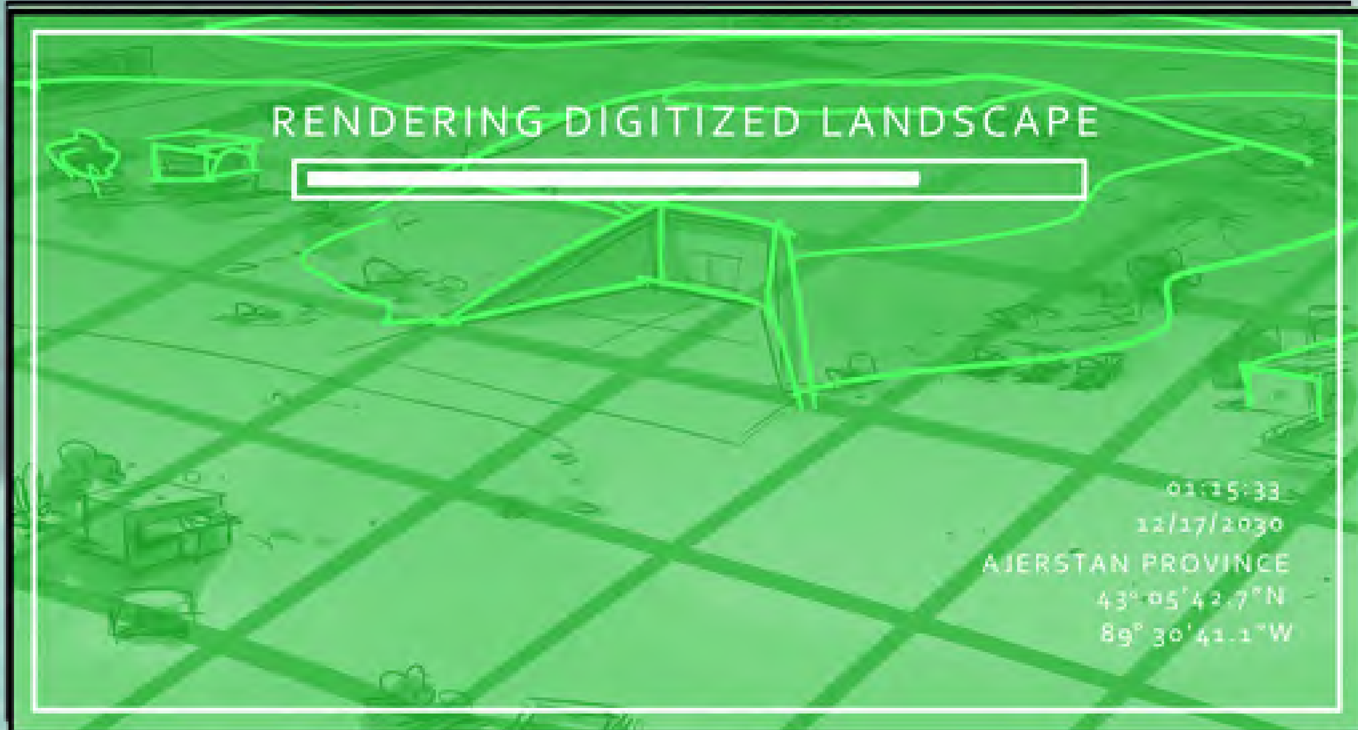
ISR COLLECTION OVER SAHARASTAN

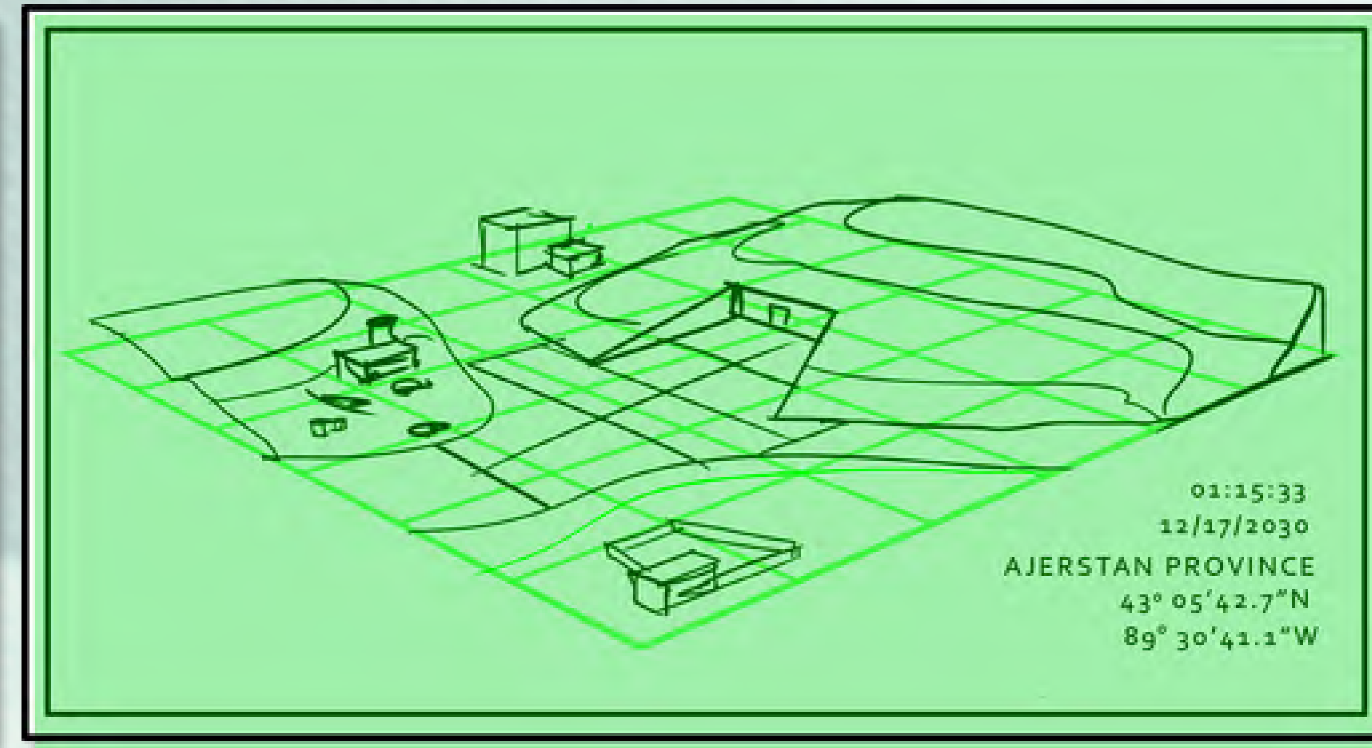


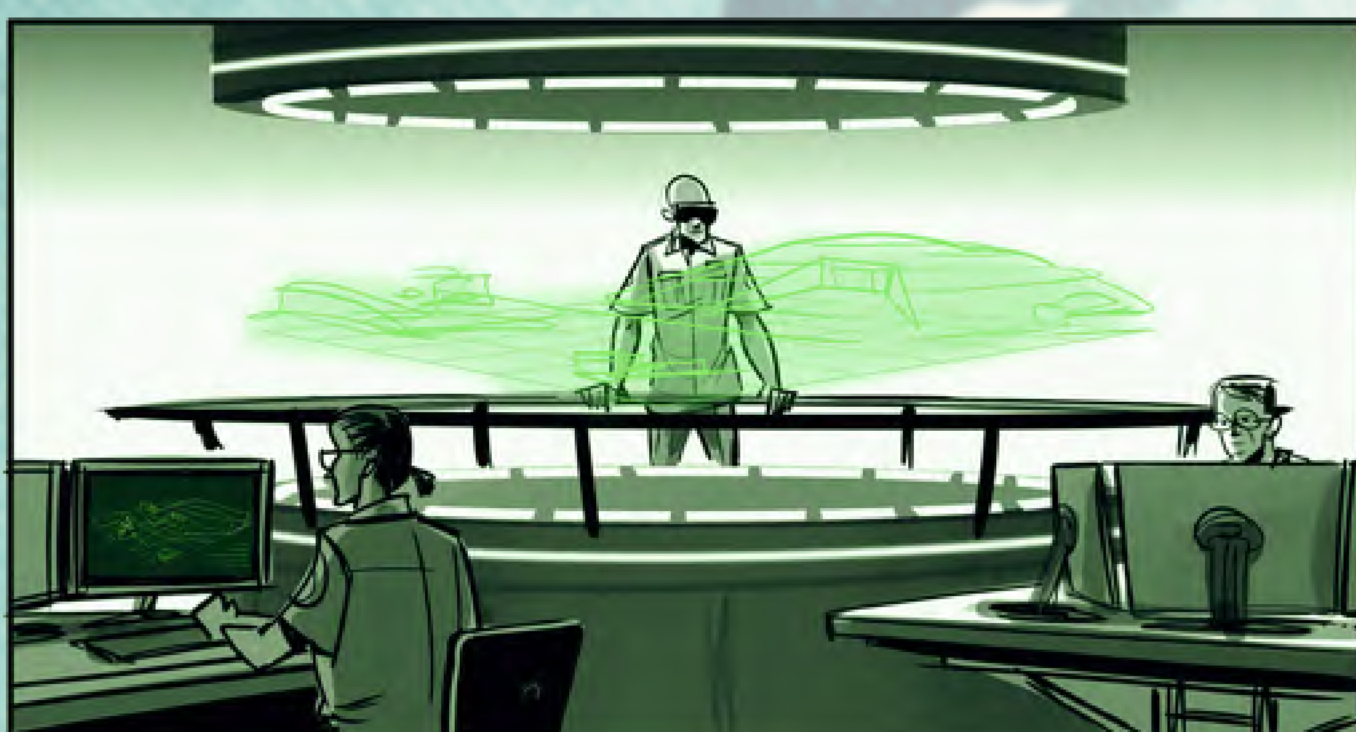
ISR data collection at Area of Interest, after several months of suspicious patterns of activity around a facility entrance in the country of Saharastan

00:30::00

BACK AT THE FOB ISR DATA IS PROCESSED





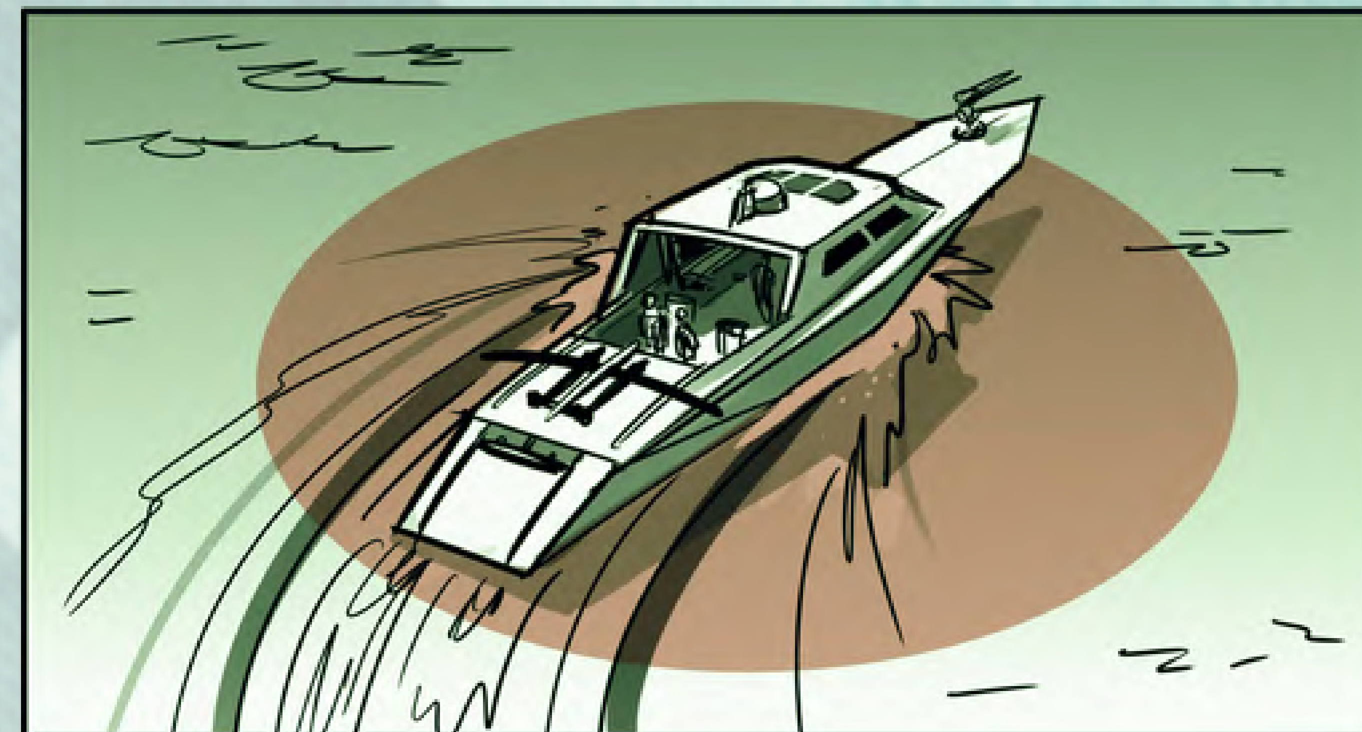


ISR data is plugged into he AI Hive mind, which converts ISR imagery into 3D wire-frame for viewing in a Virtual Reality Sandbox.

Special reconnaissance is authorized for the AOI

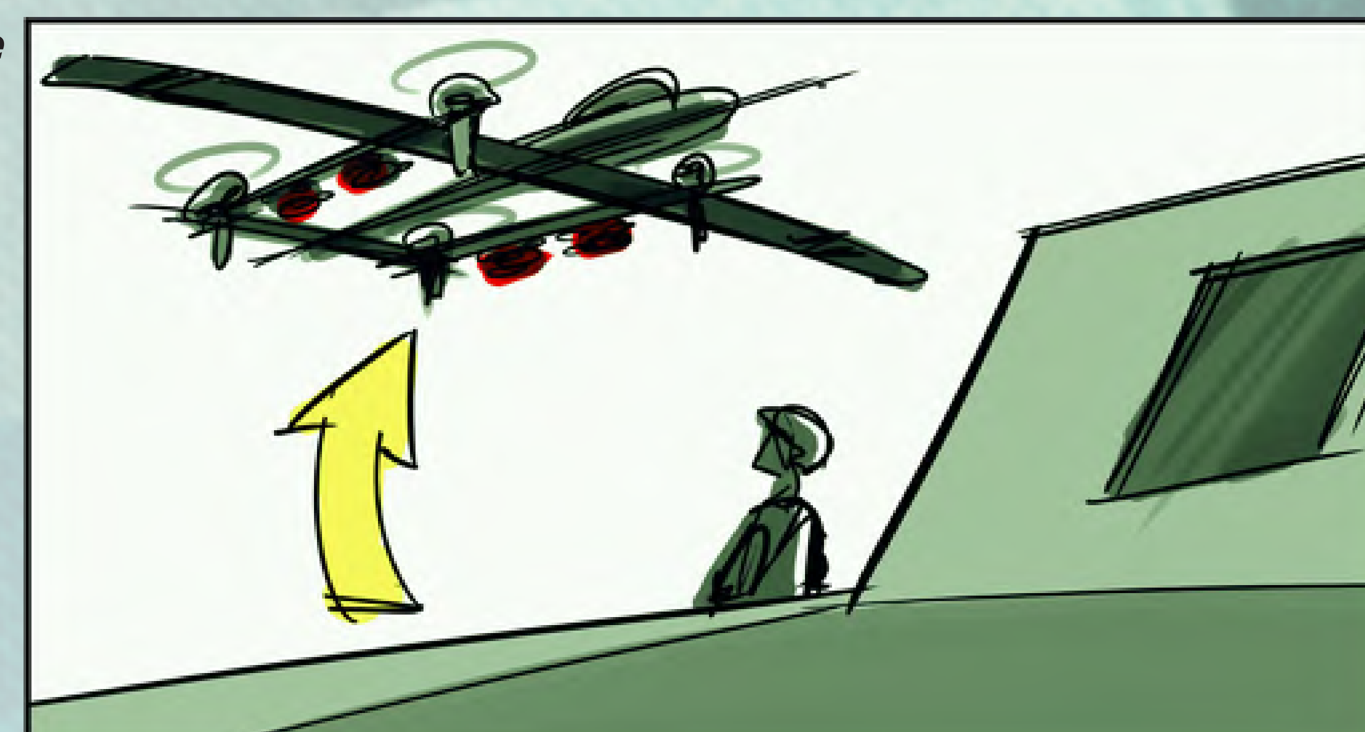
02:00::00

OFF THE COAST OF SAHARASTAN, JUST OUTSIDE THE EEZ



Maritime Special Operations Forces operate outside the Economic Exclusivity Zone.

Special Forces are notified by C2 to launch AI-SR platform



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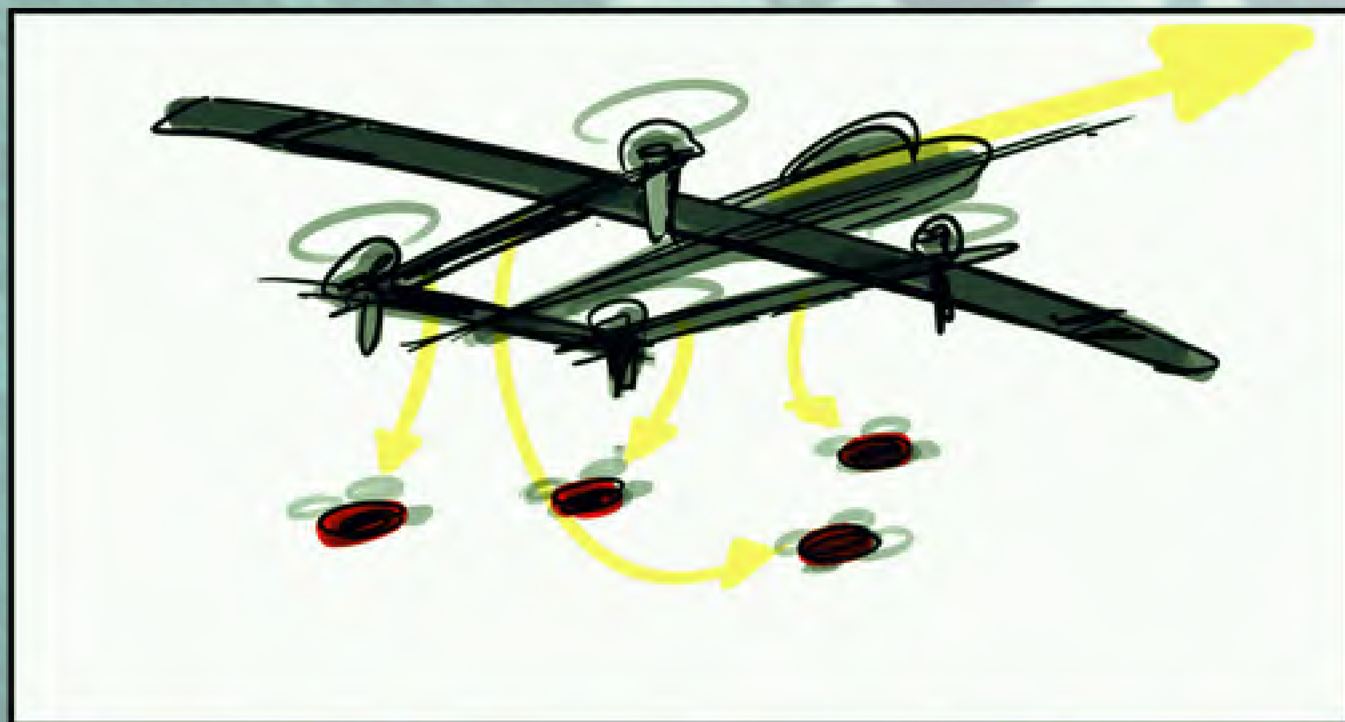
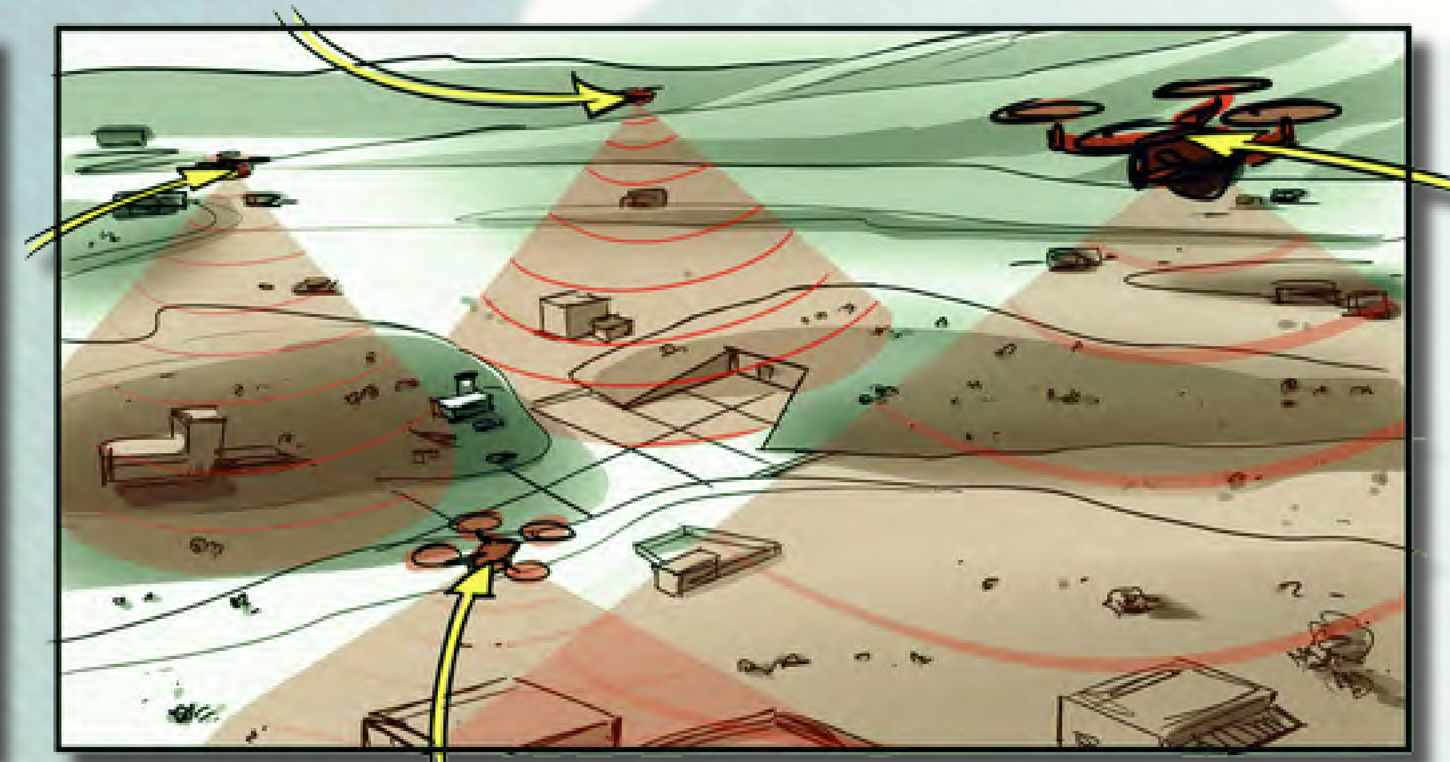
SPECIAL RECONNAISSANCE REVEALS MORE DATA ABOUT AOI





AI-SR platform arrives over AI and deploys mini drones to conduct SR.

Drones collect data on environment, buildings and local personnel.

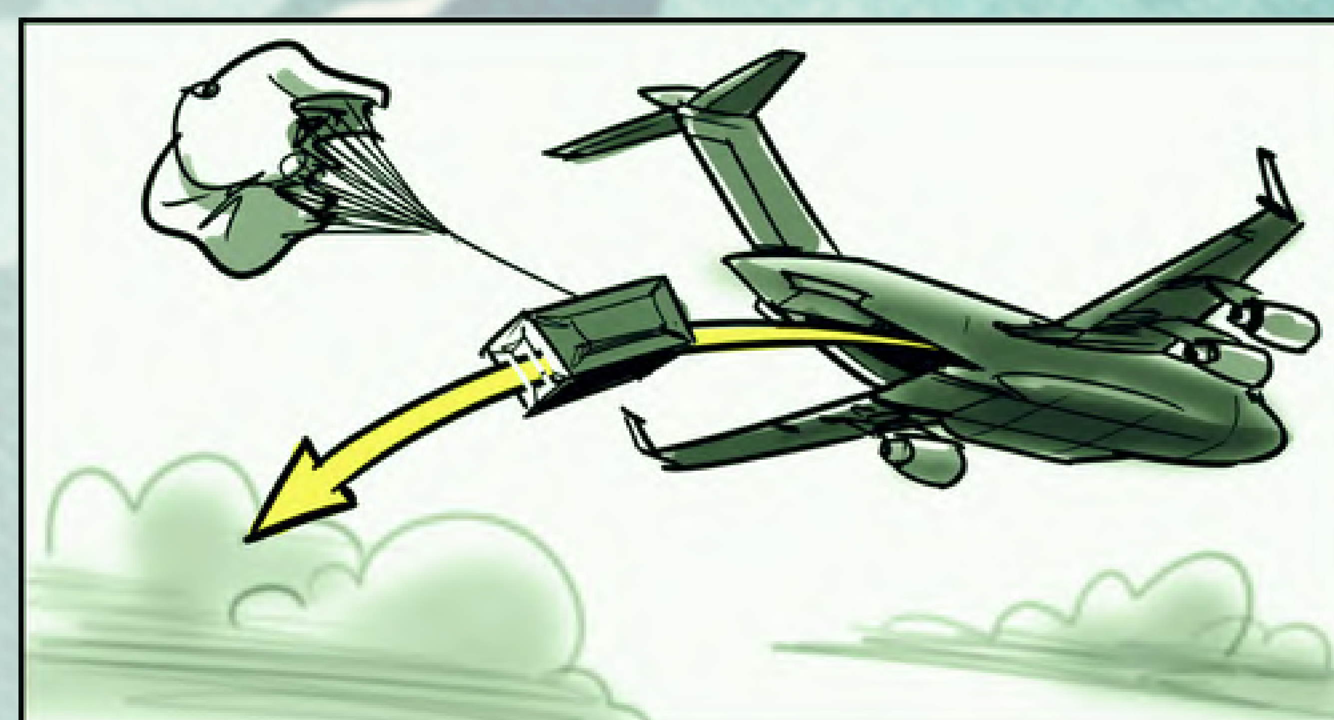
Drones detect low level signature for nuclear material

All camera and sensor data is relayed threw the sup-porting platform back to the FOB

02:30::00

AISUM DRONE SWARM IS DEPLOYED

Orders are given to deploy a drone swarm into the AOI



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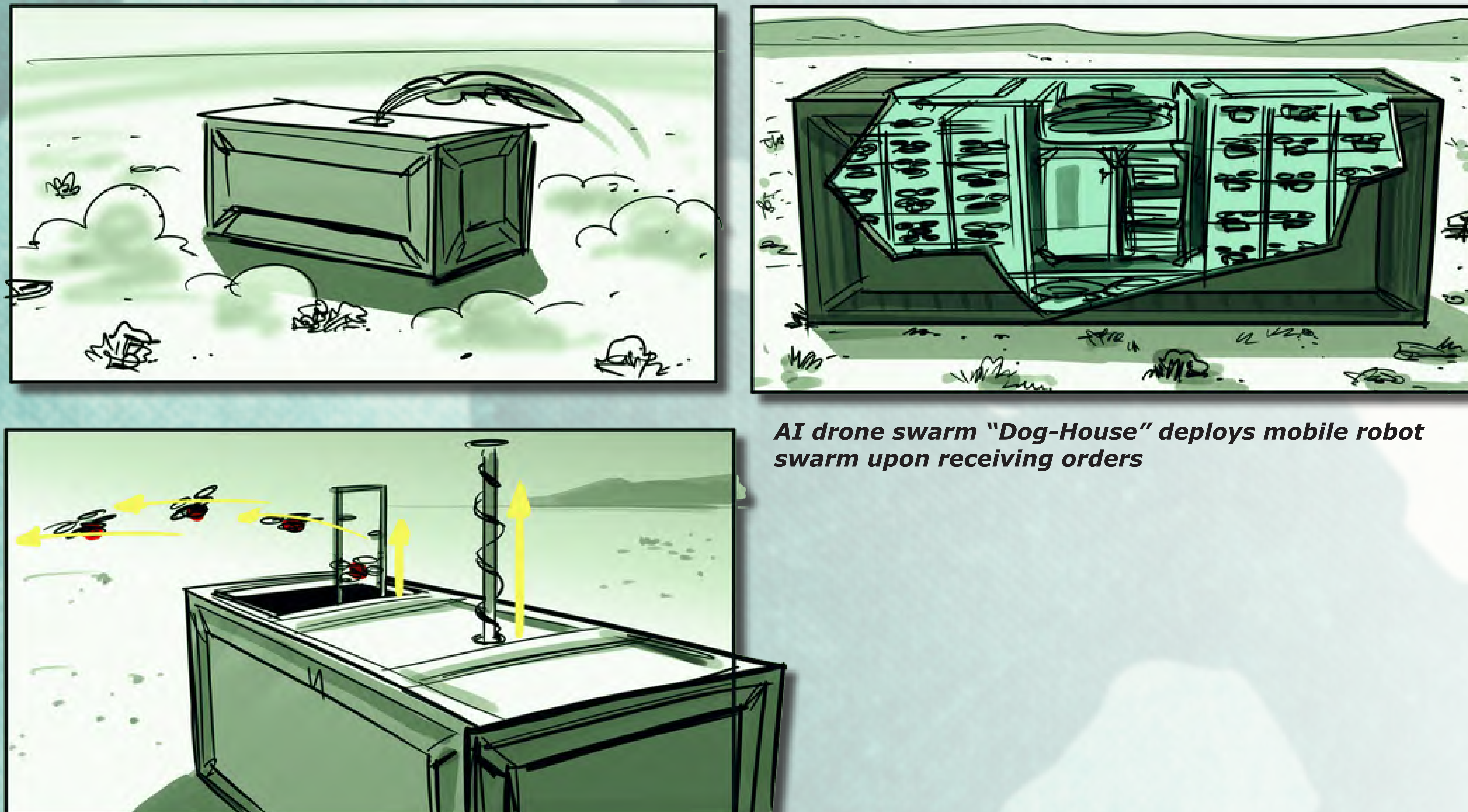
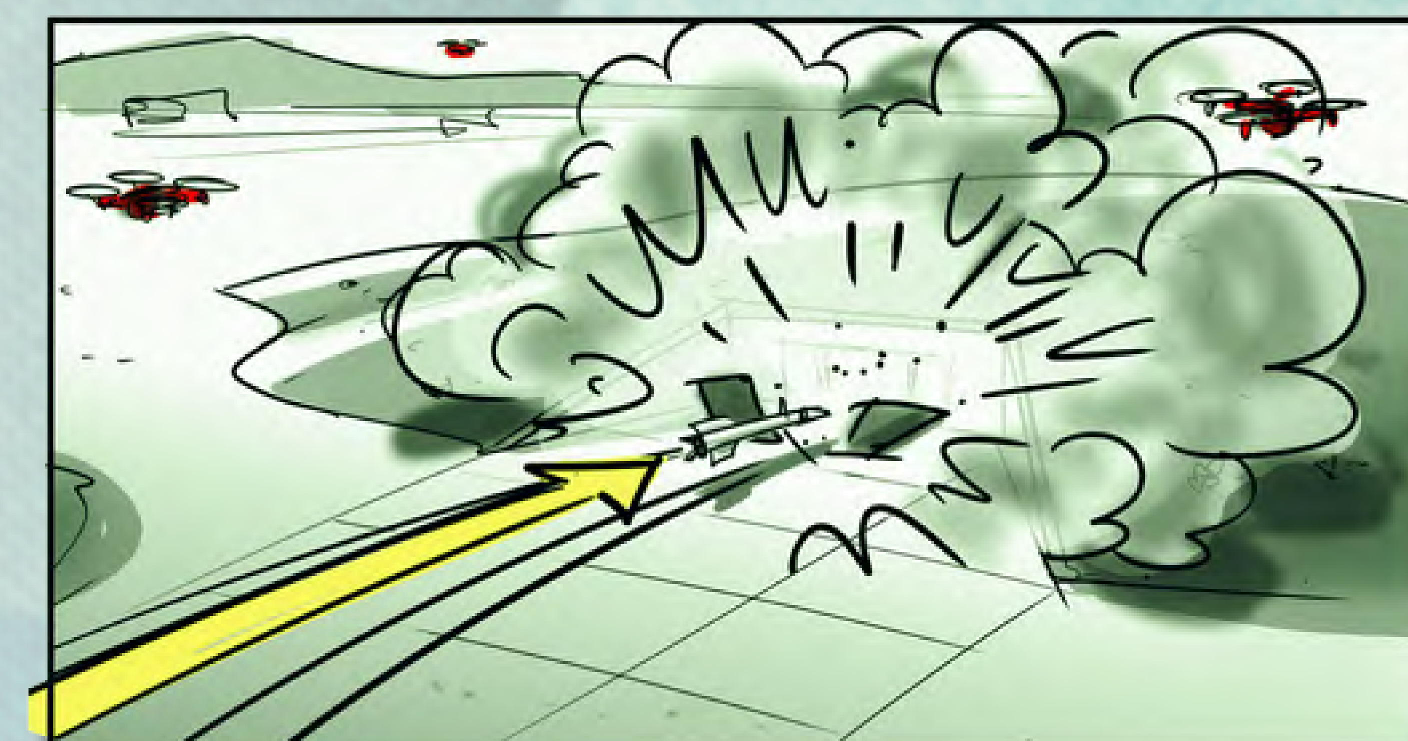
AISUM DRONE SWARM LANDS AT A STAND OFF LOCATION



AI drone swarm "Dog-House" deploys mobile robot swarm upon receiving orders

05:20::00

SUSPECT FACILITY ENTRANCE BREACH



AI mobile robot swarm confirms the presence of nuclear material, and conducts survey of entrance

AI mobile drone swarm provide target beacon

Navy ship fires tomahawk to breach facility entrance

06:00::00

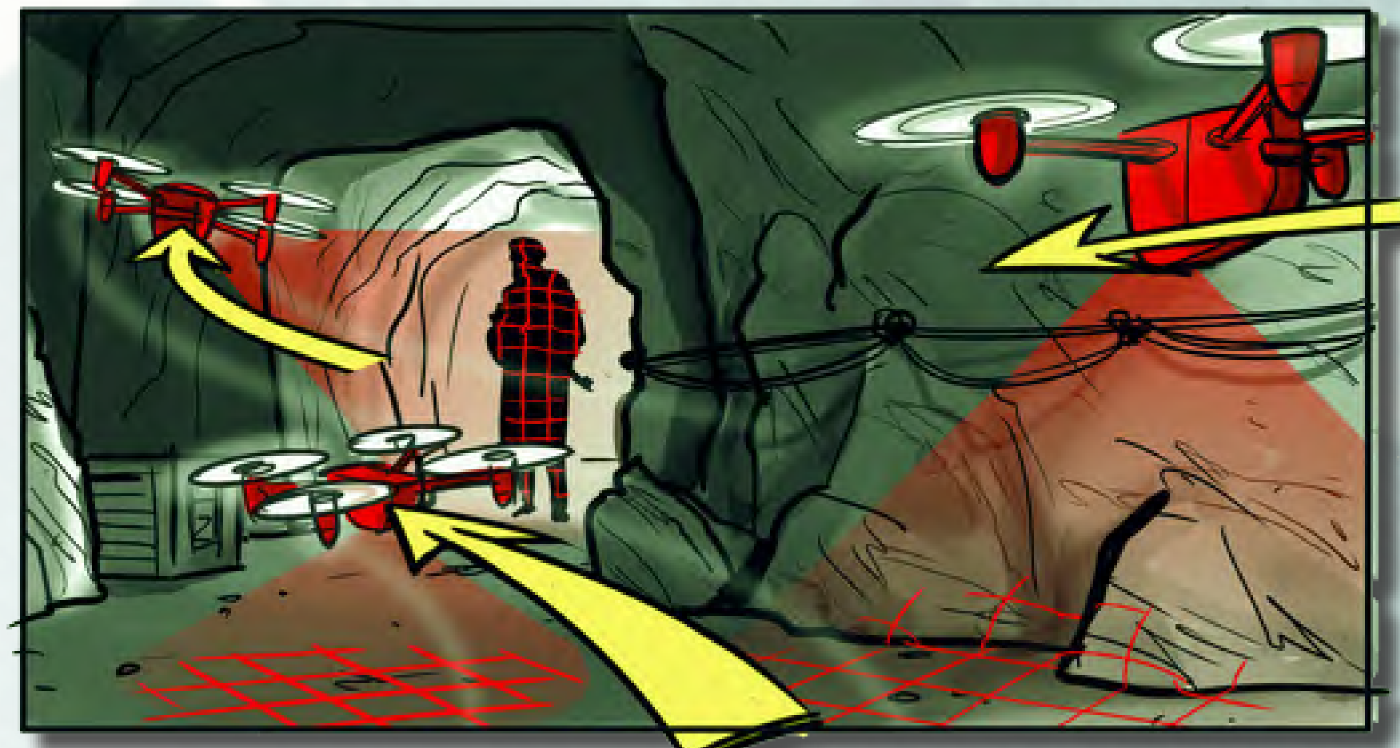
AISUM DRONE SWARM DEPLOYS, INFILTRATES FACILITY

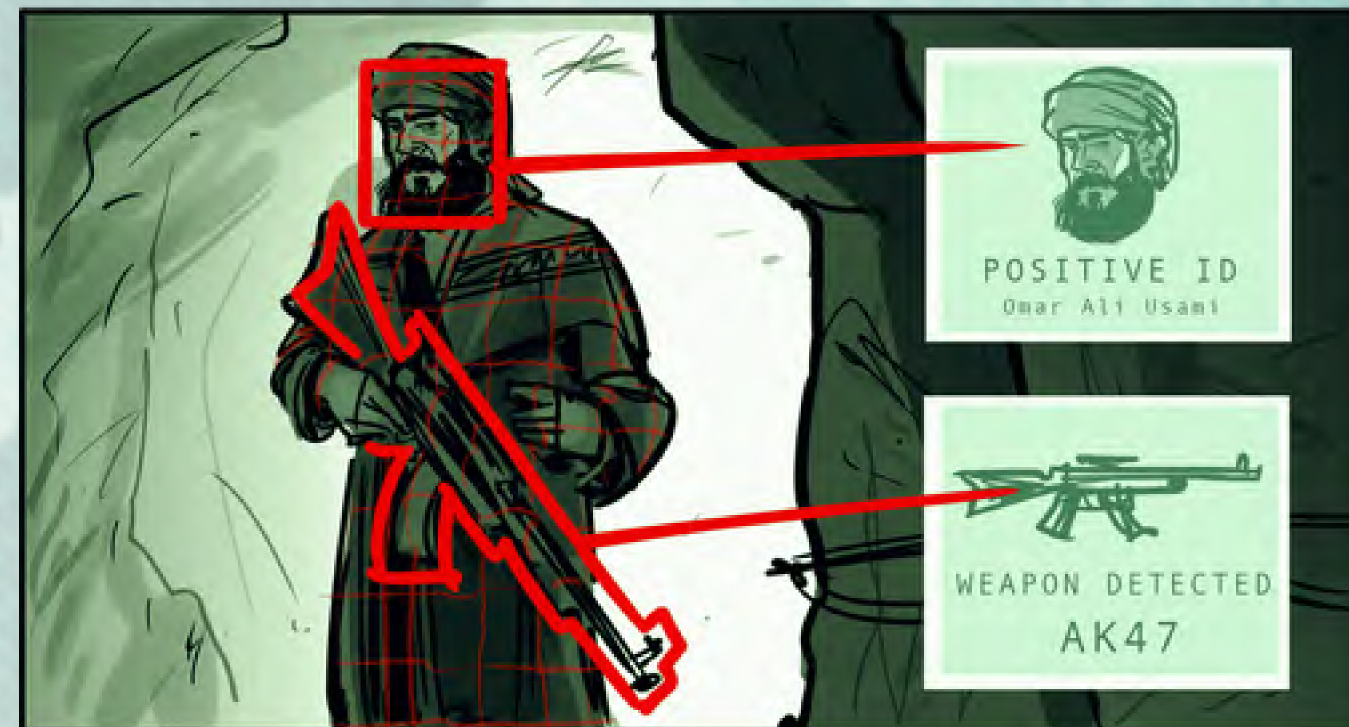
AI Mobile Robot Sewarm departs "Dog-House" and enters underground facility.

AI Mobile Robot Swarm uses Photogrammetry to rapidly 3D scan the environment.

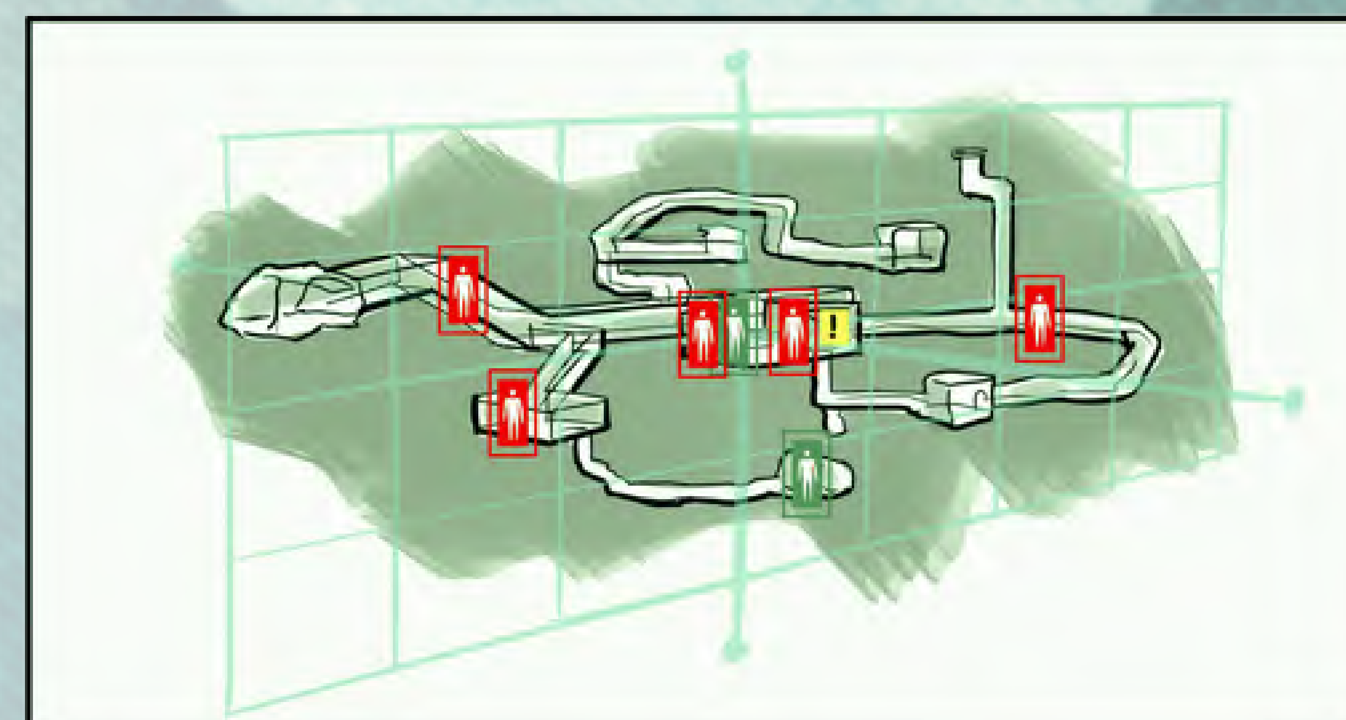
06:10::00

AISUM DRONE SWARM SCANS AND MAPS FACILITY



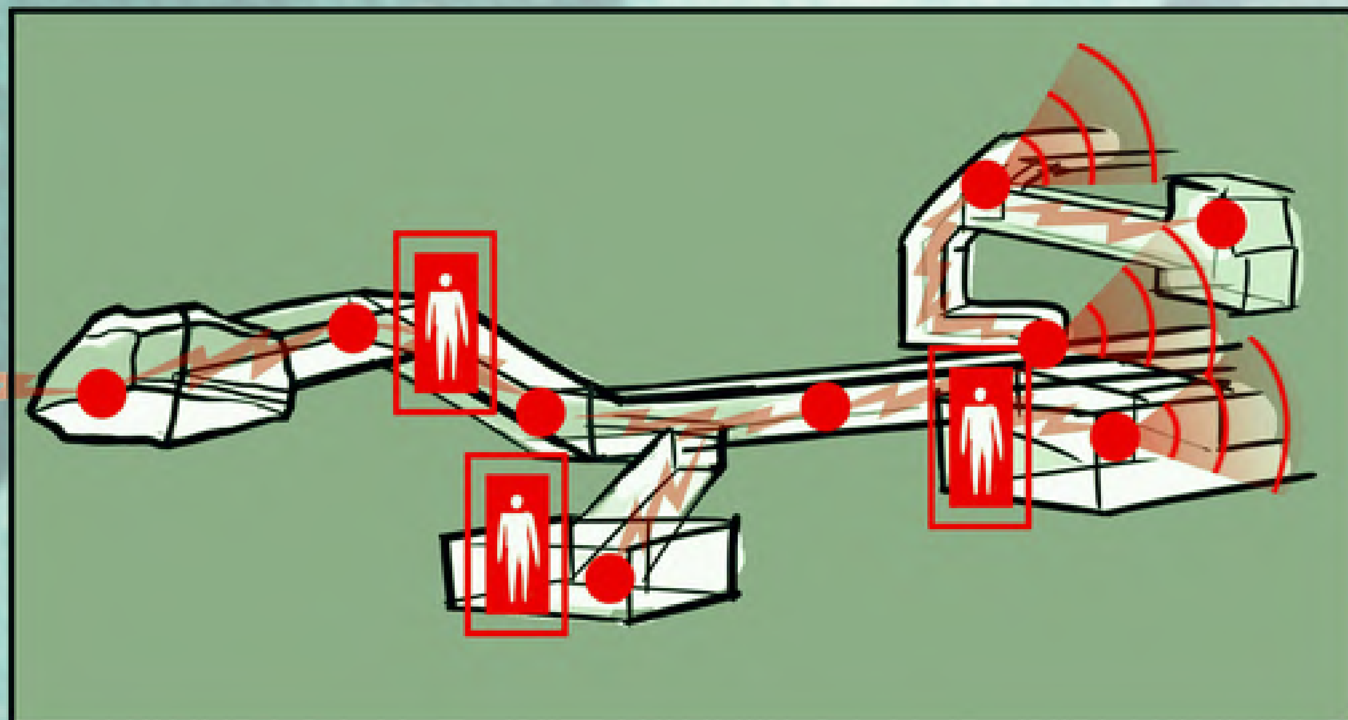


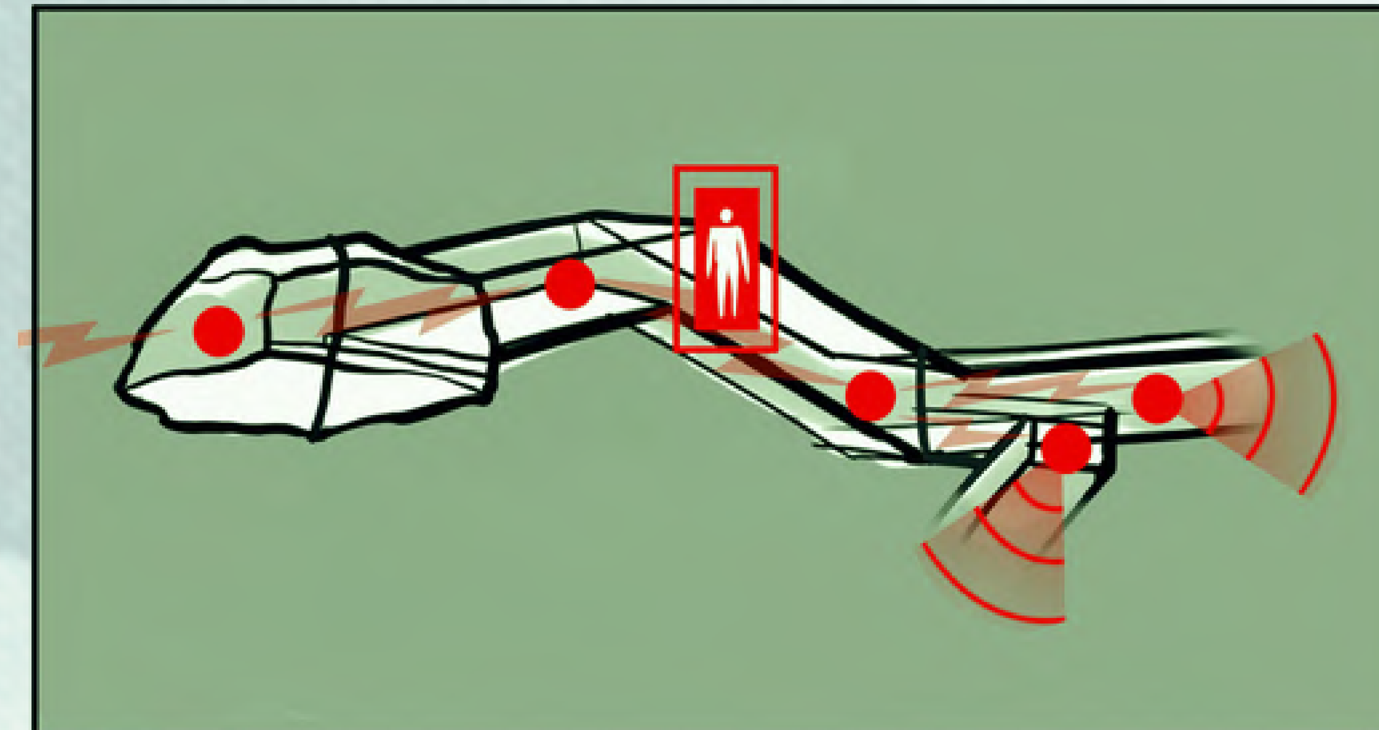
AI Mobile Robot 3D scans provide information on access, routes, object ID, and hostile or friendly ID

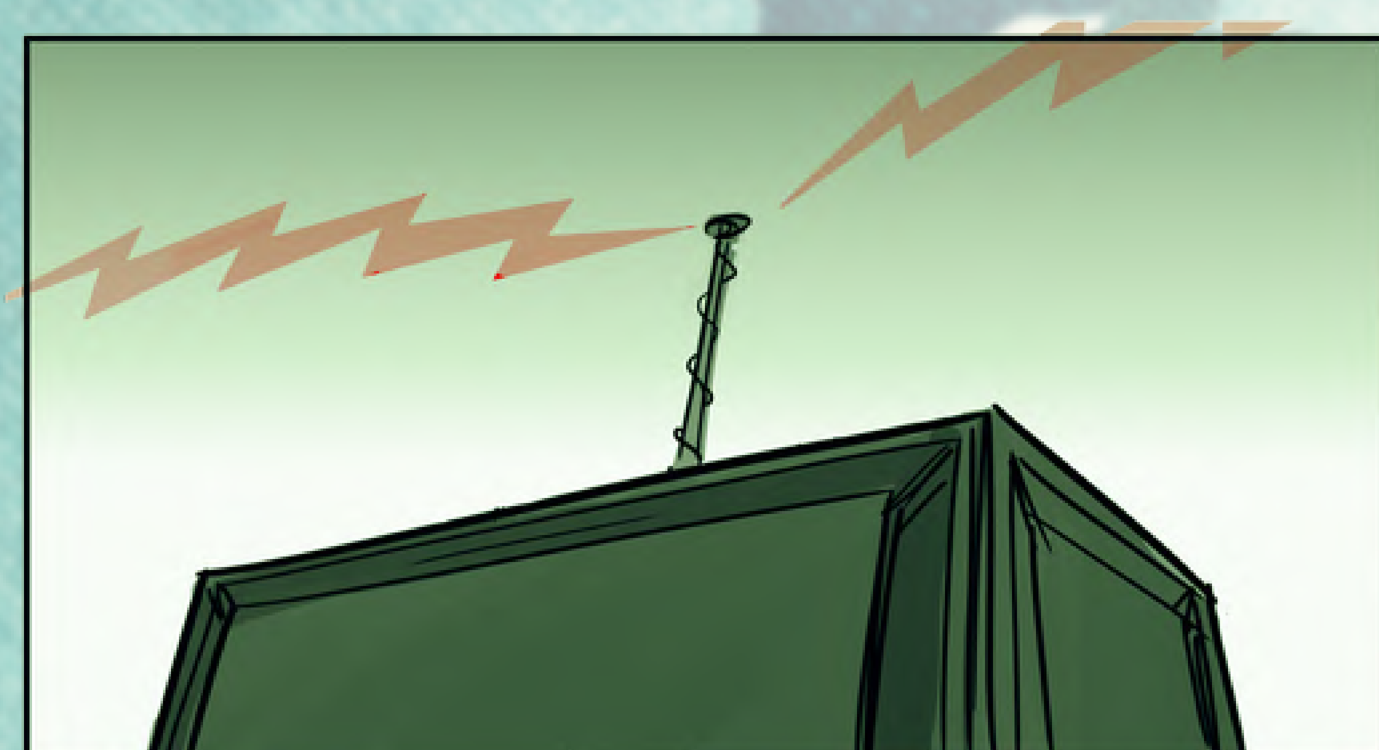


06:30::00

AISUM DRONE SWARM DATA TRANSMITTED BACK TO FOB



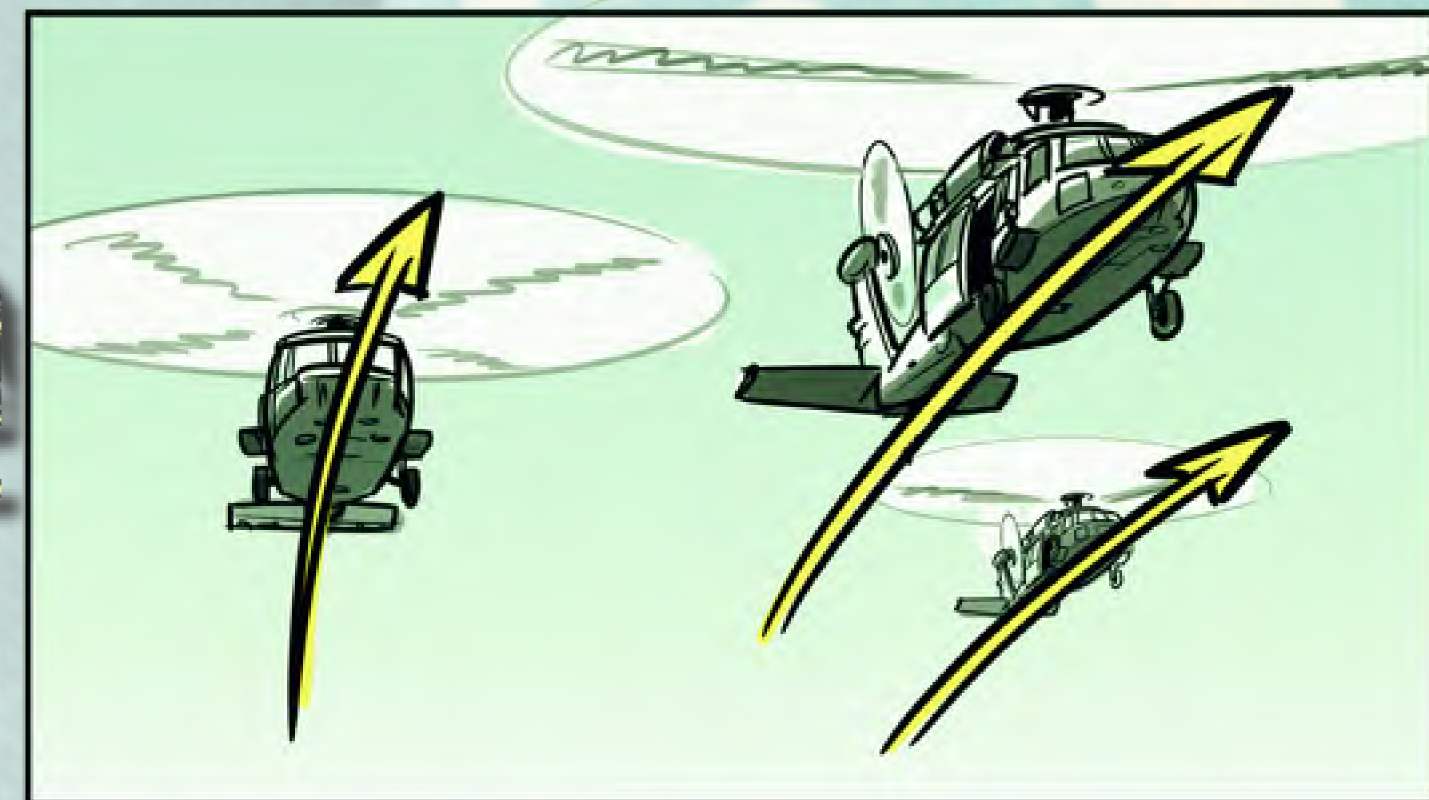




3D wireframe scans are relayed back to the "Dog-House" for processing and additional relay of data back to C2 or FOB.

07:00::00

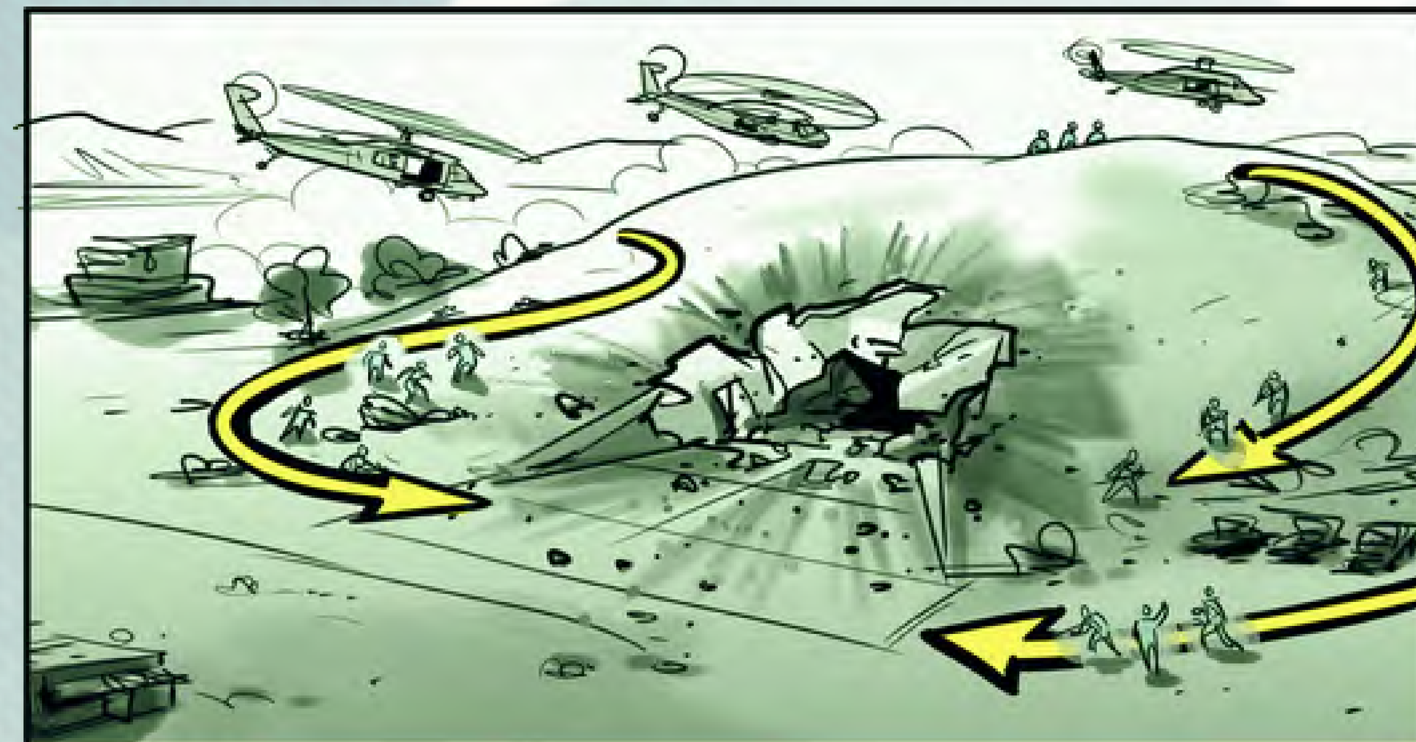
QRF DEPLOY



Based on data provided in 3D scans, QRF is deployed by C2 or FOB.

08:00::00

SOF ASSETS RECEIVE LAST MINUTE UPDATES



QRF Team receives last minute updates on Target status

08:20::00

SOF ASSETS INFILTRATE FACILITY

QRF team can quickly access facility with a very high level of SA

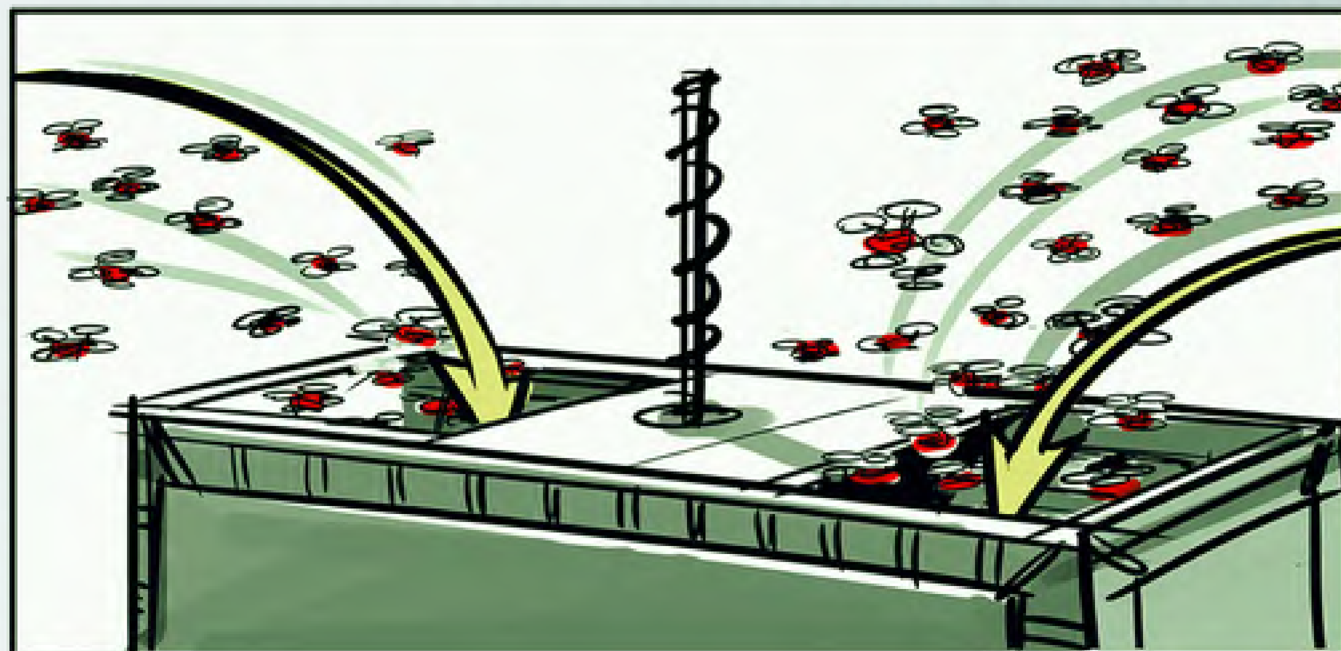
08:40::00

ACTIONS ON THE OBJECTIVE

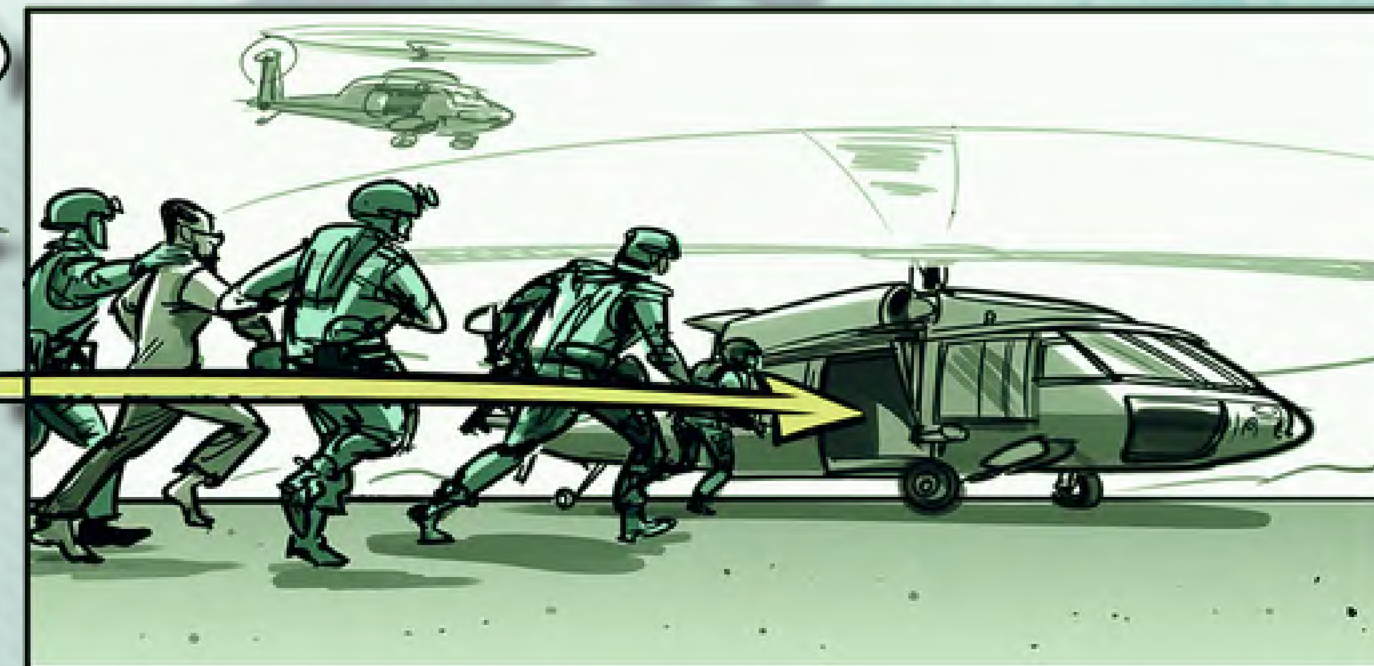
QRF Team conducts Actions on the Objective

09:30::00

AISUM DRONE SWARM AND SOF ASSETS EX FILTRATE FACILITY



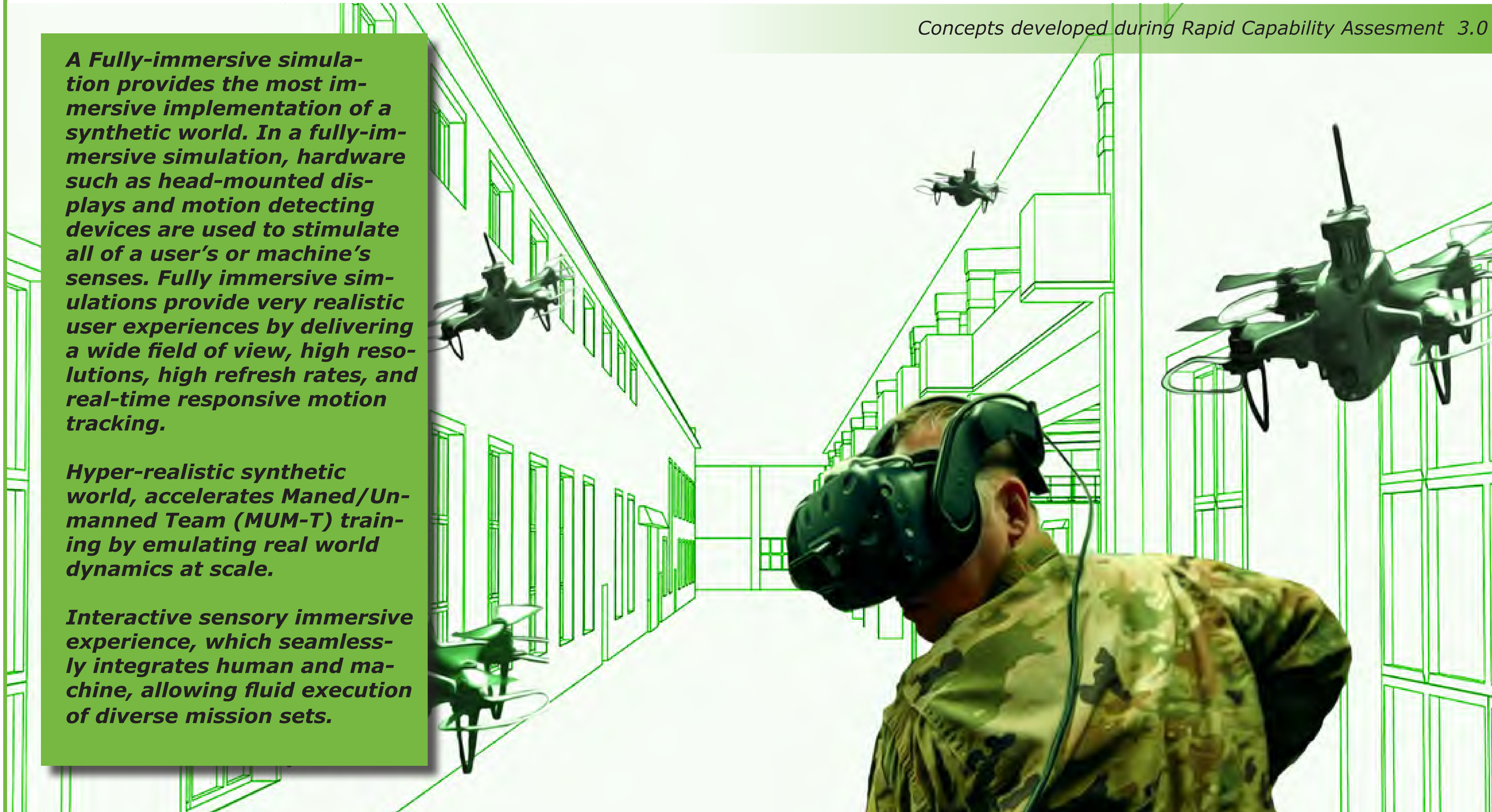
AI Mobile Robot Swarm and QRF Team Exfiltration



SECTION 7 - KEY TECHNOLOGY AREAS FOR DEVELOPMENT

7.1 AISUM SYNTHETIC TRAINING AND LEARNING

Concepts developed during Rapid Capability Assesment 3.0



A Fully-immersive simulation provides the most immersive implementation of a synthetic world. In a fully-immersive simulation, hardware such as head-mounted displays and motion detecting devices are used to stimulate all of a user's or machine's senses. Fully immersive simulations provide very realistic user experiences by delivering a wide field of view, high resolutions, high refresh rates, and real-time responsive motion tracking.

Hyper-realistic synthetic world, accelerates Maned/Unmanned Team (MUM-T) training by emulating real world dynamics at scale.

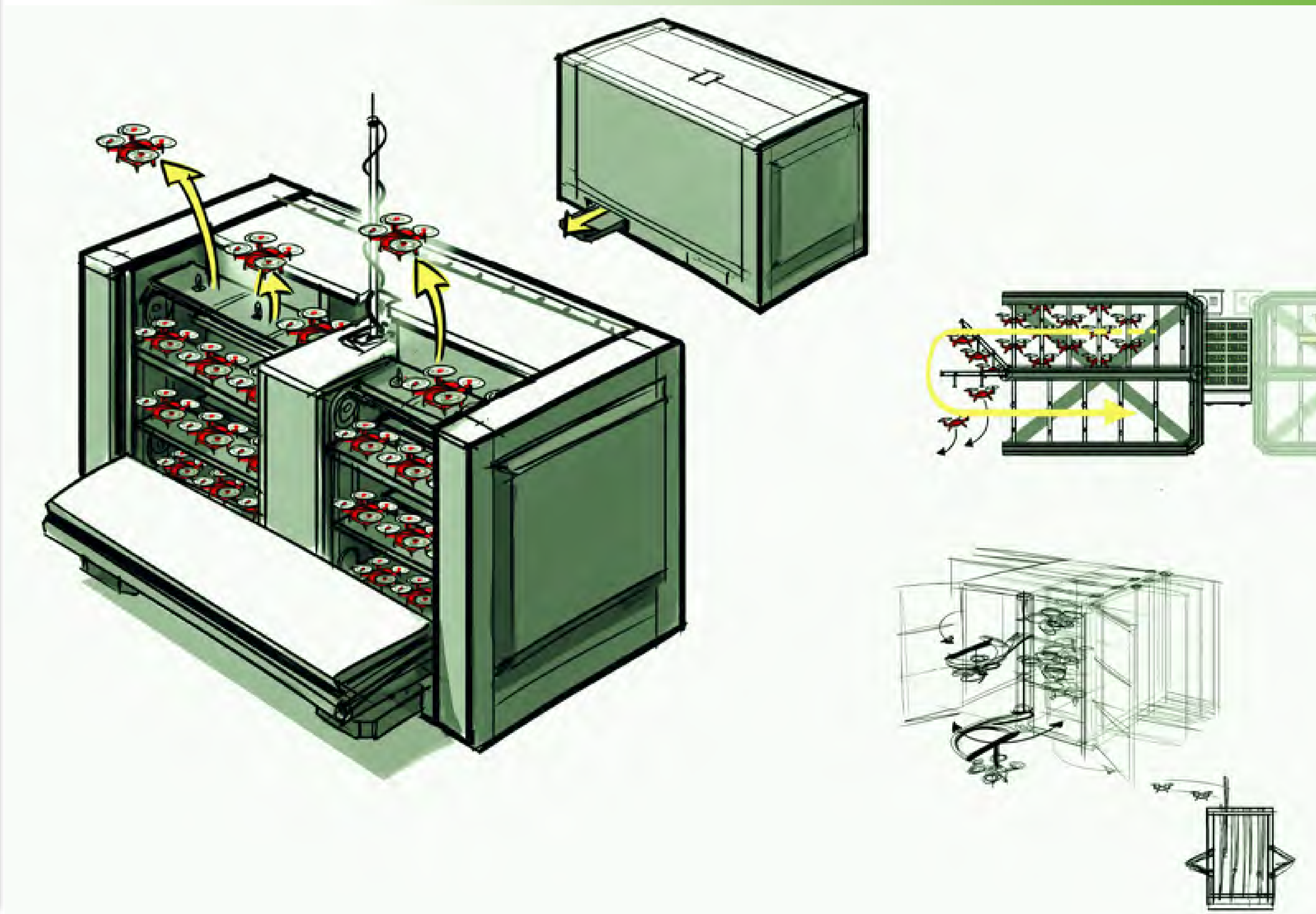
Interactive sensory immersive experience, which seamlessly integrates human and machine, allowing fluid execution of diverse mission sets.

7.2 AISUM SWARM LOGISTICS

Concepts developed during Rapid Capability Assesment 3.0

The Swarm 'Dog-house' is a reconfigurable platform that can autonomously launch, recover, recharge, redeploy, and store multiple, unmanned aerial vehicles (UAVs) of various types and sizes.

The 'Dog-house' can be deployed with or by an underwater, sea surface, land or air host, which could be a moving manned or unmanned vehicle. The hive can operate in a variety of different special operations missions.



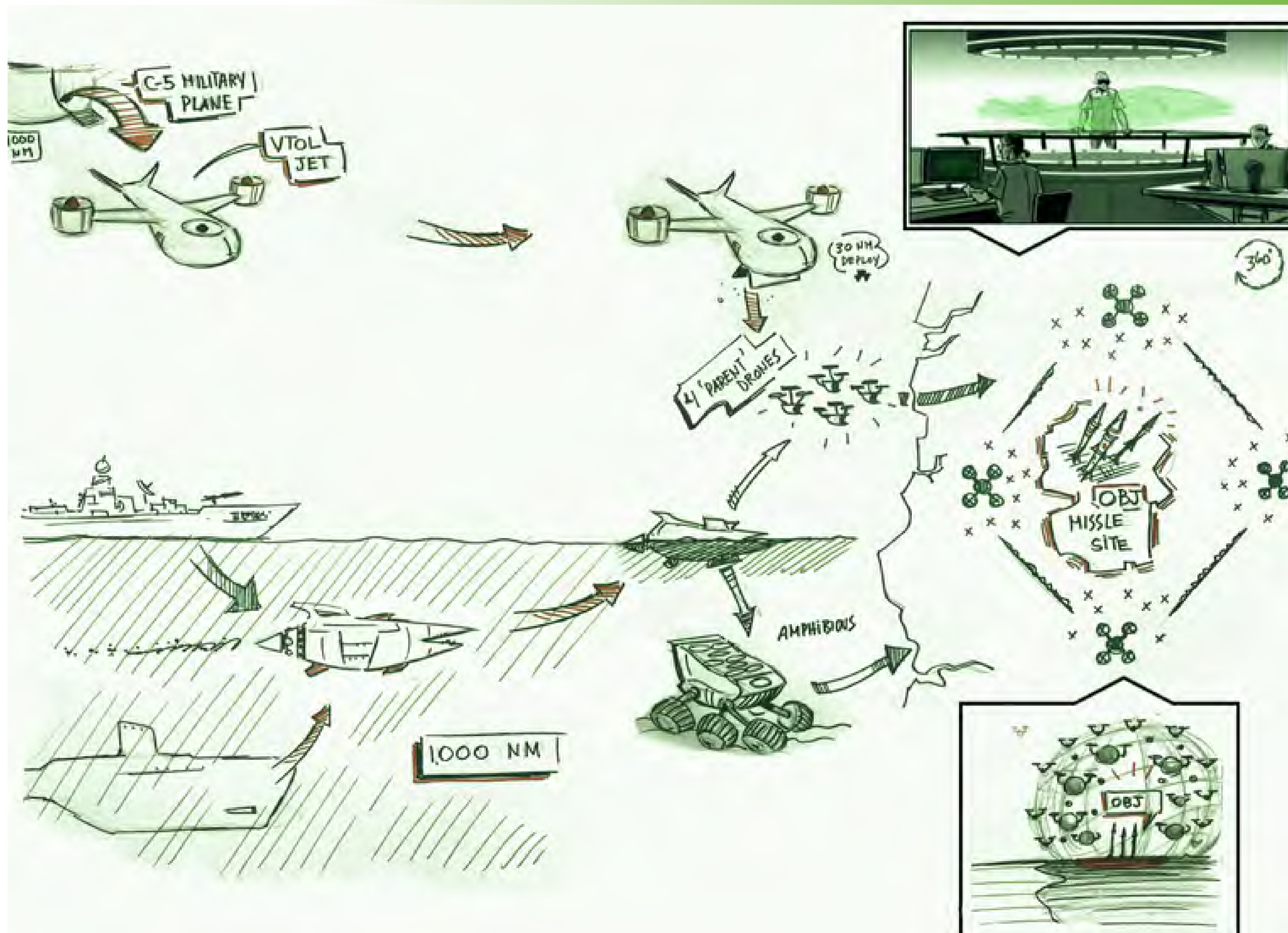
7.3 AISUM HARDWARE - SNEAK, SWARM & SENSE

The operational treat drives a 1,000 to 1,500 NM release of survivable, intermediary platforms that deliver autonomous SR/DA drone package from air or sea. Intermediary platform moves through contested space, avoiding countermeasures and delivers stealthy VTOL mother drones at optimized release point.

Stealthy VTOL mother ships move into a 360 position around the target and release the drone swarm. Mother goes to hide site to sense, compute and communicate.

Self sustaining and organizing swarm encircles the target and creates a 360 view of the target & operational area to enable commander's decision and team success.

Concepts developed during Rapid Capability Assesment 3.0

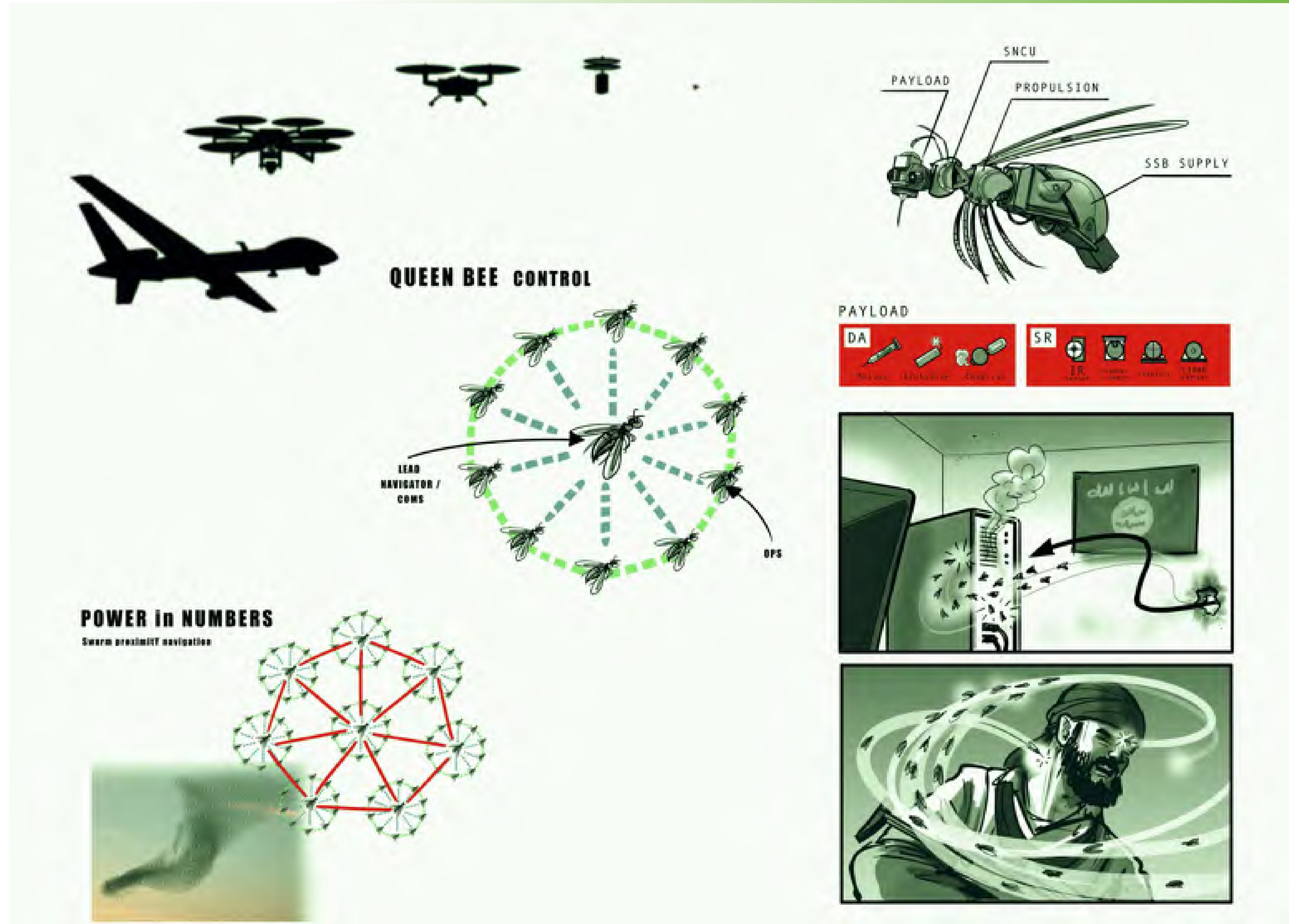


7.4 AISUM HARDWARE - DIRECT ACTION

The modularity of the Swarm 'Dog-house' is designed to fulfill a variety of mission objectives where the drones that make-up the total payload can be loaded to optimize mission requirements.

Drones are packaged into a small, medium, or large category, and designed to withstand extreme transport conditions. Drone payload options include 3 categories of functionality: lethal, non-lethal, and tools/support.

Concepts developed during Rapid Capability Assesment 3.0



SECTION 7 - KEY TECHNOLOGY AREAS FOR DEVELOPMENT (cont)

7.5 AISUM HUMAN AND MACHINE TEAMING

Concepts developed during Rapid Capability Assesment 3.0

A set of tools that allows HQ and forward operators to convey intent to and receive information from their teammates (robotic and human), enabling distributed command and control to successfully execute missions in contested and denied environments.

The tools include human-machine interfaces, mission tailored sensors, clandestine communication, and enabling software.

Iterative prototyping is necessary to achieve the desired integrated capability.

7.6 ADAPTIVE C2 FOR DENIED ENVIRONMENTS

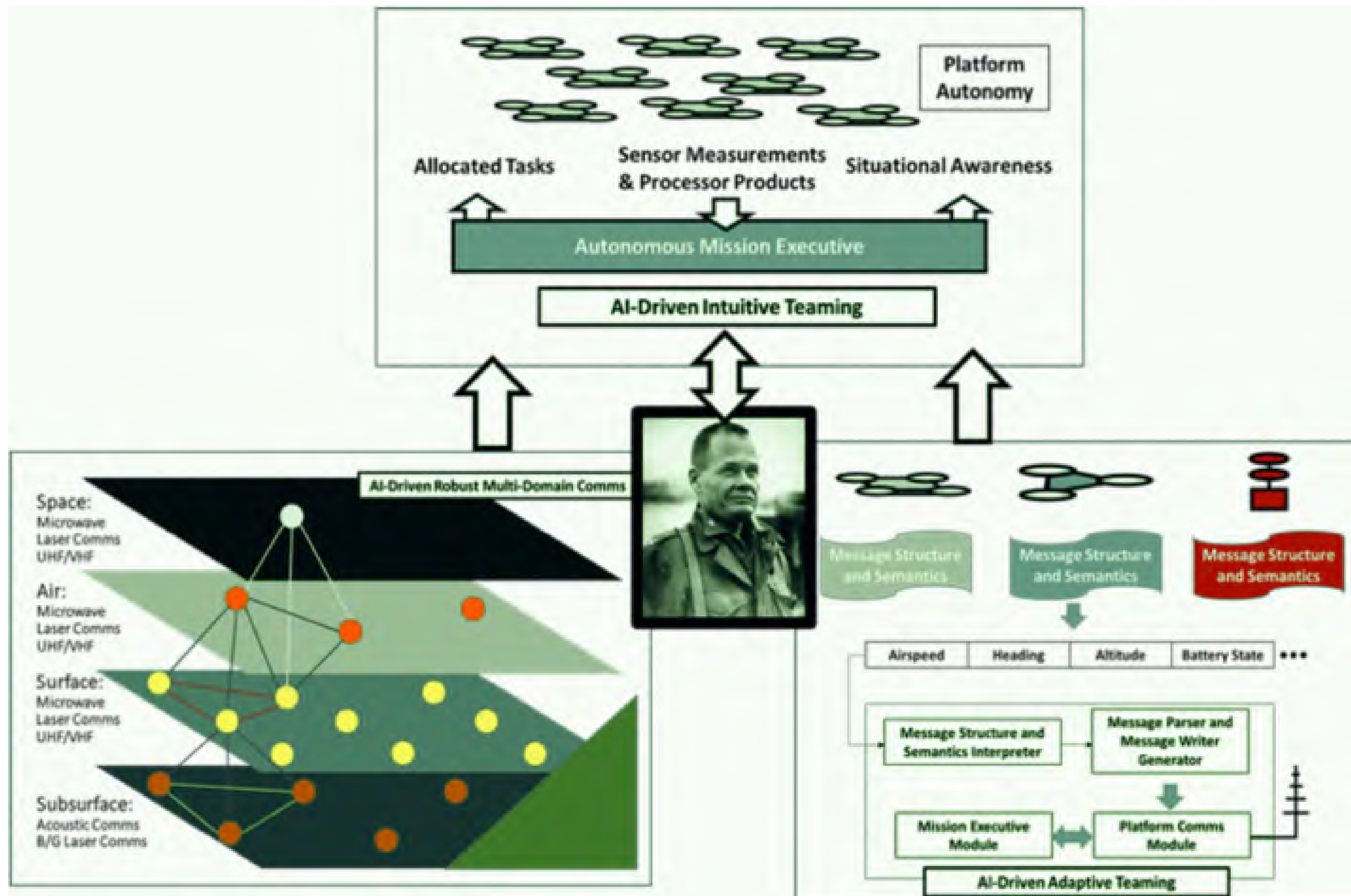
Concepts developed during Rapid Capability Assesment 3.0

Software-defined Command, Control, and Coordination. On-board platform AI for Intuitive Teaming:

Autonomous sense-making, control, and coordinated Mission Execution.

Robust synthesis of Commander SA and C2 enabled by spatially and spectrally diversified multi-domain communications infrastructure founded on coordinated platform resource management.

Adaptive Teaming enabled by AI-based integration of heterogeneous platforms.



SECTION 7 - KEY TECHNOLOGY AREAS FOR DEVELOPMENT (cont)

7.7 AISUM COMMUNICATION AND DATA

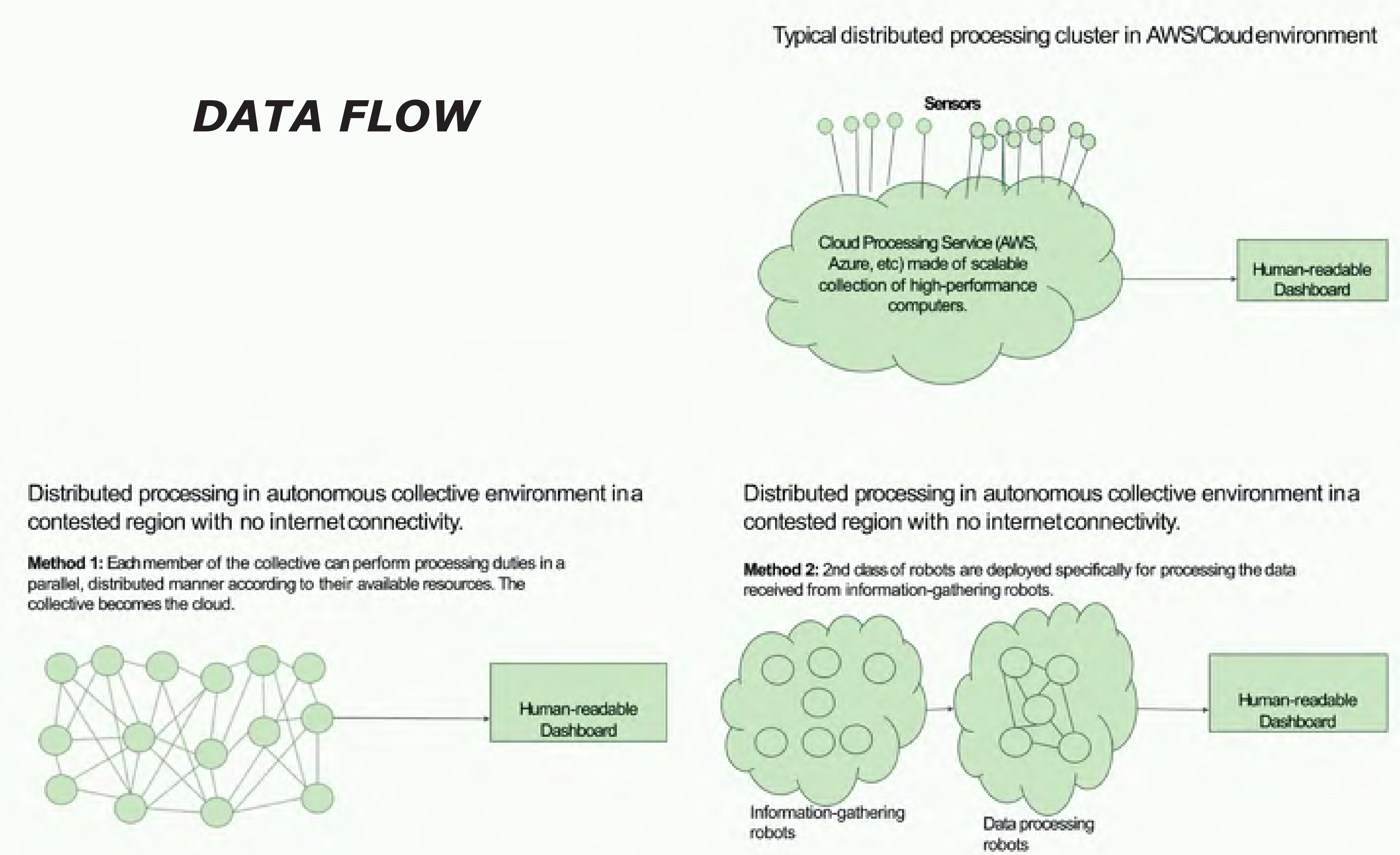
Concepts developed during Rapid Capability Assesment 3.0

SWARM COMMS INFRASTRUCTURE:
In 2030, to enable the Special Recon mission, a covert, self healing, secure communications backbone must be established and maintained for the duration of the mission, providing:
a. Inter-Robot communications
b. Robot-to-Operator communications
c. Operator-to-Robot communications

INFORMATION COLLECTION AND STORAGE:
Swarm Robots will securely store and make available mission-required information gathered from their sensors. Triage techniques like priority shedding, de-duping, and high-priority detection alarming will be employed to ensure irrelevant data does not take up more space than necessary.

INFORMATION PROCESSING:
Collected mission data must be synthesized into useful information to be surfaced to the Operator. This requires processing power deployed in the mission location. Dedicated members of the Swarm get data from other robots in the Swarm to perform these tasks. Alternatively the entire Swarm can perform smaller processing tasks in a distributed manner.

DATA FLOW



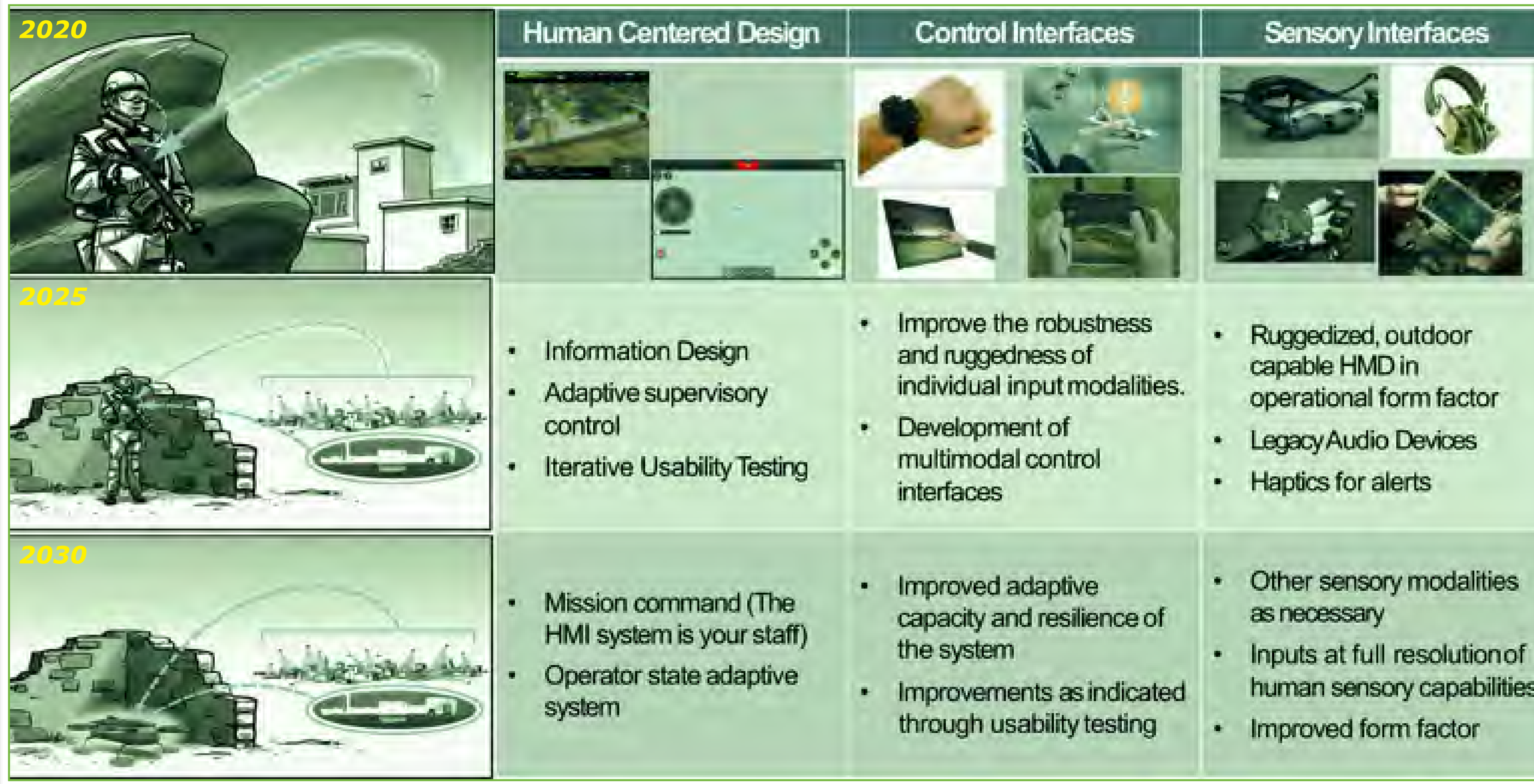
7.8 AISUM CONTROL INTERFACE

A set of tools that allows HQ and forward operators to convey intent to and receive information from their teammates (robotic and human), enabling distributed command and control to successfully execute missions in contested and denied environments.

The tools include human-machine interfaces, mission tailored sensors, clandestine communication, and enabling software.

Iterative prototyping is necessary to achieve the desired integrated capability.

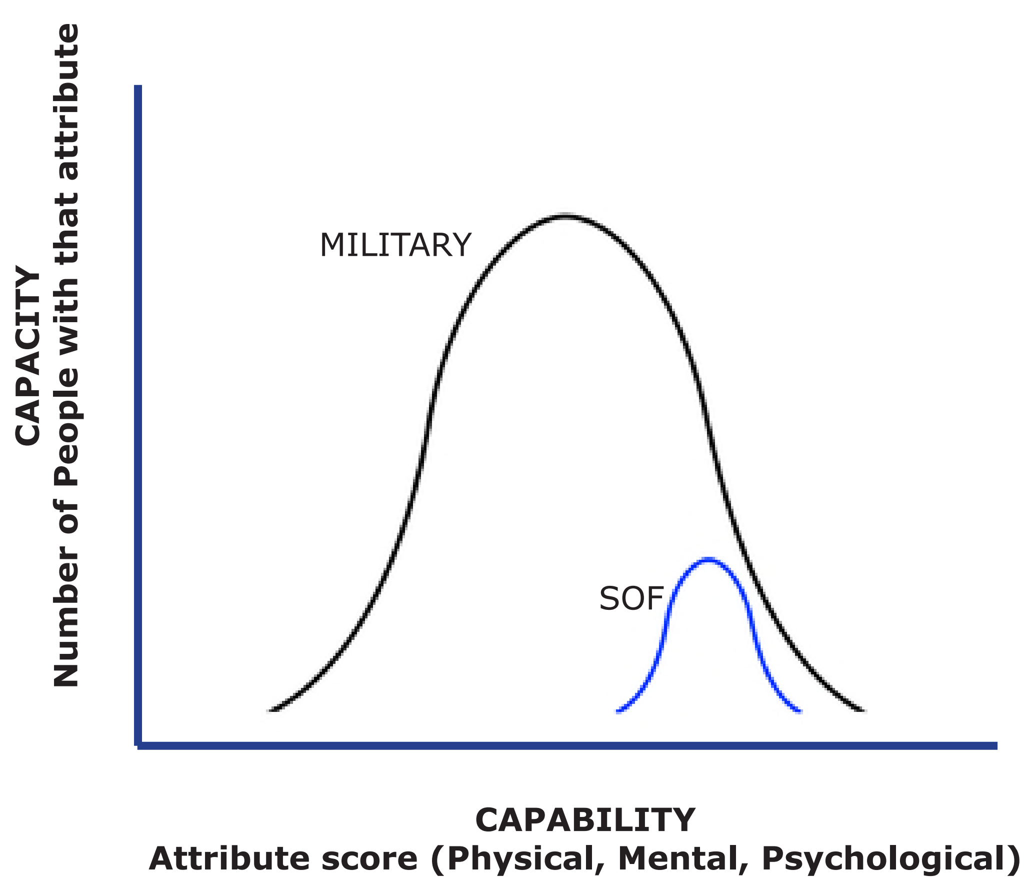
Concepts developed during Rapid Capability Assesment 3.0

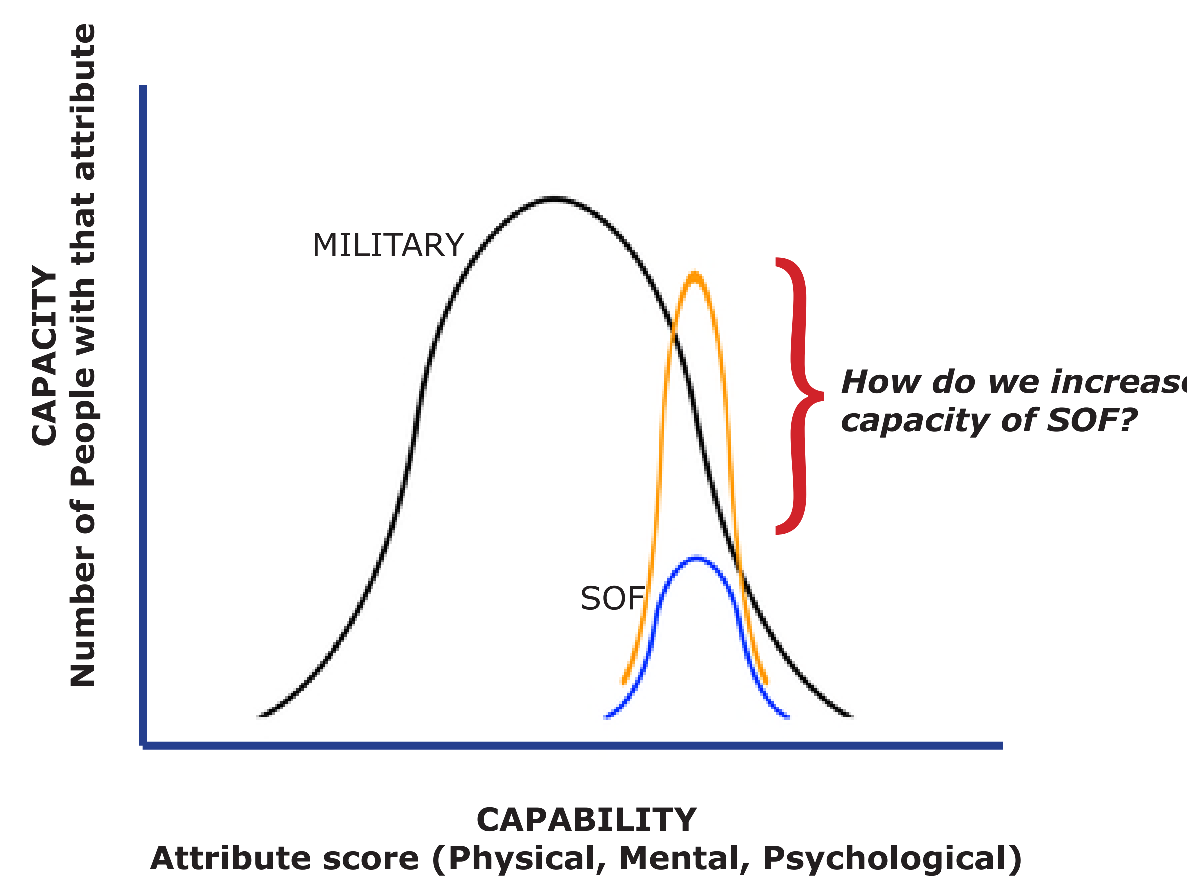


SECTION 8 – CONCLUSION

Pursuing AISUM allows NSW to improve the combat effectiveness of the future force. Development of AISUM solutions emphasizes human-machine collaboration. Integrated human-machine teams will allow NSW to operate under uncertain situations.

The AISUM concept challenges NSW leaders to visualize maneuver in fundamentally new ways in order to balance between CVEO and GPC. Only through challenging underlying assumptions and strategizing against the capabilities and goals of potential enemies will NSW create the war fighting capabilities necessary to effectively support the Joint Force.





Artist concept of AI Mobile Robot Swarm in support of SOF operations

ACKNOWLEDGMENTS

REFERENCE INFORMATION

INNOVATION FOUNDRY 3.0 - On April 23-25, 2019 SOCOM AT&L, Directorate Science and Technology (S&T) facilitated the Innovation Foundry 3.0 (IF3) in Austin, Texas. The objective of IF3 was to examine Special Reconnaissance (SR) in 2030 informed by SOCOM's Future Operating Concept via several future mission environments (Dense Urban Clutter & Subterranean Environments.) The facilitated event was comprised of experts from industry, academia and war fighters from the SOCOM components. The outcome from IF3 was a list of potential concepts, capable of success, in the future mission scenarios. The consistent solution to complete the mission scenarios was comprised of Robotic Autonomous Systems (RAS) utilizing varying levels and types of Artificial Intelligence (AI). A full report was produced and is available upon request, please contact SOCOM AT&L, Directorate Science and Technology (S&T) for more information.

RAPID CAPABILITY ASSESSMENT 3.0 - On July 8-12 2019, SOCOM AT&L, Directorate Science and Technology (S&T) executed the Special Reconnaissance Rapid Concept Asessment (RCA) event at SOFWERX. The S&T facilitated event was comprised of experts from industry, academia, and war fighters from the SOCOM components. The event focused on refining design concepts from the IF 3.0 event and developing the select design concepts. Outputs from the RCA included market research, initial breakdown of the key sub-systems of Autonomous Robotic Systems, development of potential Statements of Work for future projects and practical demonstrations of novel methods of Robot-Operator teaming. Two demonstrations developed over the 5-day event were presented at S&T's Technical Experimentation event, and received positive reviews and constructive feedback from operators and assessors. A full report was produced and is available upon request, please contact SOCOM AT&L, Directorate Science and Technology (S&T) for more information.

INNOVATION FOUNDRY 4.0 - On August 20-22, 2019 SOCOM AT&L, Directorate Science and Technology (S&T) facilitated the Innovation Foundry 4.0 (IF 4.0) in Raleigh, North Carolina. The event was designed and facilitated by Voltage Control. IF 4.0 brought together Special Operations War fighters and non-traditional technologists to explore future Special Operations scenarios over a three-day period. The outcome from IF 4.0 was a list of potential concepts, capable of success, in the future mission scenarios. The consistent solution to complete the mission scenarios was comprised of Robotic Autonomous Systems (RAS) utilizing varying levels and types of Artificial Intelligence (AI). A full report was produced and is available upon request, please contact SOCOM AT&L, Directorate Science and Technology (S&T) for more information.

RAPID CAPABILITY ASSESSMENT 4.0 - On Nov 04-08 2019, SOCOM AT&L, Directorate Science and Technology (S&T) executed the Rapid Capability Assessment 4.0 (RCA) event at SOFWERX facility in Tampa FL. The RCA 4.0 event developed select design concepts from Innovation Foundry 4.0. Event participants comprised of experts from industry, academia and war fighters from the SOCOM components. The event focused on refining design concepts from the IF 4.0 event. Outputs from the RCA 4.0 included market research, initial breakdown of the key sub-systems of Autonomous Robotic Systems, development of potential Statements of Work for future projects and practical demonstrations of novel methods of Robot-Operator teaming. A full report was produced and is available upon request, please contact SOCOM AT&L, Directorate Science and Technology (S&T) for more information.

WEEE (Iron Butterfly) - Naval Surface Warfare Center Crane held a Warfighter/Engineer Engagement Event (Iron Butterfly) the week of January 13th, 2020. This event was attended by both NSWC Crane engineers from multiple specialty areas, and by experienced warfighters. The event was based around reviewing proposed 2030 reconnaissance/direct-action missions which utilize extensive Artificial Intelligence for small unit maneuver (AISUM) on unmanned systems. The event included breaking down the storyboards to understand mission and technical details, identifying gaps in required technologies to achieve that mission capability, and then refining the storyboards in order to accurately tell the story. The mission technology gaps identified by the engineering team have been documented here as a supporting resource to the storyboards. A full report was produced and is available upon request, please contact SOCOM AT&L, Directorate Science and Technology (S&T) for more information.

BACKGROUND

SCIENCE AND TECHNOLOGY DIRECTORATE - USSOCOM's directorate of Science and Technology (S&T) vision is to "Discover, enable, and transition technologies to provide an asymmetric advantage for special operations forces and to hyper-enable the SOF operator now and in future environments. "S&T priorities are aligned with the USSOCOM Commander Capabilities and Programming Guidance (CPG). The current CPG builds upon the 2018 National Defense Strategy and SOF future operating environment. S&T is focusing its research, development, test, and evaluation (RDT&E) efforts on these four main pillars: Next Generation Intelligence, Surveillance, and Reconnaissance (ISR) and Tactically Relevant Situational Awareness: Focuses on ISR, mobile ad-hoc networks, small form factor, low probability of intercept/detection (LPI/LPD) C4 systems Network and Data Management: Focuses on cyber, Artificial Intelligence (AI)/Machine Learning (ML), and Big Data Analytics. Biotechnologies/Human Interface: Focuses on tactical combat casualty care, real-time medical monitoring, and maintaining optimal SOF performance. Next Generation Effects/Precision Strike Next Generation Effects/Precision Strike: Focuses on problems related to weapons for SOF use, ammunition, precision munitions, and devices for scalable effects. Joint Acquisition Task Force (JATF) HEO - JATF's new applied research focus is to advance technology toward a HEO in the cognitive domain. HEO seeks to enhance the SOF operator's cognition by increasing situational awareness, reducing cognitive load, and accelerating decision-making at the tactical edge. S&T must continue to strengthen relationships with Department of Defense (DOD) laboratories and other external organizations in order to leverage their larger efforts against USSOCOM S&T priorities. S&T's Strategic Engagement process seeks to discover new technologies, reduce redundancies, gain efficiencies, and synchronize long range future planning. Beyond the employment of improved technologies, adversaries will continue to rapidly evolve and adapt by employing novel tactics/techniques, capabilities, and resources to challenge U.S. interests. The challenge for SOF is pacing with the commercial technology sectors as competitors and adversaries rapidly acquire and leverage these technologies, anticipating emerging challenges and, when necessary, maintaining the ability to rapidly respond to erupting crises through nontraditional means or the employment of overwhelming force.

UNITED STATES SPECIAL OPERATIONS COMMAND

SPECIAL OPERATIONS FORCES ACQUISITION, TECHNOLOGY & LOGISTICS

SOF AT&L

Special Operations Forces Acquisition, Technology & Logistics