SKY-WATCH

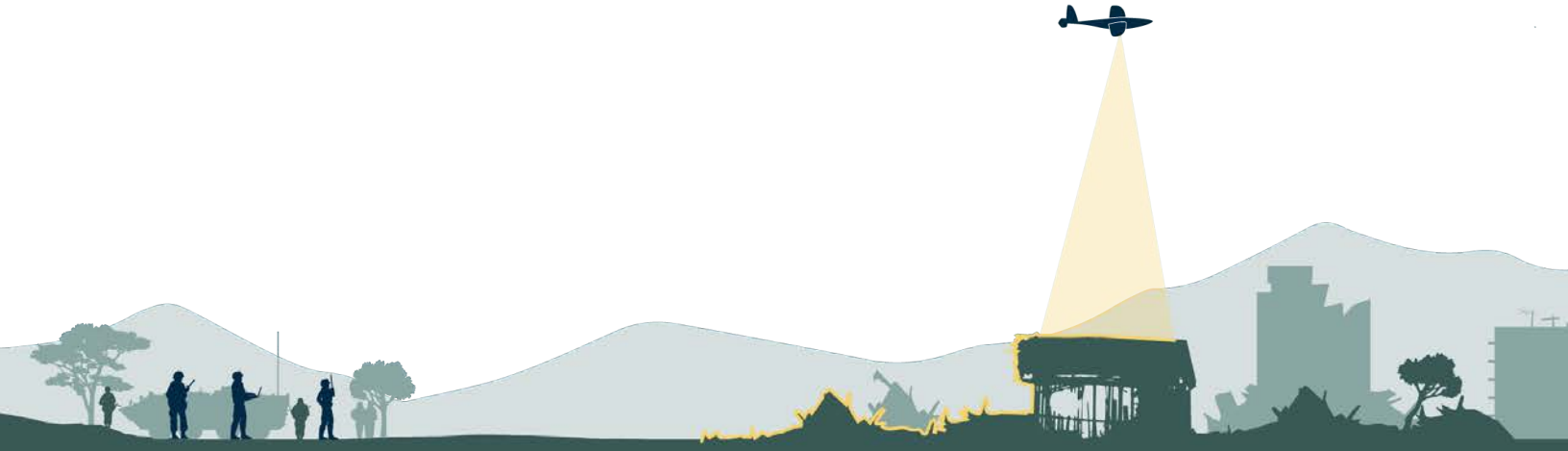

IMAGE INTELLIGENCE

WHITE PAPER

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INTRODUCTION

Since the dawn of warfare, a commander's ability to visualize the battlefield and direct his or her forces has often meant the difference between victory and defeat. Defined as the "fusion of imagery with geospatial information to describe, assess, and visually depict physical features and geographically referenced activities in the battlefield", Geospatial Intelligence (GEOINT) and Image Intelligence (IMINT) have evolved to help satisfy this intelligence requirement. By allowing everyone to "'see' the map" and understand pertinent details about the enemy and terrain in time and space, the commander's and staffs' visualization of the battlefield are enhanced.

Geospatial information exploitation technology is one of the vital enablers and defining aspects of 21st century defense, intelligence and homeland security capabilities and operations. In a digital age, where location and time can be ascribed to the majority of data, GIS and GEOINT systems provide the means to ascribe data with geographical attributes. In this visual context, complex dynamics, patterns and relationships can be revealed, analyzed and understood in a completely new way. This takes 'situational awareness' to an entirely different level and enables an unprecedented and powerful new type of capability - geospatial analysis.

In the 21st century, information superiority is essential for success in dealing with increasingly complex threats and emergencies. This makes the need for GEOINT and IMINT absolute as they are not 'nice to have' but 'must-have'-capabilities.

The reality today is however that the current collection platforms are very costly to operate, making them a scarce resource and therefore likely to be prioritized to high priority missions. The complex and scarce nature of the current IMINT assets creates a long turnaround time from identifying the intelligence requirements to delivery of latest updated intelligence & maps.

The big question is then how can a Company get to a position of always having updated maps and intelligence at hand within the very same day? Further to that, try and imagine a Company planning a mission, having the capability of mapping the same are of interest every day for a week to know exactly when to engage and be fully prepared on what to expect of enemy forces, actual state of the infrastructure and what possible obstacles to meet entering the battlefield.

This white paper will explore and outline the best practices derived from the USA Marine doctrine for GEOINT and IMINT cycles, and how a decentralized mapping/IMINT capability on Company level is achievable by adopting mini UAV solutions as a collection platform and exploitation tool for accurate situational awareness.

SETTING THE SCENE OF GEOINT AND IMINT

GEOINT/IMINT provides many advantages for the warfighters, national security policy makers, homeland security personnel, and intelligence community (IC) collaborators. It will help answer several questions.

Questions GEOINT / IMINT can help answer:

- Where am I?
- Where are the friendlies?
- Where are the enemies?
- When might they move?
- Where are the non-combatants?
- Where are the obstacles (natural/man-made)?
- What is the environment?
- What is the impact of the strike?

Historically, the interpretation of image data, which has been captured from different bands for mission-critical operations, has been a core GEOINT capability. The GEOINT mission demands utilization of geospatial data and information as close to real-time as possible. Collecting and analyzing image data is often the fastest way to provide this information to decision makers.

There are two areas of electro-optical (EO) imagery; video (real-time or post) or imagery (still images). Analysts use these sources to identify objects of interest, verify positions, establish baseline activities, and determine changes between images across time. This white paper focuses on the generation of maps based on high resolution still imagery for the applications exemplified in the below figure.

Applications within IMINT and GEOINT

Mission Planning, Rehearsal, and Command & Control (C2).

- Plan, rehearse, and execute missions; evaluate mission progress; adjust schedules; and assign and apportion forces, as appropriate.
- Create realistic, interactive scenarios that accurately depict the operational area in three dimensions and across time.

General Military Intelligence and Warning Intelligence.

- Monitoring scientific and technological developments.
- Supports situational awareness (SA) by providing warning of possible increased threats or a significant increase in the tactical positioning of adversary assets

Support to Targeting.

- Development of target materials through basic, intermediate, and advanced target development.
- Intelligence community target vetting
- Collateral damage estimation
- Battle damage assessment.

Operating Environment (OE) Awareness.

- Visualizing the OE via change detection
- Tracking movements of interest
- Monitoring land installations, support facilities, airfield site selection suitability and port activity

CURRENT STATE OF THE ART - CENTRALIZED INTELLIGENCE SETUP

Historically, GEOINT can trace its intelligence roots back to the desire for "controlling the high ground" because this gave the possessor an observational advantage. This historic recognition widens the potential GEOINT and IMINT sensors within a brigade combat team to all scouts, forward observers, and additional reconnaissance and surveillance assets.

Today GEOINT is an intelligence discipline that has evolved from the integration of imagery (IMINT) and geospatial information to a broader cross-functional effort with the purpose to support national defense missions and international arrangements. Advances in technology and the use of geospatial data throughout the joint force have created the ability to integrate more sophisticated capabilities for visualization, analysis, and dissemination of fused views of the operational environment (OE).

US Marine intelligence setup (organization, collection cycles and collection platforms) represents by its structure and processes the best practices often referred to as the blue print by other organizations building the capability.

ORGANIZATION

The GEOINT or IMNIT organization is often founded as a part of the HQ function in form of the Intelligence Operations Center (IOC). It is from this center that all tasking, collection, processing and dissemination takes place. The IOC is comprised of intelligence officers, analysts and liaisons, whom all have specific tasks. Furthermore, the IOC is also responsible for defining the intelligence requirements and the prioritization of scarce IMINT assets. The IOC needs to balance the broad distribution of supported units, the limitations of range and capability, and the need to focus IMINT resources to the commander's priority intelligence requirements (PIRs). The IOC often includes various airborne platforms as well as satellites.

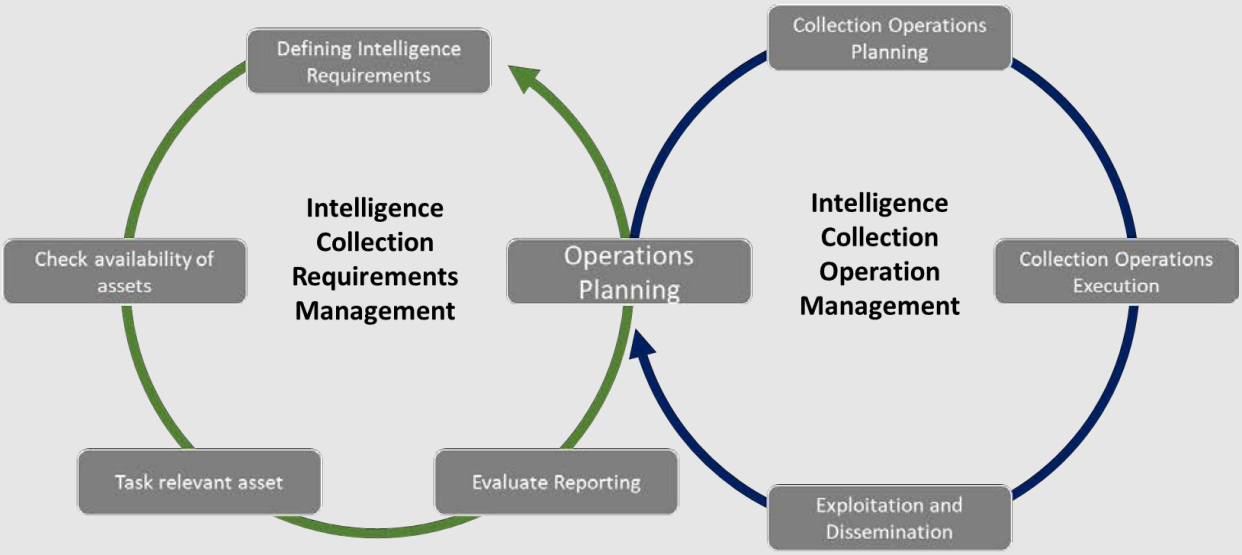
INTELLIGENCE COLLECTION CYCLE (TCPED)

The Tasking, Collection, Process, Exploit and Disseminate (TCPED) cycle is the foundation of any intelligence mission. It facilitates the conversion of a requirement to actionable intelligence. The TCPED initiates as the commander requests information and concludes when the IMINT is delivered to the

relevant end-user. The success of the cycle depends on the decision-making cycle of the end-user since the end-user needs to provide the IMINT needed to help the commander's decision. IOC will go through the following steps of the TCPED cycle:

1. Tasking - determined by a decision maker (customer) to ensure completion of objectives.
2. Collection – utilization of all available resources in order to gather and provide pertinent information within a required time limit.
3. Processing - collation of the raw data in preparation for exploitation.
4. Exploitation – establishment of the significance and implications of the processed data.
5. Dissemination- efficient distribution of derivative/actionable data.

Noteworthy, the TCPED cycle is divided into two separate cycles as illustrated below. The green cycle revolves around the task, while the blue cycle concerns the elements of Acquire, Process and Disseminate.



INTELLIGENCE COLLECTION PLATFORMS

Collection platforms have been created for all domains, which include water, ground, air, space and cyber. This white paper focuses on the aerial and space platforms as these are the most common and the most versatile.

Space platforms collects imagery data from two satellite sources: government-owned satellites and private industry-owned satellites, otherwise known as *commercial systems.* U.S. Government satellites are used for both unclassified and classified purposes. Satellites orbit at a far higher altitude than airborne platforms, enabling them to collect data above any airspace - including sovereign airspace of any nation, hostile territory, and areas where airborne platforms are denied access.

Airborne platforms consist of manned, unmanned, fixed-wing, and rotary aircrafts, as well as balloons. The sensors and cameras mounted on airborne platforms can provide continuous (known as *persistent*) coverage of a location or target. U.S. Government airborne platforms can often be employed faster than satellites. This is partially a result of military regional combatant commanders having authority over the platforms, and because they can re-task the platform in near real time if required. However, the effectiveness of airborne GEOINT collection can be limited due to denied or contested airspace and adverse weather or atmospherics.

UAVs were developed as a cost-effective, low-risk, near-real-time Reconnaissance, Surveillance and Target Acquisition (RSTA) platform to support joint task forces. Most mini and tactical UAV systems will mainly collect imagery intelligence (IMINT) but they will also collect SIGINT to some extent. They are often employed along other systems to analyze the battlefield situation, and they are designed to enhance other collection systems such as the LANTRIN (on F-15 Strike Eagle and F-16) and U-2 sensors.

CENTRALIZED INTELLIGENCE SETUP – WHAT'S THE CHALLENGE

While the organization and intelligence cycles described in the previous section are well suited for large forces with persistent presence in a region, it lacks some qualities that are needed for more dynamic and temporary missions where the situation might change from day to day. Today's very centralized approach to intelligence collection and processing means that some missions are neglected on behalf of higher priority missions, which take up the capacity of tactical UAVs or manned aircrafts. The challenges can be summarized as follows:

1. Limited availability of IMINT Assets – Today, most IMINT missions rely on data coming from satellites, large UAVs or manned aircrafts. All of these are assets that have high acquisition costs. Consequently, they are only deployed in small numbers.

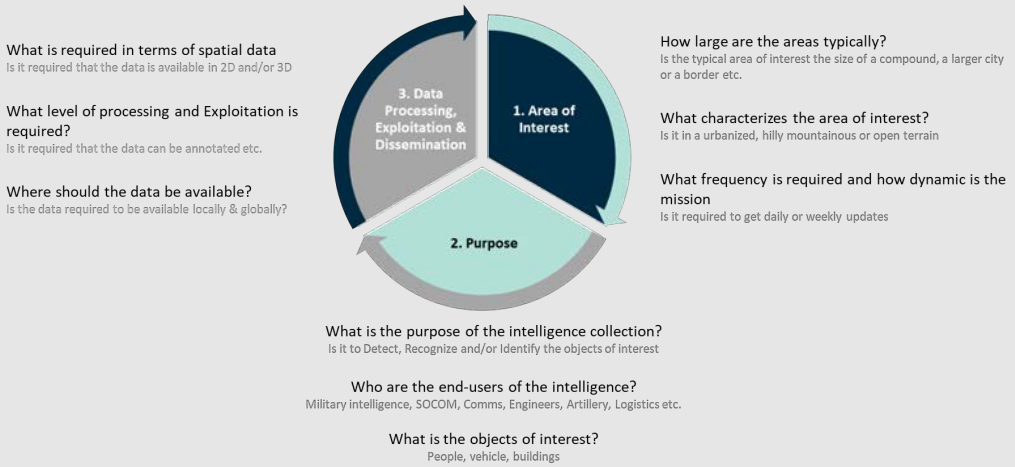
2. Centralization of the TCPED Cycle – The number of stakeholders makes tasking, acquisition, processing and dissemination slow leading to long response time.

3. Logistical complexity in transferring heavy data to and from the frontline – Unless the UAVs or manned aircrafts are deployed from the same area as the IOC, the data will need to be transferred from the site to the IOC.

CHOOSING THE RIGHT INTELLIGENCE COLLECTION PLATFORM

Choosing the right Mini UAV solution requires considerations about 1) the area of interest 2) the purpose, and 3) the data processing, exploitation and dissemination.

A single mini UAV without the backwards integration will only be able to provide the desired actionable output to a limited extend.



COLLECTION PLATFORM 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	Satellite Imagery
Mission Scenario	Urbanized Area, Hilly/Mountainous & Open Areas	Urbanized Area, Hilly/Mountainous & Open Areas	Urbanized Area, Hilly/Mountainous & Open Areas
Response Time	Minutes	Hours	Hours / Days
Intel Lead Time	2-6h	>12h	>24h
Mission Duration	0-2h	6-12h	+12h
Data Acquisition Costs	Very Low	High	High
Organisational Level	Platoon & Company	Brigade	Army
Training/Skill Level	2 weeks	Months	Months
Roll Out Time	2 month	Year	>4 Months
Operational Team Size	1-2	5-6	N/A
Deployment Infrastructure	Hand Launched	Catapult/Net/Runway/Helipad	N/A
Data Quality	High Resolution (Centimetre)	Medium Resolution (Centimetre)	Low (Meter)
Data Type	2D/3D	2D/3D	2D
Stealth Level	No visual in 1.000 ft No noise in 700 ft	No visual in 20-30.000 ft No noise in >10.000 ft	N/A N/A

A NEW AND RESPONSIVE MINI-UAV IMINT CAPABILITY DEPLOYED AT COMPANY LEVEL

While the first part of this paper was concerned with providing a high-level overview of the challenges, the following section will focus on mini UAVs as an alternative or addition to the existing centralized intelligence setup.

The use of mini UAVs targeted for IMINT collection platform in military organizations are relatively new and not a widely adopted capability outside the intelligence organization today. For several years mapping UAVs have been used in the civil professional market but only a very few solutions exist designed specific for the defense market.

Decentralizing the TCPED

By exploiting the best practices from US Marine's existing structures and processes and by reducing the overall complexity through decentralization of not only the IMINT collection platform but also the first layers of the data exploitation, it is possible to reduce the time span from intelligence request to providing forward deployed units with actionable data. This decentralization is supported by advancements in a number of the key technologies such as more capable mini UAVs and ruggedized laptops.

For a decentralized company level intelligence collection process to be efficient, it is required that the tools are implemented alongside the collection platform which supports every step of the TCPED cycle. Furthermore, the decentralized TCPED needs to enable a fast and user-friendly exploitation solution which ensures that the required tools can add a mission Layer to the maps generated.

A decentralized intelligence solution needs to support high mobility at all levels, including:

1. The collection platform - The UAV needs to be able to operate without support infrastructure, be easy to deploy and be possible to operate and service in the field.

2. The ground hardware infrastructure - Everything from the UAVs ground control station to the laptop needed for processing and exploitation needs to be light, mobile, ruggedized – but powerful.

3. Exploitation tools - The software tools required for processing, exploitation and dissemination needs to be able to run of ruggedized laptops, have a simple and integrated workflow all the way through Processing to Dissemination, and as well be able to offload the imagery data in a standard format that can be used in the centralized IOC as an additional intelligence source.

Operational Execution

Aerial observation of enemy tanks, scout platoon identification of enemy elements, engineer reconnaissance assessments of bridges, and reported locations of friendly units would all fit within the definition of geospatial data. Compared to other aerial and space assets, mini UAVs offer a distinct value proposition in relation to this kind of data.

Due to the relative low acquisition cost, mini UAVs are being considered for deployment more often at company, platoon and even squad level for a live overview of the operating environment. However, mini UAVs equipped with mapping cameras have mostly been deployed by the intelligence community. Mini UAVs, as an IMINT collection platform for local situational awareness, increases the flexibility and responsiveness of a forward deployed company or platoon. Mini UAVs can provide high-quality and low-cost intelligence with little or no risk for the operator. In addition, the data can be used to determine:

- Hight and size of structures
- Width of roads
- Line of sight and blockings from specific positions
- Condition of critical infrastructure
- Number of building and vehicles
- Position of hostiles, neutrals and civilians
- Damage assessment
- Etc.

Deployment of Tactical UAVs or Manned Aircraft

When deploying a tactical UAV or a manned aircraft for intelligence collection, the scarcity of assets creates some operational challenges for dynamic missions. The asset

1. can only be at one place at the time
2. is dependent on support infrastructure
3. is easy recognizable due to a large footprint

Deployment of Mini UAVs

By using mini UAVs to support the intelligence collection at company level, it will be possible to deploy more UAVs at a much lower cost, and that are closer to the area of interest. The mini UAVs can be deployed by mounted and dismounted units since they are hand launched and do not require any infrastructure.

These are distinct advantages compared to deploying tactical or manned aircraft for intelligence collection and key to the operational execution of building the IMINT capability on Company level.

SKY-WATCH UAV SOLUTION

In the context of creating a decentralized intelligence collection offering, Sky-Watch has introduced a sub 2.5 kilogram (operational take off) mini UAV platform to the market. The Heidrun mini UAV is targeted towards defense and security forces from company level and down. 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 military operations:

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

2. Intelligence, Surveillance and Reconnaissance (ISR) via live video feed that can be transmitted to ground systems 30 km away from the UAV.

3. 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.

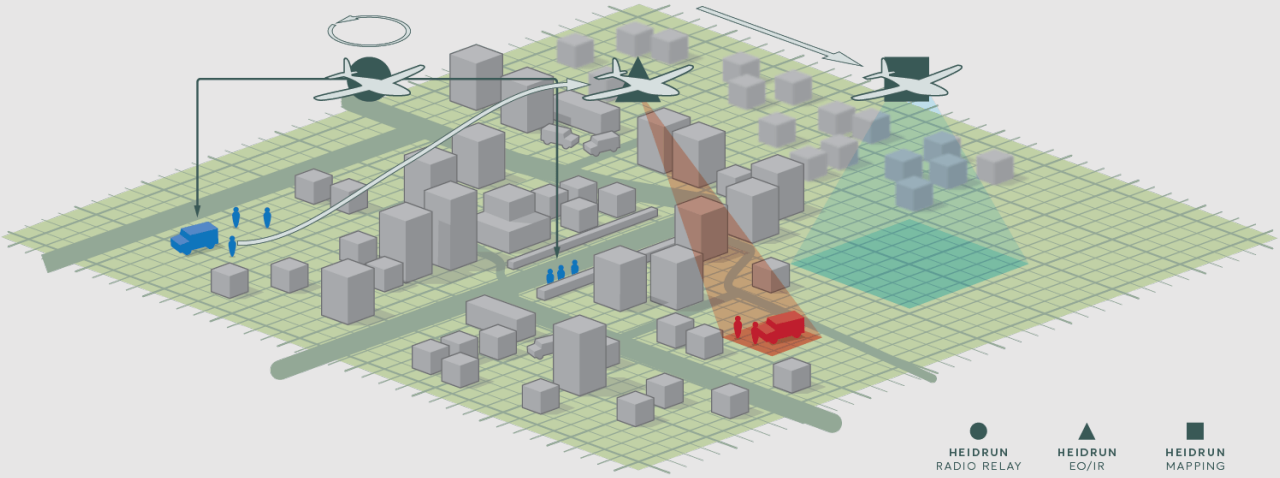
The Heidrun platform is a small, mobile & man-portable fixed wing UAV with a length of 107 cm and with a wing span of 165 cm.

Common for all Heidrun configurations are a unique balance between weight and performance. The Heidrun is hand-launched and it is collected through 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 very easy and user-friendly, and the UAV's workflow is specifically designed for forward operations with access to ruggedized laptops and tablets.

Due to the visual and technical design the Heidrun mini UAV is very stealth and is invisible at only 1000 ft and at 700 ft you won't be able to hear the UAV flying by. This is a very essential element using airborne assets for Intelligence, Surveillance and Reconnaissance missions and allow you to get really close to subject of interest.

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 MAPPING SOLUTION

The Heidrun mapping solution offers a high level and easy-to-use solution for precision mapping, surveying and terrain reconnaissance. Thereby, it offers a versatile intelligence collection platform. The operational UAV takeoff weight is only 2.2 kg, and the UAV provides large terrain coverage due to the combination of an endurance of 2.5 hours and a high cruising speed. With high reliability and advanced flight controller, the Heidrun produces high quality (20 megapixels) and high resolution (down to 2-3 cm of ground resolution) imagery even during rough weather conditions.

In order to provide the end-users with a turnkey solution, the Heidrun mapping solution also offers a number of software tools that support the complete intelligence collection process from tasking to dissemination in a smooth and integrated workflow.

The main application of the Heidrun Mapping falls into two sub-groups:

1. Open Environments
   In deployed environments, ground commanders, military planners, engineers, and practitioners can use 3D models that have been generated by the Heidrun for mission planning and rehearsal, terrain generation, route mapping and clearance, base layout and design, infrastructure planning, IED modeling and post-blast assessment, cover/concealment, and more.

2. Urban Environments
   Operational units, such as infantry and special operators, can use the Heidrun to produce models with the purpose of mapping the battle space and enhancing defensive preparation efforts or model assault objectives. In that way, units can quickly determine mission conditions and answer questions such as: "Can our vehicles fit in that alleyway?", "Can we land a helicopter on that roof?", "What is my line of site at this location?", "How long time will it take to reach a point of interest?", and "How high and thick is that wall?".

Heidrun Mapping Solution – Key USPs

- Highly mobile and man-portable due to low weight
- Hand-launched & Deep-stall precision recovery
- 2.5 hours mission endurance
- Stealth operation protecting and securing successful missions
- Short turn-around time from need to actionable intel data
- High quality resolution imagery data for detailed 2D and 3D modelling
- Autonomous flight missions – just throw & collect
- Intuitive UAV command and control UI for easy operation
- User-friendly integrated workflow from planning to actionable intel data
- Easy-to-use feature-rich Processing and Exploitation software tool

A COMPLETE TURNKEY COMPANY LEVEL INTELLIGENCE SOLUTION

The complete solution supports a light-weight operational deployment on Company level covering the principles of the collection cycle (TCPED) while providing high value actionable intelligence data quickly and easily. The TCPED cycle and supporting tools are described and presented below.

1. **Tasking** - The Company Commander defines the mission in terms of mission objectives and priority (e.g. counting targets, damage assessment or determining strength of the enemy), desired ground resolution (depends on the objects of interest - e.g. vehicle, buildings or people), and data visualization (2D and/or 3D).

2. **Collection** – Based on the defined task, the Heidrun UAV operator will plan the UAV mission - taking weather, launch/recovery and payload selection into consideration. The mission planning is done in the Sky-Watch mission planning UI, which runs on a Windows tablet or laptop. The UI enables users to exploit established map engines (e.g. ESRI, ArcGIS, Google Maps, BingMap, Open Street Map, etc.) as well as own generated maps.
   Setting up mapping missions is simplified by using pre-defined mapping profiles for 2D, high quality 2D, 3D or custom maps. Each mapping profile has a pre-set configuration (e.g. ground resolution, overlap

and side-lap). Mission data such as flight time, area coverage, distance, altitude and elevation conflict are displayed to avoid any in-flight incidents.

Once the UAV is airborne, it will execute the mission fully autonomous. Should the UAV get out of telemetry range, it can continue its mapping mission and return to the home zone/landing spot by itself once the mission is completed.

3. **Processing** – Once the UAV has completed the mission, Sky-Watch's processing software enables that the data can be extracted with the required information so that the images can be georeferenced and combined to create a precise map. The software has an automated workflow which ensures the generation of high-resolution 2D maps and textured 3D mesh models from 2D photographs. The software application combines unlimited scalability with superior precision to produce consistent and accurate 3D models that enhance the realism of any 3D visualization.

2D map

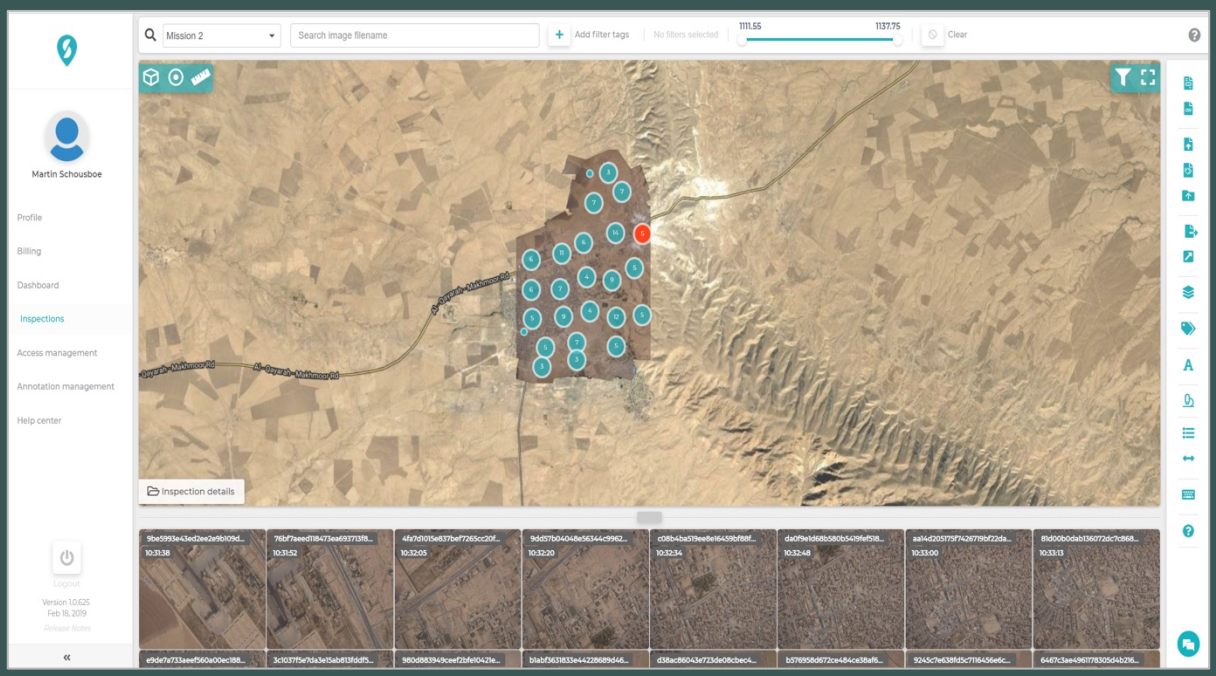
3D map

4. **Exploitation** – By using the Sky-Watch software, the Company can annotate key elements such as entry/exit routes to a compound, width of a river, line of sight from an observation point or Hight of a wall within hours. For exploitation of the generated high-resolution maps, The Explorer Viewer and Creator functions provide powerful tools for creating a high-resolution 3D environment that can be used to view, query, analyze and present the UAV data. These functions also allow the user to navigate through and perform advanced terrain analysis along with do basic editing of high-resolution 3D world environments. In order to complete the IMINT, the user is provided with advanced objects and drawing tools for adding annotations in the maps and models.

3D Map annotation

3D Line of Sight estimation

3. **Dissemination –** After exploitation, the annotated and refined maps can be made available to the company and platoon leaders during the weekly or daily mission briefings. The Sky-Watch software enables that the images are curated and organized in respect to where and when they were taken. Furthermore, the software allows the operators to generate intelligence reports with the annotations made during the exploitation.



CONCLUSION

The centralization of the intelligence collection cycle has proven effective in relation to processing large amount data from a broad array of sensors by using advanced tools and intelligence specialists. However, forward deployed mounted and dismounted infantry companies and platoons have been left with an unmet requirement for a faster and more agile intelligence cycle, which is needed in daily operations.

This paper concludes that it is possible to implement an intelligence cycle which is based on cost effective mini UAVs, ruggedized computers and simple exploitation software. If a turnkey intelligence solution is deployed at company level, it will enable the company to be more self-reliant while exploiting the capabilities of the centralized intelligence operations center.

Sky-Watch has developed a fully-integrated mini UAV mapping solution, which builds on best practices and facilitates all steps of the established Task, Collect, Process, Exploit and Dissemination cycle from the US Marine Intelligence Doctrine. Thus, a fast deployment program with Sky-Watch will cover all roll out aspects - including the implementation of a Heidrun fleet in terms of acquisition, fleet management, operational and specialist training, service and maintenance, and establishing a decentralized intelligence organization and build competences.

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