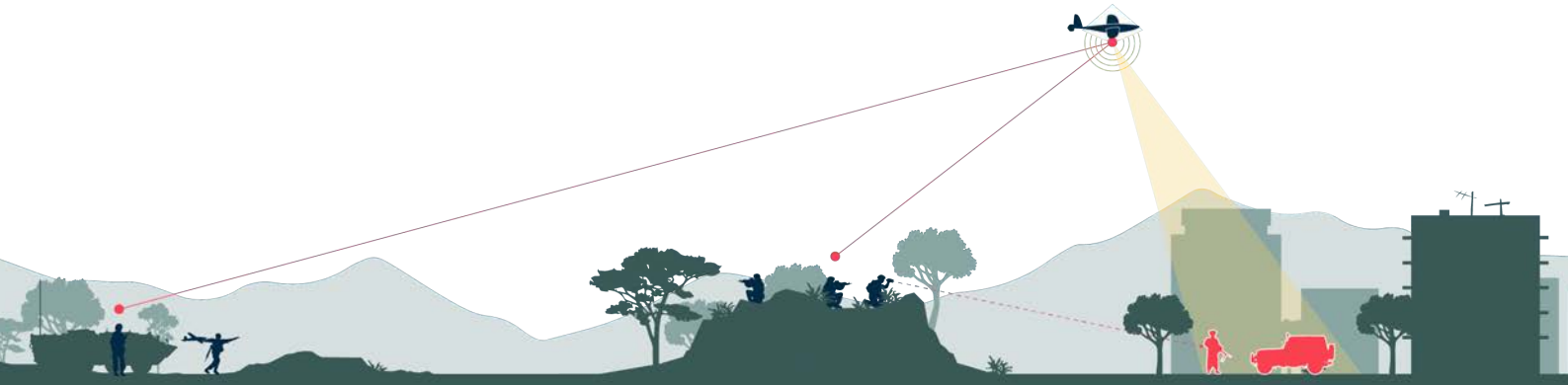
SKY-WATCH



INTEGRATED UAV RECONNAISSANCE OPERATION

CASE STUDY

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INTRODUCTION

The fog and friction of war will never allow the commander to obtain a perfect picture of the battle space. However, reconnaissance operations can reduce uncertainties regarding an unfamiliar area and/or an enemy who is actively trying to conceal information concerning their forces and intentions. This reconnaissance is often carried out by a reconnaissance team (e.g. Scouts, Special Forces or Forward Observers).

Reconnaissance should always precede a commitment of forces as a failure in conducting a thorough reconnaissance may lead to a loss of initiative or to an inability to exploit fleeting opportunities. The lack of reconnaissance can give the enemy the element of surprise, inflict unacceptable losses on friendly forces, and ultimately cause the mission to fail. As part of the overall intelligence effort, reconnaissance operations support the commander's decision-making-process by collecting information to develop situational awareness and to satisfy critical information requirements.

If infantry units are detected on a reconnaissance mission, they find themselves in a high-risk situation. The task of obtaining accurate intelligence while remaining undetected is particular difficult in complex environments where there is limited line of sight. In terms of overcoming this challenge, the application of airborne unmanned assets has proven to be extremely valuable resources, yet very scarce resources.

This case study will explore:

- How to choose the right type of UAV platform and how it can be deployed organically at infantry and company level to increase responsiveness in relation to aerial reconnaissance.

- How the workflow between an infantry deployed UAV and a Scout or Forward Observer can be improved significantly.

- How mini UAVs can support the Company Commander's decision-making-process.

- Case studies revolving efficient UAV reconnaissance deployment scenarios at Company level.

SETTING THE SCENE OF COMPANY LEVEL RECONNAISSANCE

The Company Commander uses reconnaissance units and assets to collect information but also to gain and maintain knowledge of the enemy. Reconnaissance activities range from passive surveillance missions where the objective is to systematically watch an enemy force or named area of interest, to supporting aggressive measures through Close Air Support (CAS).

TYPE	**Aggressive**	**Passive**			
PURPOSE	**CLOSE AIR SUPPORT** In an indirect fires mission, CAS FO provide eyes on the objective to verify if hits.	**ROUTE RECONNAISSANCE** Directed effort to obtain detailed information about a specified route and all terrain from which the enemy could influence movement along that route.	**AREA RECONNAISSANCE** Is is a directed effort to obtain detailed information on the terrain or enemy activity within a prescribed area, such as a town, ridge line, woods, or other feature critical to operations.	**ZONE RECONNAISSANCE** Is a directed effort to obtain detailed information on all routes, obstacles, terrain, and enemy forces within a zone defined by boundaries. A zone reconnaissance normally applies when the enemy situation is **vague.**	**FORCE-ORIENTED RECONNAISSANCE** Is a directed effort to find a specific enemy force quickly and stay with it wherever it moves on the battlefield.
FOCUS	In an indirect fire mission, CAS FO provide eyes on the objective to verify hits	Route reconnaissance focuses along a specific line of communications, such as a road, railway, or waterway, to provide new or updated information on route conditions and activities.	The focus in an area reconnaissance can be a single point, such as a bridge or installation, and could include hostile headquarters, key terrain, objective areas, or critical installations.	Supports the total integrated intelligence picture of an area defined by length and width. The size of the area depends on the potential for information on hostile forces, terrain, and weather in the zone; the requirements levied by the commander; and the reconnaissance forces available to exploit the intelligence value in the zone.	Force-oriented reconnaissance focuses on a specific enemy organization, wherever it is or may go.

CURRENT STATE OF THE ART

Units that are assigned to a reconnaissance mission attempt to answer the commander's questions about the enemy and the battlespace. Reconnaissance missions can be conducted in air, on ground, or under water, and are undertaken to obtain information about the activities and resources of the enemy by visual or other detection methods. In layman's terms, reconnaissance obtains information about the characteristics of a particular area and any known or potential enemy within it. In order to obtain this kind of information, all commanders have organic reconnaissance units at their disposal. These build the foundation of the Company's capability to prepare and execute well informed missions. The reconnaissance units are equipped with technology that can observe, mark points of interest and/or targets, and share this information in near real-time with allies.

Company Level Reconnaissance Equipment

The reconnaissance equipment can vary since it depends on the mission type, the proximity of the enemy, and whether the reconnaissance team is mounted or dismounted. However, most modern reconnaissance teams have the following at their disposal:

- One or more handheld optical systems (Laser Range Finder / Laser Designator): This kind of equipment is used for getting accurate target/POI location information. Using a gimbal, optical systems have a range up to 11km and can support night as well as day operations in many cases.

- One or more personal tactical radios: Radio systems ensure voice communication to and from the reconnaissance SR-team as well as relaying data from the C2/C4I system. Depending on the unit, tactical radios support various data types (voice, video, images etc.) and levels of encryption. In recent times, MESH radios have gained traction as a way to increase the bandwidth, so more data can be put through to soldiers.

- C2 or C4I system on portable tablets: The implementation of new soldier systems has enabled reconnaissance units to carry a portable C2 or C4I system, which enables them to share information and see the position of registered hostiles, civilians and allies. This facilitates a more complete situational awareness picture.

The emerging role of organic mini UAVs in modern day warfare is apparent through the fact that large tactical UAVs and manned aircrafts have supported missions on Brigade

Combat Team levels and higher for decades. However, it is also evident from the growth in use of mini UAVs in missions of lower levels such as Company, Platoon or Squadron within the last 10 years.

CHALLENGES

On company level today, mission reconnaissance relies mostly on reconnaissance teams that are equipped with handheld line-of-sight (LOS) optical systems. While these systems excel at persistent surveillance from a secure vantage point, the LOS restriction means that they only provide a small piece of the total situational awareness picture. Manned or unmanned airborne assets can add to this picture, but they are rarely deployed at lower levels (company and below) due to the scarcity of large assets. At the same time, the mini UAVs, which are implemented, do not support organic missions because they are not deployed in the correct way.

The scouts or reconnaissance units are usually in the best position to determine areas/points of interest, fire support requirements, etc. Therefore, a responsive aerial reconnaissance support solution, which enables a Company Commander to respond to rapid changes on the battlefield and exploit fleeting opportunities while also supporting organic needs from scouts and reconnaissance units, defines an unmet need.

Regardless of the size of the aerial asset, it needs to be responsive, flexible, fast to deploy, and integrated into the recon workflow. Today, there are two main barriers that need to be dealt with in order to enable the development of such an aerial asset:

1. Limitations of UAV platforms.
    - The deployed UAVs are either too small to support a relevant payload, too scarce for fast deployment, too complex to operate for none-UAV specialists or too large to carry in the field.

2. Limitation concerning the level of integration between UAVs and ground assets.
    - Lack of inter-connectivity between dismounted positioning devices and UAV controls leadsg to a manual and disconnected workflow.

Based on the US Marine Doctrine for effective Close Air Support, five initiatives for increasing the responsiveness and effectiveness of a Close Aerial Reconnaissance System for mission reconnaissance have been identified:

(1) Increase the availability of the aerial assets at the lowest possible tactical level.

(2) Place the aerial assets in connection with e.g. armored or tactical vehicles, a forward operating base (FOB) or a forward operating location near the operational area but within radio communication range of the reconnaissance units.

(3) Delegate launch authority to the Company Commander and if needed in direct coordination with the reconnaissance units.

(4) Enable flexible re-tasking of the UAVs in response to POI updates and higher priority emerging POIs.

(5) Delegate payload control authority to the closest unit but leave the advanced UAV control to a UAV team in the company.

The implementation of mini UAVs using these steps are associated with two main challenges that needs to be addressed:

1. Coordination complexity.
   The coordination-process between the reconnaissance units and the UAV operator when requesting and receiving the right intel at the right time needs to be supported by a problem-free and smooth integration between reconnaissance units' ranging/positioning systems.

2. Mission effectiveness.
   Flight time is identified as a critical parameter of success. To support the reconnaissance units' missions, the solution therefore needs to increase the overall flight time (this poses a conflict since the systems also needs to be light weight and stealth) or increase the effective flight time (more relevant information in the same time).

CHOOSING THE RIGHT MINI UAS FOR RECONNAISSANCE

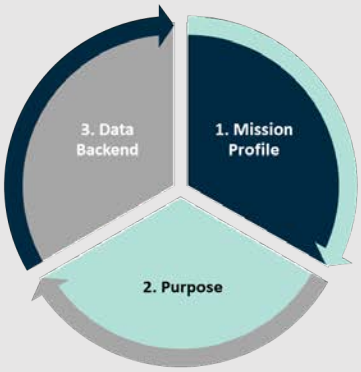
Choosing the right UAV system is more than just choosing the platform. This can be underscored because the UAV platform must also be viewed in the context of the mission profile and how the collected data needs to be used and distributed within the organization.

Consequently, it is vital to consider the three key areas of 1) Mission Profile, 2) Purpose and 3) Data Backend, along with their core nature/features. In that way, it is ensured that the most suitable UAV is chosen for the specific reconnaissance mission. This consideration should include answering the questions associated with the three key areas:

What is required in terms C2/C4I integration
Is it required that the data can be added to the existing situational awareness picture?

What data link is available?
is there bandwidth available to share video from the UAV team to the reconnaissance team or is required that the reconnaissance team can access the video directly

Which optical systems are available for the reconnaissance team
Is Laser Range Finders or designators available? And if yes can these be used to create georeferenced POIs?



What is the purpose of the reconnaissance mission?
Is the mission route, area, zone or force oriented focused

What are the objects of interest
Is it people, vehicles and/or buildings?

To what extend is time a factor?
Is it required that the UAV can get on target within minutes or hours?

What is the environment of reconnaissance mission
Is it in a urbanized, hilly, mountainous or open terrain

What is the risk level exist for the reconnaissance
Is the reconnaissance unit close to a hostile force

What is the mission dynamics
Is the launch site of the mini UAVs mobile or stationary? Is it expected that the situation can chance during the mission?

In the illustration below, the key features of the three identified UAV solutions are highlighted. The findings will help you narrow the scope to one of the approaches for UAV supported reconnaissance and therefore ensure that you will make a well-informed decision based on your mission profile.

	Mini UAV Systems	Micro UAV System	Nano UAV System
Mission Scenario	Urbanize, Hilly/Mountainous & Open Areas	Urbanized, Hilly/Mountainous & Open Areas	Urbanized Areas
Mission Duration	0-2h	0-45 min	0-25 min
Organisational Level	Platoon, Company, Battalion	Squad, Section, Platoon	Squad, Section, Platoon
Comms range	25-30 km	<5 km	<2 km
Stealth Level	Undetectable at 300m	Undetectable at 800m	Undetectable at 20m
Weather robustness	Wind 12 m/s Rain, Snow, Dust	Wind 12 m/s Rain, Snow, Dust	Wind 8 m/s

Recently, small micro VTOL (0,7-1,5kg) UAVs have been deployed more and more at platoon level. However, for covert reconnaissance operations in hostile areas, these VTOL UAVs have only experienced limited success, which is mainly due to the limited flight time (20-30 min) that prevents them from operating far away from the UAV operator. In addition, a high audible footprint, which makes them easy to detect and there by increases the risk of being exposed, has also caused the somewhat limited success.

For a few years, Nano UAVs (< 100 gr) have been utilized – particularly by special operations units, who often have applied them in urban environments for 'around the corner' reconnaissance. The extremely small size of these UAV systems also makes them good for close proximity reconnaissance. That being said, it is also what makes them unsuited as a short-range reconnaissance system. Furthermore, the Nano AUVs' size do not leave space for a broad array of payloads, while it also reduces the weather robustness.

In the mini UAV class (up to 7.5 kg), fixed winged platforms have for many years supported the intelligence collection for military intelligence and Special Operations forces. These systems' characteristics ensure that they need little or no support infrastructure, have a long flight time, and have versatile payloads. Mini fixed winged UAVs can be deployed from a safe position and they are virtually undetectable because of their flight height. These UAVs can also stream real-time video down to the UAV team or the Commander. However, some of the most common mini fixed winged UAVs have been restricted due to the lack of e.g. gimbals, poor aerodynamic performance and difficulties in performing take off and landings in highly complex environments (e.g. forests and mountains).

SKY-WATCH MINI UAV SOLUTIONS

In relation to creating an integrated aerial mini UAV that offers reconnaissance support, Sky-Watch has introduced a sub 2.5-kilogram mini UAV platform to the market. The Heidrun mini UAV is targeted towards defense and security forces, which operate on levels from Company level down to Platoon and Squad level.

The Heidrun is based on battle proven technology and years of experiences from field deployments along with live operations. The Heidrun is a multi-purpose mini UAV, which is delivered in three configurations. These have been developed for different specific military operations:

1) Heidrun Mapping: Mapping of areas, infrastructure and terrain in 2D and 3D models with high quality output.

2) Heidrun EO/IR: Intelligence, Surveillance and Reconnaissance (ISR) via live video feed that can be transmitted to ground systems 30 km away (line of sight) from the UAV.

3) Heidrun Radio Relay: Radio relaying, which provides tactical soldier personal radios in the battlefield with a radio communication network that overcomes non-line-of-sight and beyond-line-of-sight challenges.

SKY-WATCH

HEIDRUN EO/IR

Live video reconnaissance
30 km data transmission
1.5 hours endurance

SKY-WATCH

HEIDRUN MAPPING

Terrain & POI mapping
2D and 3D models
2.5 hours endurance

SKY-WATCH

HEIDRUN RADIO RELAY

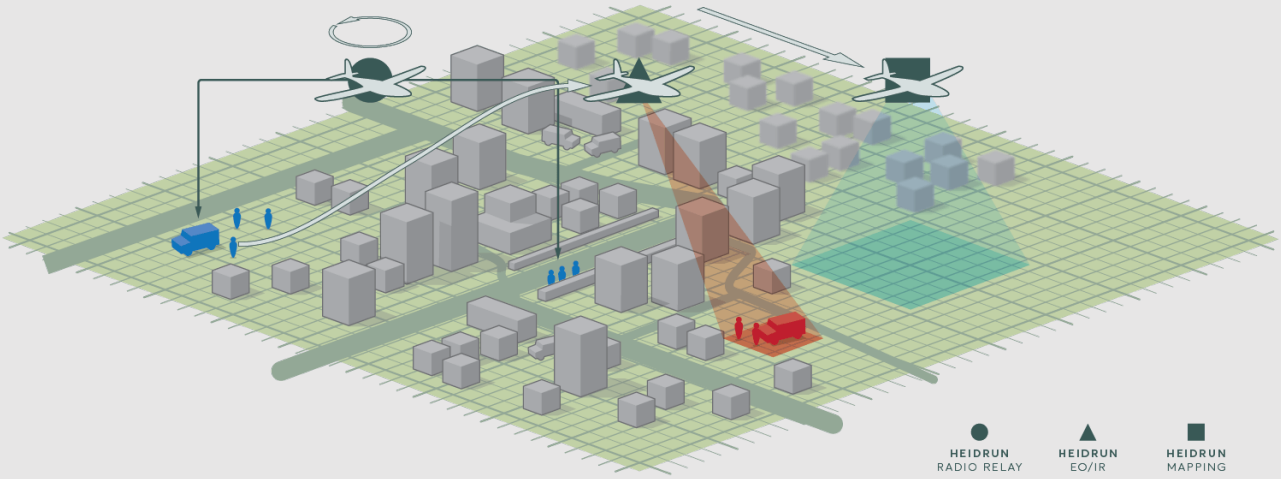
Extending Comms range
ANW2-C & STNW waveforms
1.5 hours endurance

The Heidrun platform is a small, mobile & man-portable fixed wing UAV with a length of 107 cm and with a wing span of 165 cm.

Common for all Heidrun configurations are a unique balance between weight and performance. The Heidrun is hand-launched and it is recovered using high precision deep-stall landings. The Heidrun has a long endurance and provides encrypted radio and data communication. The entire operation and maneuvering of the UAV is easy and user-friendly, and the UAV's workflow is specifically designed for field operations with access to ruggedized laptops and tablets.

HEIDRUN UAV SOLUTIONS – IN COMBINATION A TRUE FORCE MULTIPLIER

Individually, the three Heidrun UAV solutions deliver valuable intel, data and connectivity in the mission planning and/or the mission execution phase. However, the individual capabilities can also be viewed from a holistic perspective where the product synergies create a true force multiplier, which combines the different capabilities to address all needs that are present at company level.



Mission Planning

Maps form the basis for any military plan, and the Heidrun Mapping UAV provides updated maps for the planning of the ground mission. It also provides critical input to the Heidrun EO/IR in terms of identification of obstacles, suitable launch and recovery sites when configuring the flight mission in the mission software. Identification of POIs, which will be the target of a further reconnaissance mission with Heidrun EO/IR, is another capability of the Heidrun Mapping UAV.

The same applies to the deployment of the Heidrun Radio Relay where updated 3D maps can help to predict where line-of-sight will be lost. This information is critical for planning effective radio coverage for the ground units.

In the same way as the Heidrun Mapping can improve the deployment of the Heidrun EO/IR, the Heidrun EO/IR can optimize the usage of the Heidrun Mapping solution. This stems from the fact that the Heidrun EO/IR can be used to identify areas of interest, such as critical infrastructure, potential hostile forces or areas where civilians might be at risk, during the mission planning phase. This close to near-real-time information can help plan and prioritize the Heidrun Mapping mission. In return, the Heidrun Mapping can add more details, cover large areas and provide data for creating 3D models. These models allow decision makers to analyze, plan and simulate missions in the mission planning phase.

Mission Execution

Once a mission enters the execution phase, the Heidrun EO/IR and the Radio Relay solution become critical for success. However, it is their combined capabilities that make them indispensable assets. The effectiveness of the Heidrun EO/IR depends on the ability to make intelligence available at the right time, at the right place and to the right people. In an environment where the line-of-sight is challenged, the communication between the units on the ground and the UAV operator is at best unreliable. The Heidrun Radio Relay addresses this issue by extending the range of the radio communication between ground units in an open environment and by maintaining communication in complex mountainous, urban or forested areas. A reliable communication link provides ground units with the opportunity to request organic UAV assets.

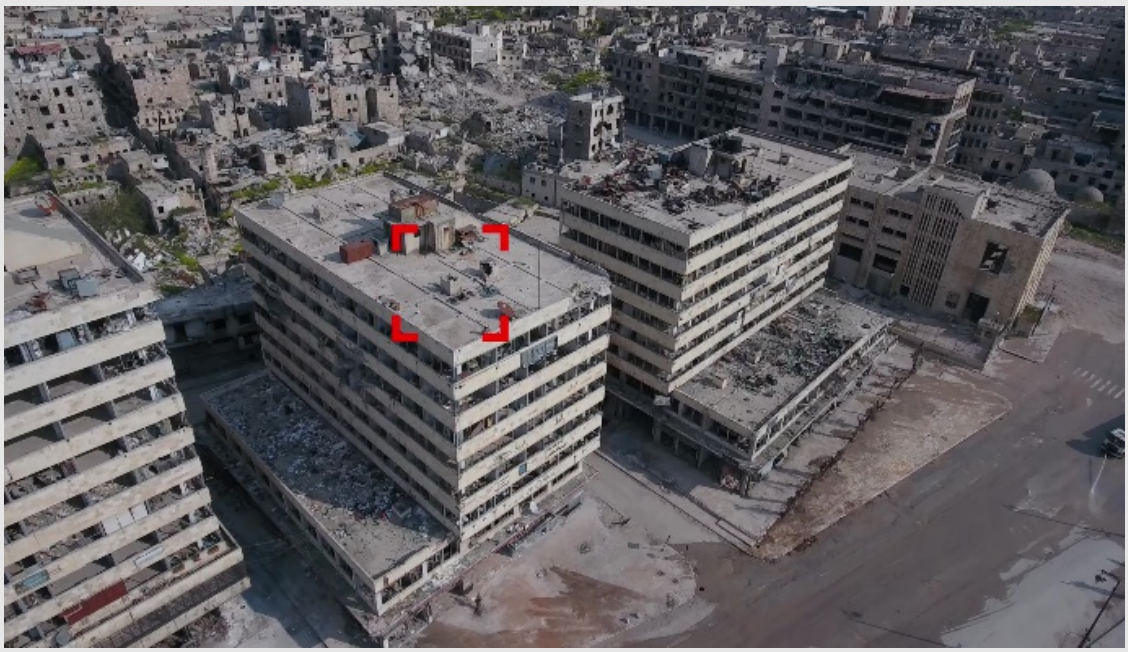
Deploying the Heidrun Radio Relay and the Heidrun EO/IR at the same time thereby ensures fast, effective and responsive UAV support in complex environments.

HEIDRUN EO/IR SOLUTION

The Heidrun EO/IR solution has a dual sensor payload (EO and IR) and offers an easy-to-use solution for intelligence, surveillance and reconnaissance operations in various operating environments. Operational UAV takeoff weight is only 2.3 kg, and the UAV provides an endurance of 1.5 hours. The UAV has a high level of stealth due to the fuselage design and the low noise electrical engine, meaning that in 2-300 m altitude the UAV is undetectable and perfect for covert operations.

A standard configuration provides a data transmission range of 12 km line-of-sight (LOS) for live video streaming. Adding the Lone Range Antenna Tracker the data transmission range is extended to 30 km LOS.

The intuitive UI for operating the UAV and the autonomous flight mode means the maneuvering the UAV is very easy, and the personnel can focus on the critical content of live video footage. Easy point-and-click operation of payload, controlling object tracking and POI management combined with the ability to record video on both the on-board SD card and on the tablet on ground, makes Heidrun EO/IR a high valued asset for Companies and reconnaissance units during their missions.



Heidrun EO/IR Solution – Key USPs

- Highly mobile and man-portable due to low weight
- Hand-launched & deep stall precision recovery
- 1.5 hours mission endurance
- 30 km data transmission range
- Stealth operation protecting and securing successful missions
- Intuitive UAV command and control UI for easy operation
- Object tracking, and POI management with GPS target position
- Option to integrate with MOSKITO TI (Target Laser Range Finder)

DEPLOYMENT CASE STUDIES

DEPLOYMENT CASE STUDY #1

Mini UAV supporting a Special Reconnaissance Team.

Mission Objectives

1. Verify position of enemy forces and civilians.
2. Visual identification of critical POI's within the area of interest.

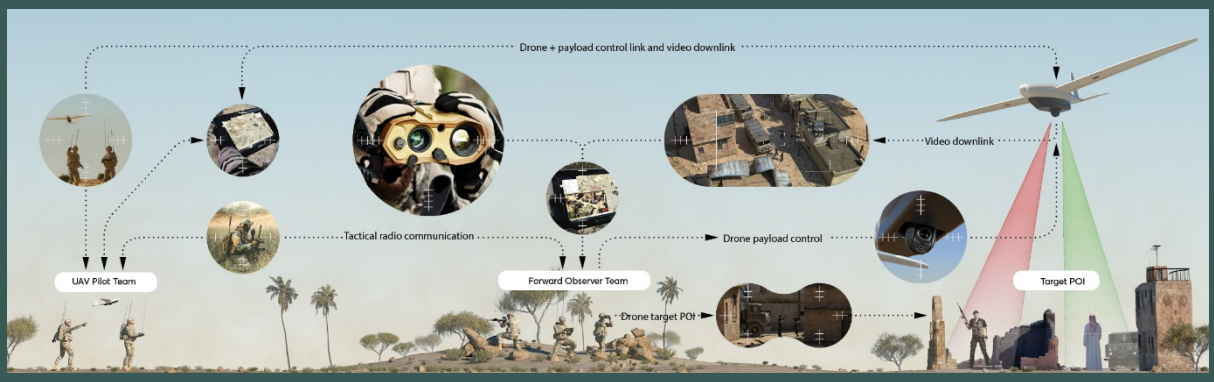
Equipment Setup:

UAV PILOT TEAM	SPECIALRECONNAISSANCE TEAM
1x Heidrun EO/IR UAV 1x Compact Ground Control Station 1x Long Range Antenna Tracker 2x Tablet running Sky-Watch UAV Control UI application and Video Viewer.	1x Compact Ground Control Station 1x Close Range Antenna 1x Tablet running Sky-Watch UAV Control UI application. 1x MOSKITO TI Laser Range Finder

Concept of Operations (CONOP):

The task regarding controlling the UAV is separated from the observer by enabling a Laser Range Finder (LRF) to assign Points of Interests (POI) to the UAV's mission. The CONOP can be extended to other UAVs, which means that it can support more ground teams.

1. POI's are marked and georeferenced using a Laser Range Finder.
2. A mini UAV is launched and deployed towards the Area of Interest.
3. The POI's are uploaded to the UAV flight mission once within range.
4. The video from the UAV is streamed in real-time to the ground unit and the UAV team.
5. Once all POIs are completed, the UAV is recovered by the UAV Team.

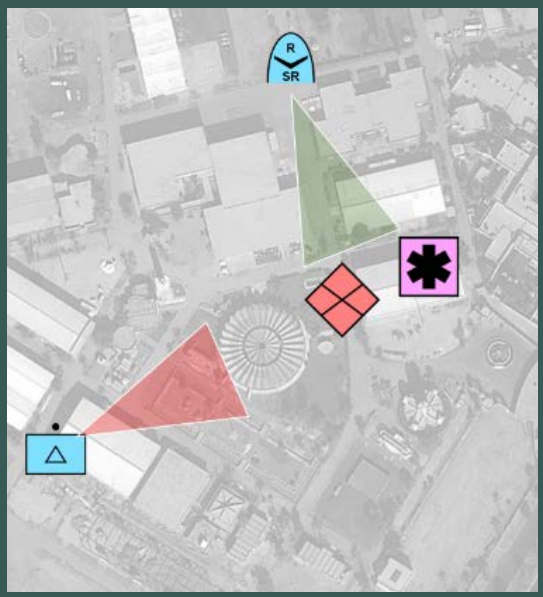


Deployment

A mission was planned in a remote urbanized area situated in mountainous terrain. In preparation for a larger mission in the area, a Special Reconnaissance (SR) Team was deployed with the purpose of gathering information about hostile forces and location of civilian infrastructure. The SR team was supported by an organic UAV team in order to 1) increase the quality of the intelligence and 2) reduce the risk connected to the SR team's mission.

The UAV deployment was supported by the constant intelligence information from the SR team, who assigned prioritized points of interest to the UAV. This meant that the effectiveness of the UAV was improved significantly since more intelligence was collected in a shorter period of time.

The SR team was mounted in the outskirts of the industrialized part of the area of interest. Throughout the day, the SR Team observed the area of interest and marked the POIs. At one point, the SR Team spotted a potential hostile vehicle. However, the vantage point did not offer line-of-sight for verification. As a result, the SR Team marked a nearby POI and passed the information to the UAV Team. In response to the information given, the UAV team deployed an UAV to the area of interest. Using the AUV, it was quickly verified that the vehicle was hostile. The UAV and its team also verified its armament and number of units.



DEPLOYMENT CASE STUDY #2

Mini UAVs supporting a mounted or mechanized Infantry Company by collecting intelligence.

Mission Objectives

1. Verify position of enemy forces.
2. Visual inspection of critical routes - entry and exit.

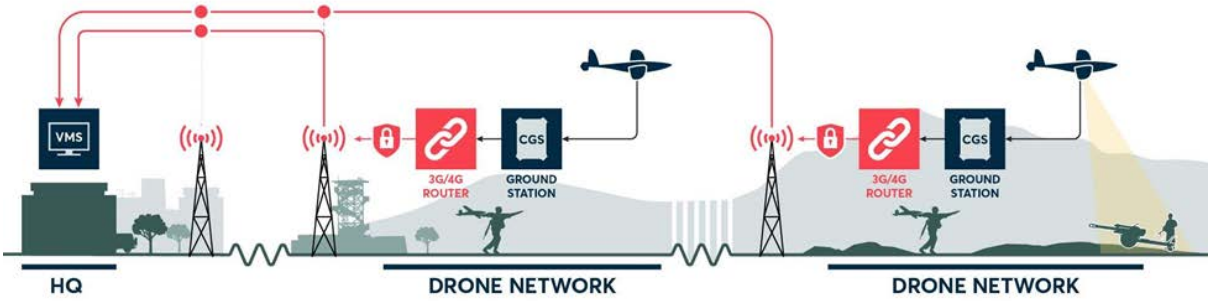
Equipment Setup:

HQ	UAV TEAM
1x PC for video analysis	1x Heidrun EO/IR UAV 1x Compact Ground Control Station 1x Long Range Antenna Tracker 2x Tablet running Sky-Watch UAV Control UI application and Video Viewer Back at FOB: 1x laptop with video editing/trimming software 1x peplink cellular router

Concept of Operations (CONOP):

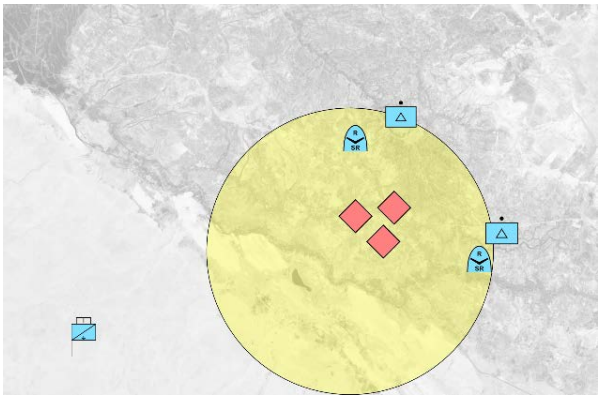
One or more organic UAV Teams are deployed to support an intelligence collection mission. The intelligence from the field is made available to HQ using secure communication, which utilizes existing high bandwidth networks. POIs and other pieces of mission information are prepared from the base in coordination with other intelligence assets.

1. Critical POIs are uploaded to the UAV mission.
2. UAV Teams are deployed.
3. Once the UAV Teams gets access to the high bandwidth communication infrastructure (e.g. at Forward Operating Base - FOB), the mission data (complete footage or only selected high priority footage) is uploaded to the Video and Image Management System (VIMS).
4. The data is analyzed and shared with relevant units.



Deployment

In preparation for a larger mission, where the objective is to secure access to a critical mountain pass, two organic UAV teams were deployed to gather the required information regarding the conditions of roads and other infrastructure, positions of potential enemies, as well as positions and condition of any fortifications. Due to the critical nature of the operation, it was crucial that the reconnaissance was collected without being detected. This meant that the UAV Teams had to deploy UAVs with minimal audible and visual footprint and be able to operate them from a safe distance. One of the UAV teams was deployed 22 km north from the target area, and the other team was deployed 12 km south-east from the target area.



The two UAV teams deployed two UAVs each and provided more than three hours of intelligence for further analysis. The UAVs undetectable footprint meant that the reconnaissance teams could operate below the cloud cover in a latitude of 200-300 m AGL. As a result, the data could be used to identify the number of vehicles and their type, along with the condition of the bridges that might had been tampered with. The two UAVs teams also provided critical knowledge about the terrain in terms of pointing out important vantage points, areas with limited line-of-sight and other high risks positions.

Once the two UAV Teams returned to the Forward Operating Base (FOB), they were able to review the collected video intelligence material, conduct a rough trimming of it and add further intel annotation to recorded POIs and video clips. The collected intelligence material was sent via a secure mobile end-to-end VPN-router (utilizing existing 3G/4G network) back to HQ and stored in the centralized VIMS repository for further analysis and for the planning of the upcoming mission.

CONCLUSION

This white paper has outlined how fixed winged mini UAVs can support mounted and mechanized infantry as well as forward observers on Special Reconnaissance missions. Furthermore, it outlines an integrated aerial reconnaissance solution, which provides scouts and SR teams with the capability to extend their vision beyond line-of-sight – thereby addressing one of their key challenges. The extension of the line-of-sight is accomplished by implementing a close integration between the existing technologies of laser range finders, radio and C4I/C2 systems and state of the art mini UAVs.

Implementing an organic integrated aerial reconnaissance asset will increase the effectiveness of the deployed reconnaissance units without putting additional pressure on the scarce large tactical assets and decrease the inherent risk of reconnaissance missions. In continuation hereof, the UAV can now act as a direct source of situational awareness when the Video and Image Management System and the secure link routers are added to the solution. This can be concluded since the intel video footage can be streamed in real-time or uploaded to a central intelligence repository on the move. This is of high value for the Commander's and HQ's decision-making and mission planning.

Sky-Watch A/S

Østre Allé 6F – 9530 Støvring – Denmark

E-mail: sales@sky-watch.com

www.sky-watch.com