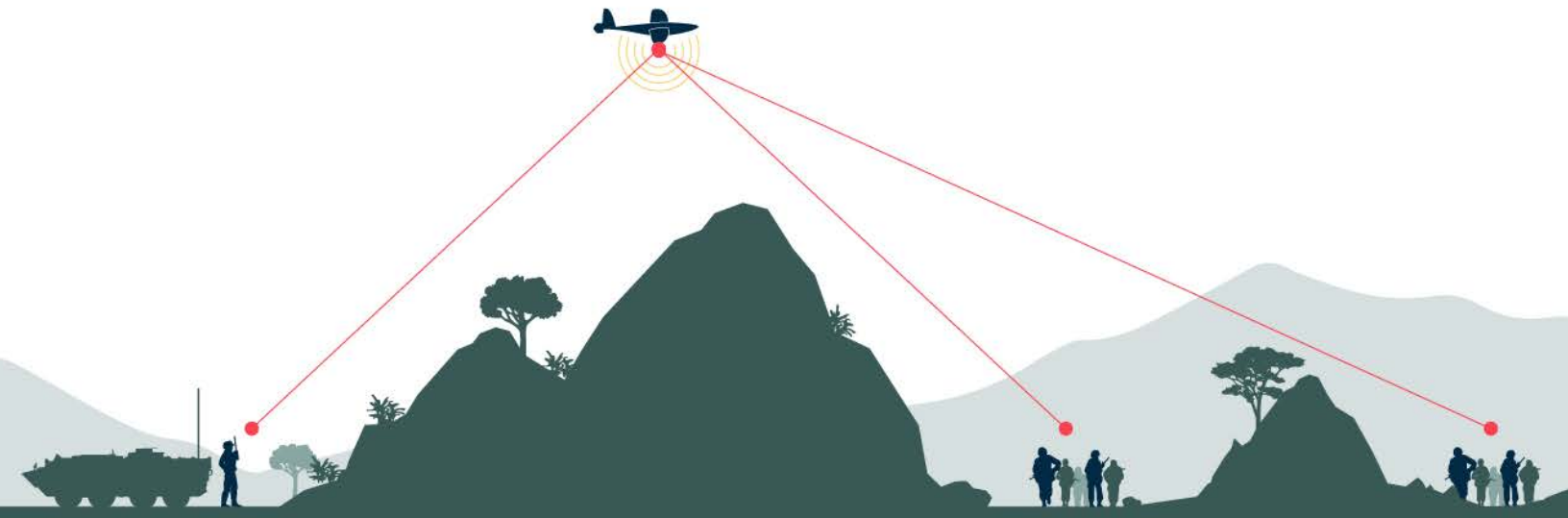
SKY-WATCH



RADIO RELAY

CASE STUDY

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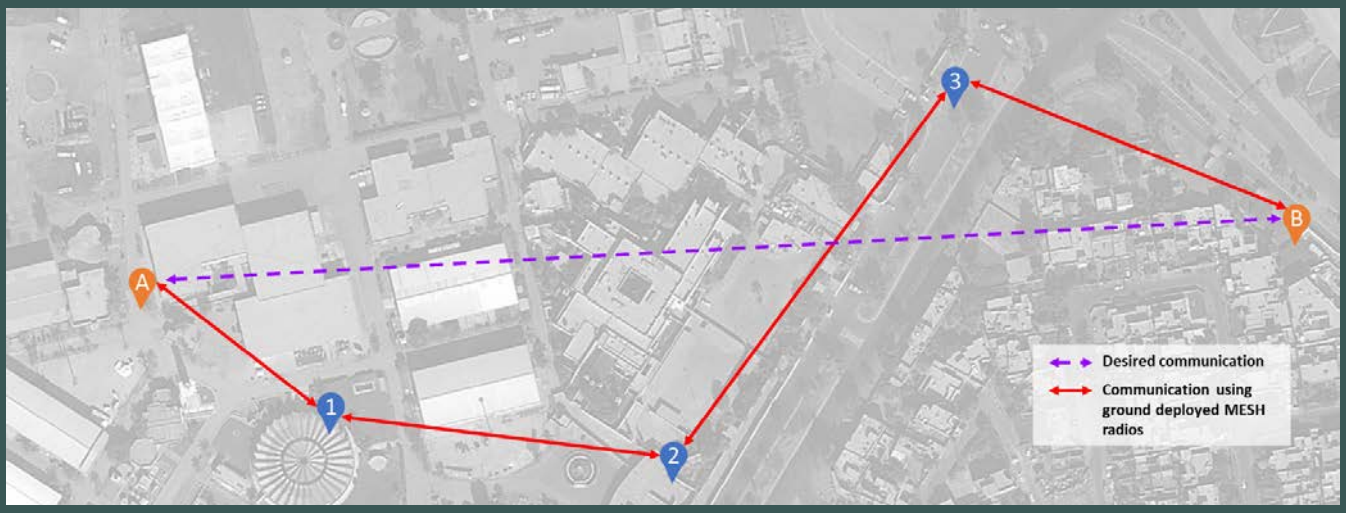
INTRODUCTION

With the accelerating shift towards data driven warfare, the importance of having access to and being able to share critical mission data in real time are becoming the main drivers for many soldier modernisation programs. Portable C4I systems, real-time shot detection sensors, laser range finders, etc. are thereby driving the need for staying in constant communication throughout missions regardless of how challenging the environment is. Critical as well as routine missions are in many cases complicated as a result of complex environments with limited line of sight (e.g. urbanized or mountain areas). By adding additional network nodes, which cover everything from air to ground in the communication infrastructure, it can be ensured that situational awareness can be extended at all levels of a modern army.

CURRENT STATE OF THE ART – ADDING AD-HOC NETWORK

The usage of existing line-of-sight communication methods have long proven ineffective in dynamic and complex missions. The challenges scale exponentially when units are deployed in joint or combined operations where allies operate close together or work across air, land and sea. Efficient communication and real-time data-sharing are key not only for a successful mission execution but also for avoiding friendly fire and collateral damages.

Mobile ad-hoc MESH networks are seen by many as the solution to the challenge related to establishing a secure radio in e.g. an urban environment. MESH networks use all the nodes in the network to relay and extend the coverage. However if this technology is only deployed at ground level, it will be greatly affected by obstacles such as buildings. The coverage will therefore at best be limited, while the connectivity will be unpredictable as it is affected by the distribution of ground radios and the size and material of the obstacles.



Communication needs to be established between point A and B but buildings are obstructing the line of sight. To overcome this problem, the MESH network utilizes other ground deployed radios. However, this solution is not optimal as it depends on having sufficient ground radios deployed at the right place at the right time or by having a number of MESH radios installed in strategic locations. Neither of these approaches are fast, flexible or simple to deploy in a complex environment.

ADDING A DIMENSION TO THE COMMUNICATION INFRASTRUCUTURE

To address the challenge of establishing a robust and predictable MESH communication infrastructure, which functions regardless of line of sight, many have found themselves deploying airborne assets or tall mast solutions to add another dimension to the communication infrastructure.

These include:

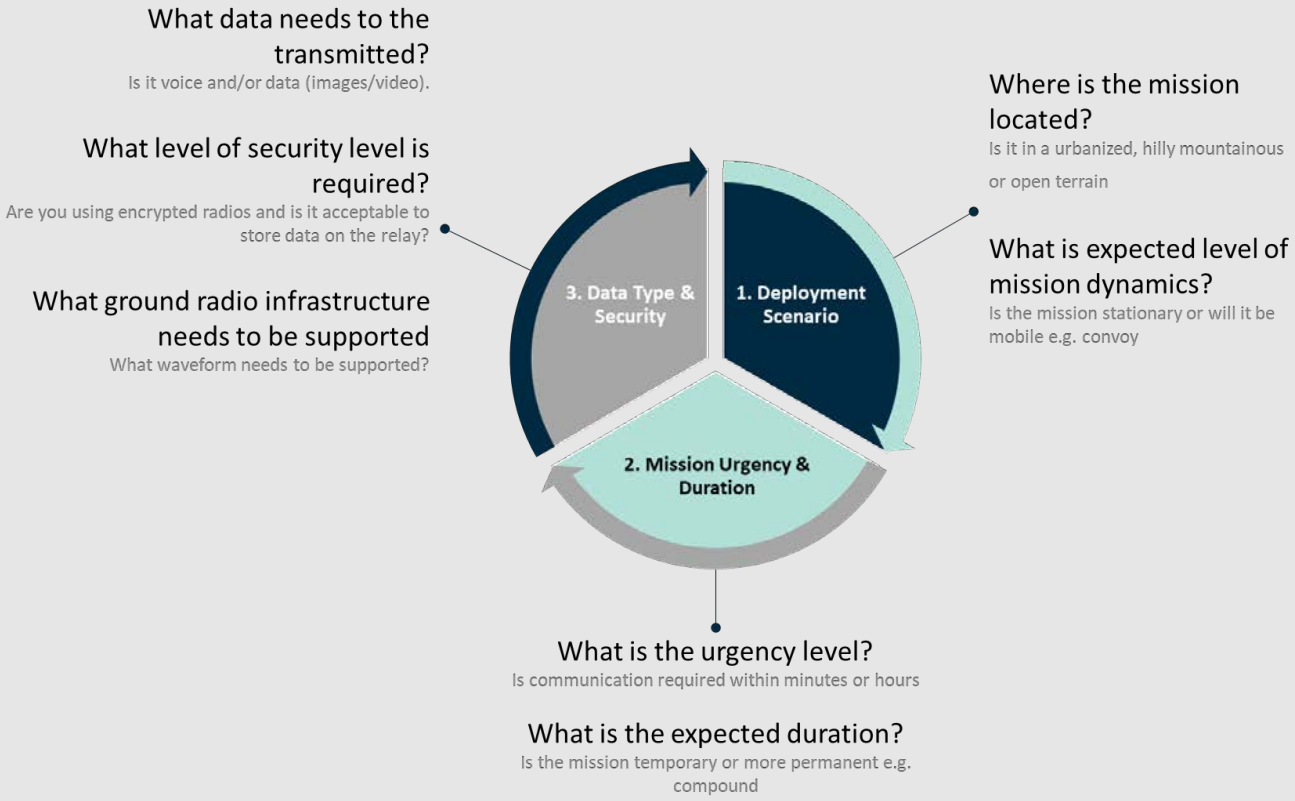
a) Large tactical UAVs (e.g. Blackjack or RQ-1 Predator)
b) Manned aircrafts or helicopters (Blackhawks)
c) Mast antenna solutions (e.g. Fth 34/5 truck, Ftm 15-4shelter or FWB 2530 Wide Band Dipole).

However, all the above share the same drawbacks in terms of high acquisition/operating costs and being complex to deploy and operate. This paper explores the considerations needed when choosing the right infrastructure for supporting your ground radios in beyond line of sight scenarios. Furthermore, the paper outlines the main differences between the various alternatives. Lastly the paper addresses some insights into the deployment of small/mini UAVs for communication relaying.

COMMUNICATION NETWORK ON THE BATTLEFIELD – WHAT'S THE CHALLENGE?

Shared Situational Awareness (SA) is recognized as one of the most critical elements in successful decision-making. A core element to achieve real-time Situational Awareness within a company or across a company, a platoon or a battalion is a reliable, secure and robust communication network. Essential, this network should support a broad range of missions and network configurations without overburdening the soldiers with heavy radios, etc.

There are 3 categories with key questions that need answering when defining your radio relay requirements: 1) Deployment Scenario, 2) Mission Urgency & Duration, and 3) Data Type & Security. Answering the key questions within these categories will help you find the right tool for the problem.



DEPLOYMENT SCENARIO

Where is the mission located? Coverage and quality of radio communication is heavily influenced by the environment in which the mission is taking place since the presence of several obstacles can 'break' the communication. Therefore, it is important to understand whether the environment is urban, mountainous or forest – environments where it is unlikely to maintain a high degree of line of sight.

What is the expected level of mission dynamics? It is important to determine if the mission has a high level of dynamics (mobility) or not. More specifically, you need to take into account whether the mission will cross multiple environments or if it will take place within a more permanent position with a single type of environment. The mission dynamics will increase the need for a flexible relay solution that can be re-deployed fast as the mission progresses.

MISSION URGENCY & DURATION

What is the urgency level? Different relay solutions have different response times and some solutions cannot comply with high urgency due to their nature. Where a large helicopter or an UAV will need to be deployed from airfields, a small UAV can be available at the discretion of the company and therefore be deployed fast.

What is the expected duration of the mission? Duration is a broad term that can apply to the entire mission or in this case to the relay mission. Where some missions might require a sustained radio relay capability for hours or days, other missions might only require radio relay for short periods of time. In these short missions, the cost and time associated with the deployment of e.g. a helicopter might outweigh the benefits. Using small UAV assets with a few hours of endurance might be a more sufficient solution, especially if it provides the possibility to extend the radio relay mission by deploying two UAVs which overlap. Consequently, the UAV solution might replace the need for a helicopter in many cases.

What data needs to be transmitted and shared? The functions available to the deployed companies and platoons include everything from voice, text applications, picture sharing to video transmissions. It is important to consider which of these functions must be available in the communication network.

DATA TYPE & SECURITY

What level of data security is required? It needs to be taken into account if there are any security requirements for e.g. encryption of communication which the solution must adhere to. The consequences of a node of your communication network falling into your enemy's hand could be great.

What ground radio infrastructure needs to be supported? It is important to know which radio assets are deployed. Find a relay solution that supports existing ground infrastructure and implemented waveforms.

SOLUTION COMPARISON SUMMERY

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

	Mini UAV Systems	Tactical UAV or Manned Aircraft	Tactical Mobile Antenna Masts
Mission Scenario	Dynamic Urbanized Area, Hilly/Mountainous & Open Areas	Dynamic Urbanized Area, Hilly/Mountainous & Open Areas	Stationary Open Areas
Response Time	Minutes	Hours	Hours / Days
Mission Duration	0 – 2h (single UAV Setup; Dual Setup Countinous)	6 – 12h	+12h
Asset Acquisition Costs	Very Low	Very High	Low to High
Organisational Level	Platoon & Company	Brigade	Company, Battalion & Brigade
Communicational Type	Beyond Line of Sight	Beyond Line of Sight	Line of Sight
Operational Team Size	1 - 2	5 - 6	2 - 5
Deployment Infrastructure	Hand Launched / None	Catapult / Net / Runway / Helipad	Vehicle Accessible Roads

NEXT GENERATION AIRBORN RELAY – SMALL/MINI UAV SYSTEMS

While the first part of this paper was concerned with providing a high-level overview, the following section will focus on mini UAVs as an extension of the communication network.

The use of mini UAVs for relaying applications is relatively new and only a few UAV platforms have this capability today. The relay capability is leveraged to the next generation light-weight radio relay modules (<85 gram), which are being introduced by leading communication companies such as Harris.

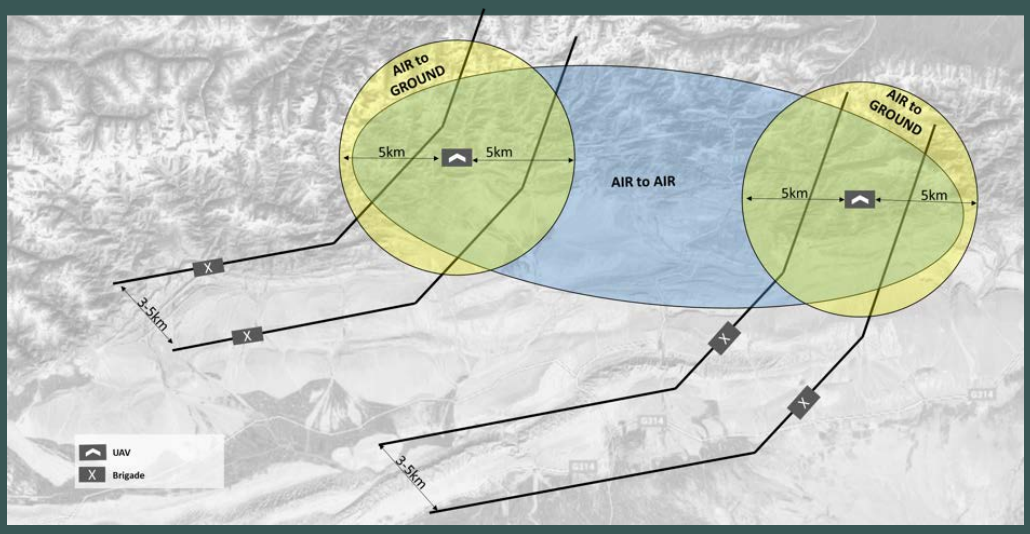
The implementation of relays on small UAVs can be succeeded on everything from Vertical Take-off and Landing to Fixed Wing platforms. Regardless of the type of UAV platform, the integration of a radio module faces the same challenges concerning the establishment of an effective airborne communication node. These challenges effect all aspects of the UAV, including the mechanical integration, flight control, antennas and mission specific user interface.

Communication at all levels

Although a mini UAV finds its natural place on a company level, it can, as a relay, support all levels of communication in e.g. platoons and brigades. A dual UAV setup can even support communication between two different brigades. The advantage of a mini UAV is that it can be deployed where it is needed without having to rely on other support infrastructures. A mini UAV can operate up to 3,500 AMSL, which provides sufficient altitude even in mountainous environments. Once in the air, a mini UAV, acting as a communication relay note, can support ground as well as other aerial platforms - extending the range even further. The illustrations below shows how a mini relay can support missions ranging from company to brigade level.

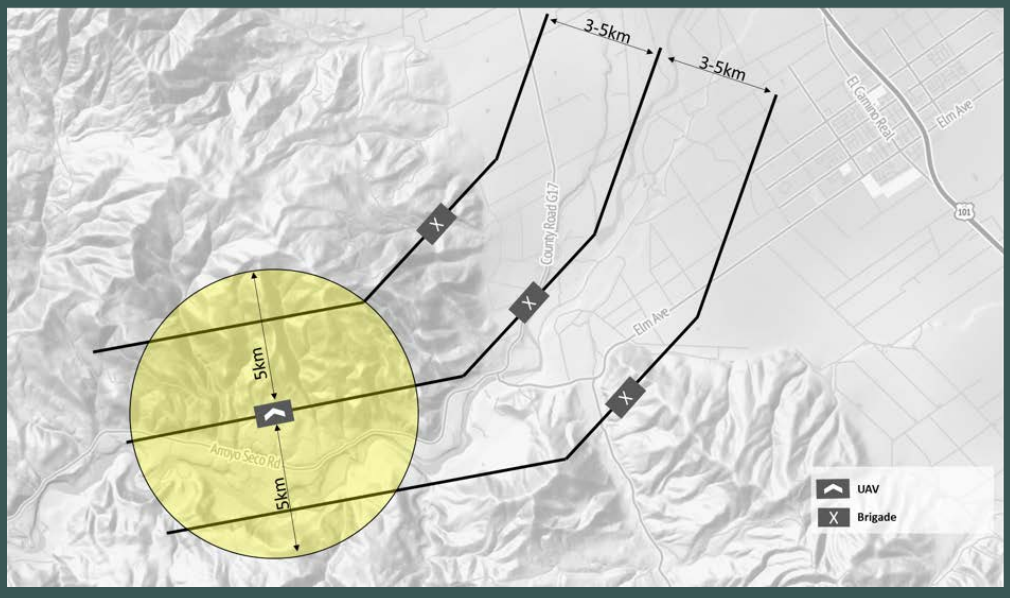
Cross-Brigade Level Communication

In this situation, two brigades are deployed in a none-line-of-sight (NLOS) environment. Each brigade has a mini UAV equipped with a radio relay. Once deployed, the mini UAV relay can provide coverage on the ground but the relays can also facilitate air to air communication. This enables real-time situational awareness across the two brigades.



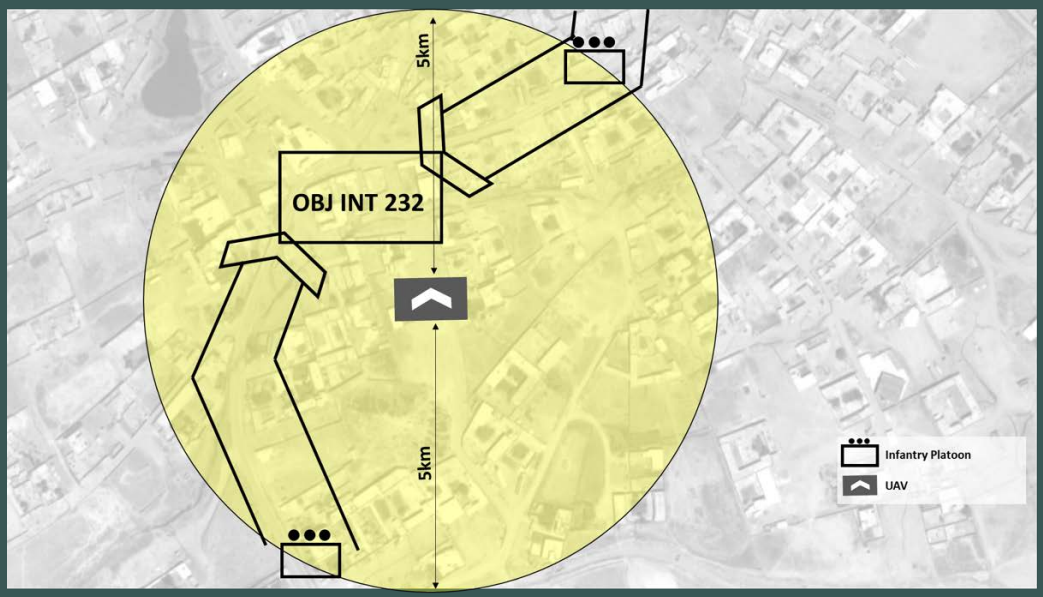
Brigade Level Communication

As illustrated, one mini UAV can naturally support the communication within a Brigade and between two brigades that are in the same location.



Company and Platoon Level Communication

Lastly, a mini UAV relay solution can support company level missions in e.g. urban environments where critical situational awareness needs to be shared in real-time. In this context, Mini UAVs have an advantage over larger airborne assets in terms of being harder to detect both audible and visual.



SKY-WATCH UAV SOLUTION

Sky-Watch has brought a sub 2.5 kilo UAV to the market that supports existing Harris communication infrastructure by using the STNW and ANW2 waveforms. The Radio Relay UAV is based on the battle proven technology platform Heidrun. The Heidrun is a multi-purpose mini UAV, which besides radio relay, is delivered in two different configurations (applications) that are targeted for specific military operations covering:

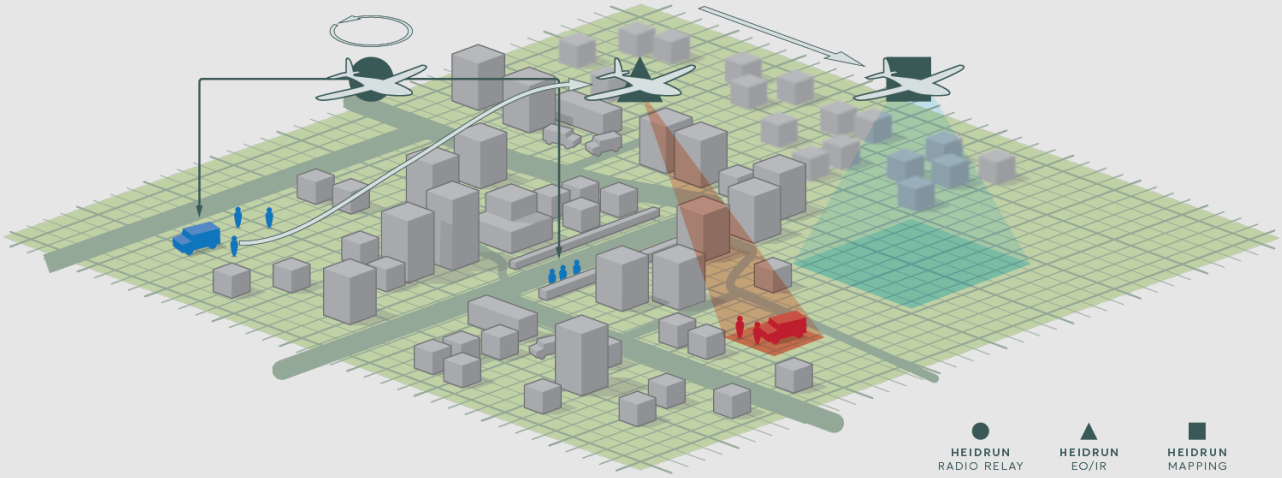
a) Intelligence, surveillance and reconnaissance (ISR) missions via live video feed
b) 2D/3D mapping of critical terrain and infrastructure POIs.

The Heidrun platform is a small, mobile & man-portable fixed wing UAV with a length of 107 cm, a wing-to-wing span of 165 cm and a height of 17 cm when assembled. Yet, it is a very robust UAV.

Common for all Heidrun configurations are a unique balance between weight and performance. The Heidrun is a robust, light-weight portable UAV, which weighs less than 2.5 kg. It is hand-launched and can manage high precision deep stall landings long endurance operations, and encrypted radio and data communication modules. The entire operation and maneuvering of the UAV is very easy and user-friendly because of an intuitive control UI, running on a ruggedized 11.7" tablet.

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 RADIO RELAY SOLUTION

Harris' micro-sized secure radio relay 'RF-330E-CM' is integrated in the Heidrun Radio Relay. The Embeddable Modular Radio (EMR) is a software-defined radio while the supported waveforms are either ANW2-C or STNW. The mechanical integration of the EMR covers cooling and powering, which leverage the design and architecture of the UAV platform.

The EMR module has its own dedicated antenna, separate from the UAV communication module (telemetry). This allows for an easy exchange of the EMR antenna in relation to service & maintenance but it also enables optimization of the radio frequency range used in the deployed ground radio.

The design of the antenna integration is fundamental in the facilitation of the deep stall landing method used in the Heidrun platform. Furthermore, it ensures maximum effectiveness of the antenna's ground coverage. The integration also enables the user to remotely control the operation of the EMR along with the the increase/decrease signal strength, and engage the silent mode for maximum RF stealth.

The Heidrun Radio Relay Solution has been designed specifically to be a dedicated radio relay mini UAV, which emphasizes key features such as:

1) Rapid Deployment From the moment you realize the need for radio relaying to get the Heidrun Radio Relay airborne is a matter of 3 minutes.

2) Radio Relay Mission Planning Wizard Easy configuration of radio relay point parameters as part of the general UAV mission planning process before uploading complete mission to the UAV.

3) Radio Relay Remote Control Remote control of EMR functions integrated in UAV command and control UI application.

4) Intuitive Radio Relay Control UI application A full-featured ground station application for ruggedized platforms provides an intuitive and user-friendly touch-based interface which has been designed and optimized for radio relay missions.

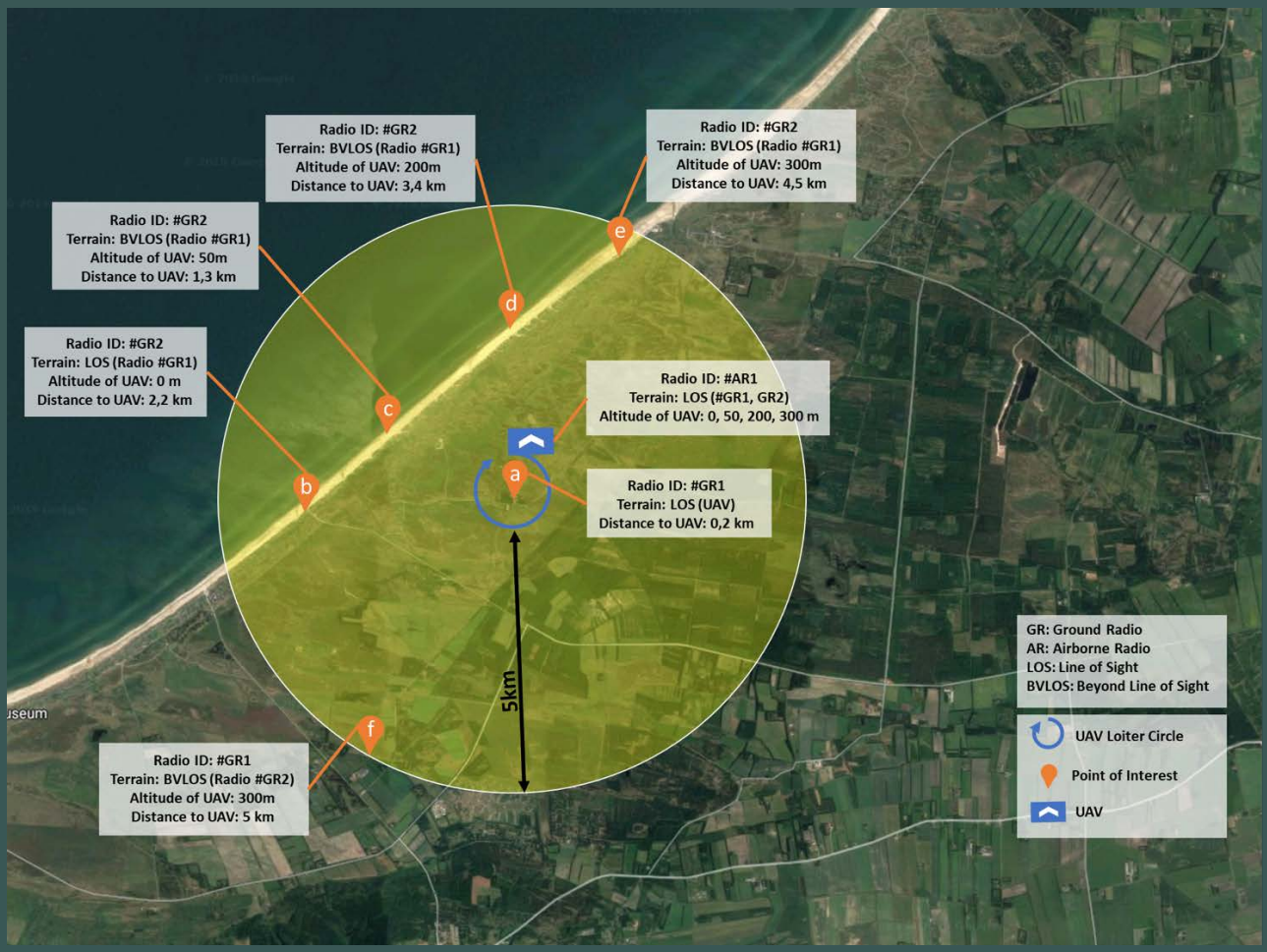
SKY-WATCH RADIO RELAY TESTED IN OPERATION

Test Objectives

1. Validate the ratio between radio coverage and flight height.
2. Test the effect of terrain with and without the Heidrun Radio Relay

Test scenario:

SOLDIER PERSONAL RADIO EQUIPMENT	RADIO RELAY UAV EQUIPMENT
2x HARRIS PRC 152A (with ANW2-C waveform) (Ground Radio: #GR1, #GR2)	1x Heidrun Radio Relay UAV 1x Harris RF-330E-EM radio relay EMR (fully integrated in Heidrun UAV) (Airborne Radio: #AR1) 1x Short range antenna kit for Heidrun (UAV 433 MHz ground station for UAV telemetry, 10 km range omni-directional antenna). 1x Tablet running Sky-Watch UAV Control UI application.



Test Procedure

1) At position "a", a radio link is established between the two ground radios (#GR1 & #GR2) in a line of sight and open environment.

2) While #GR1 remains close to the starting position "a", #GR2 is moved, while staying in line of sight, 2 km away to position "b". During this, the radio link is maintained.

3) When #GR2 is relocated to position "c", the line of sight between #GR1 and #GR2 is broken due to high sand dunes.

4) At position "a", the Heidrun Radio Relay Mini UAV is launched with a Harris EMR radio relay onboard. The UAV enters loiter mode at 50m AGL. The distance from #GR1 to the UAV is 0,2 km while the distance to #GR2 from the UAV is 1,3 km. The communication link is re-established by using the UAV as a relay since both #GR1 and #GR2 are within line of sight from the UAV.

5) The procedure is repeated at position “d” and “e” by increasing the UAV altitude until connection between #GR1 and #GR2 is re-established.

6) Lastly, #GR1 moves to position “f”, 5 km away south of the UAV position. The communication link to #GR2 is maintained with approx. 10 km distance between the 2 radios.

Conclusion:

In overcoming the challenge of securing a shared Situational Awareness (SA) across the battlefield to ensure successful decision-making in different dynamic mission types with diverse environments, the mini UAV with radio relay assets underscores its clear advantages when compared to traditional communication network methods. It is possible to extend communication with approximately 2 km end-to-end for every 100m of altitude above ground level. The specific test was limited to 300m AGL. Yet, its results proved that a radio relay mini UAV, operated by a UAV pilot team of 2 persons, can extend the communication coverage from 2km to 10km in diameter from the UAV loiter position in a NLOS environment.

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