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Base defence demonstration at Trident Juncture 2018

– TACT unmanned systems for base and force protection

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Summary

Trident Juncture 2018 (TRJE18) was a high-profile military exercise held in Norway in the fall of 2018. The Norwegian Defence Research Establishment (FFI) had a large demonstration venue close to Værnes airport together with NATO Allied Command Transformations (ACT). This report accounts for the base defence demonstration, which was a part of the venue. The demonstration was a Transformational Activity (TACT) under NATO ACT in the exercise.

The demonstration showed a base defence concept using unmanned systems, where sensors and effectors were connected by a network to provide improved situational awareness and decrease the time from a threat is discovered to one is able to act upon or attack the threat. The purpose of including this activity in TRJE18 was twofold; primarily to demonstrate to key decision makers the potential of using cooperating unmanned systems for force and base protection, and secondarily to have soldiers using the system to gain insight into its benefits and potential improvements.

FFI had its first base defence demonstration in 2016 and a second one in 2017. The TRJE18 demonstration was a continuation and was done in cooperation with many industrial partners.

The demonstration was held at Sutterøya northwest of Værnes Airport. The scenario was that soldiers from the Norwegian Home Guard were tasked to protect the peninsula from incoming attacks from northwest. To their aid they had two Remote Weapon Stations (RWS), an Unmanned Ground Vehicle (UGV) with an RWS, an Unmanned Surface Vessel (USV), a nano Unmanned Aerial Vehicle (UAV), different types of field sensors, a Battlefield Management System and a Soldier C2 System. The demonstration attracted many visitors, among them The North Atlantic Council (NAC) and the NATO Military Committee.

The different technical subsystems had to be integrated into a common network. This was done through Kongsberg Defence & Aerospace’s Integrated Combat Solution (ICS). For this a network between the subsystems had to be established, which involved many radio systems. In addition all the subsystems had to be integrated with the ICS.

Our base defence concept was successfully demonstrated for numerous high-ranking officials. Thus we achieved our main goal. The secondary goal, an evaluation of the operational value of the system, was only partially achieved due to time constraints.

Sammendrag

Trident Juncture 2018 (TRJE18) var en høyprofilert militærøvelse i Norge høsten 2018. Sammen med NATO Allied Command Transformation (ACT) arrangerte Forsvarets forskningsinstitutt (FFI) en stor arena for demonstrasjoner ved Værnes. Denne rapporten beskriver baseforsvarsdemonstrasjonen, som var en del av dette. I denne øvelsen var demonstrasjonen en Transformational Activity (TACT) under NATO ACT.

Demonstrasjonen viste et baseforsvarskonsept hvor vi brukte ubemannede systemer, der sensorer og effektorer var koblet sammen i et nettverk for å gi økt situasjonsforståelse og redusere tiden fra en trussel blir oppdaget til man reagerer på eller angriper trusselen. Hensikten med denne aktiviteten i TRJE18 var todelt. Det primære målet var å demonstrere for viktige beslutningstakere hvilket potensial ubemannede systemer har for beskyttelse av baser og personell. Det andre målet var å få soldater til å bruke systemet slik at de kan få innsikt i systemets fordeler og hva som kan forbedres.

FFI gjennomførte også demonstrasjon av baseforsvarskonsept i 2016 og i 2017, og TRJE18-demonstrasjonen var en fortsettelse av dette. 2018-demonstrasjonen ble gjort i samarbeid med mange industripartnere.

Demonstrasjonen ble holdt på Sutterøya nordvest for Værnes flyplass. Scenarioet var at soldater fra Heimevernet skulle beskytte halvøya mot angrep fra nordvest. Til hjelp hadde de to våpenstasjoner (RWS), ett ubemannet bakkekjøretøy (UGV), én ubemannet overflatefarkost (USV), én nano ubemannet luftfarkost (UAV), forskjellige bakkesensorer i området, ett stridsledelsessystem (BMS) og ett soldatsystem for kommando og kontroll. Demonstrasjonen hadde mange besøkende, deriblant Det nordatlantiske råd og NATOs militærkomité.

De forskjellige tekniske undersystemene måtte integreres med hverandre. Dette ble gjort ved å bruke Integrated Combat Solution (ICS)-teknologien til Kongsberg Defence & Aerospace. For å få til dette var det nødvendig å etablere et nettverk mellom de forskjellige undersystemene, noe som involverte mange radiosystemer. I tillegg måtte alle undersystemene integreres med ICS.

Vårt baseforsvarskonsept ble demonstrert for mange viktige beslutningstakere, og vi lyktes således med vår hovedmålsetting. Det andre målet, som var å evaluere den operative nytten til systemet, lyktes vi ikke like bra med. Dette målet ble bare delvis oppnådd, noe som skyldtes tidsbegrensninger.

Contents

Preface

In January 2017 we submitted a one pager to be a part of the Trident Juncture 2018 exercise in Norway. When looking back we see that the experiment grew much larger than first anticipated. Our initial guess on how many scientists and engineers that were needed was ten, but the final demonstration involved probably more than four times that if we include our industry partners. This report tries to summarize what we did leading up to the event, how the demonstration was conducted and lessons learned.

The initial planning group consisted of Jens Inge Hyndøy, Einar Østevold and Kim Mathiassen, but many others contributed. This activity spanned many research areas at FFI, and we would like to thank everyone that contributed, even if not all initiatives made it for the final demonstration. We would also like to thank FFI staff that assisted us before and during the demonstration.

We had tremendous help from the Norwegian Home Guard, both as a guard force and as role players. We would like to thank them for their assistance. We also had a good collaboration with industry partners and NATO ACT, and would like to thank them as well.

Kim Mathiassen

Kjeller, 3 June 2019

1 Introduction

Coalition operations have over the last two decades demonstrated that NATO forces are vulnerable to enemy attack even when this enemy is technologically inferior to own forces. Considerable effort is needed to protect NATO forces, installations and logistics. The task of protecting forces and bases is both tedious and dangerous, and it may require a lot of manpower. Soldiers also need systems that can improve their ability to perform the task at night and in unfavourable weather conditions. The reported activity will demonstrate a base defence concept using unmanned systems where sensors and effectors are connected by a network to provide improved situational awareness and decrease the time from detection of threats to engagement.

NATO ACT has published a series called “Innovation in Capability Development” where one of its volumes is dedicated to autonomous systems [1]. This shows how important autonomous systems are considered to be when it comes to developing new capabilities. Supreme Allied Commander Transformation Jean-Paul Paloméros says in the foreword that autonomous systems potentially can transform the way in which warfare is conducted.

This activity was included in TRJE18 for mainly two reasons; firstly and foremost, to demonstrate to key decision makers the potential of using cooperating unmanned systems for force and base protection. Secondly, to have soldiers using the system to gain insight into its benefits and which improvements that can be made.

Through this Transformational Activity (TACT) we wanted to demonstrate and test our base defence concept, where sensors, effectors and unmanned systems are connected through a network. The goal was to demonstrate that our concept can increase the effectiveness of the base protection force, increase situational awareness for the personnel protecting the base, and reduce the need for manpower.

1.1 Background

For a military land force to succeed with its mission, it is essential that it is able to protect own forces (e.g. command posts, headquarters, etc.) and bases (including logistics bases, landing sites etc.). Traditionally this has been a challenging task requiring a lot of personnel for 24/7 surveillance and defence. Probably the biggest challenge is to have adequate situational awareness.

Application of modern technology, in particular sensor technology, robotics (autonomy) and network technology can mitigate this problem. Networking of sensors and effectors to a dedicated command and control post is in this context one issue, application of (networked) unmanned systems is another.

Recent and expected developments in autonomy and computer vision (artificial intelligence) will enable unmanned vehicles in all 3 domains (land, sea, air) that can operate coordinated and autonomously as extended sensors to collect, process and submit information about possible intruders or other threats. They can also act as effectors to counter the threat, though this has some moral implications that must be sorted out. Such systems have the potential of reducing the need for personnel significantly, and they can operate at a 24/7 basis.

FFI has since many years run projects on base and force protection. More recently, in June 2016, an experiment was conducted at Rena Camp. The purpose was to explore the benefits of having networked sensors (including unattended ground sensors and acoustic sensors), remote weapon station and unmanned ground vehicle (OLAV[1]) as elements in a camp protection system. The network applied Kongsberg’s ICS (Integrated Combat Solution) as electronic backbone. The experiment confirmed that it is possible, by intelligent use of modern technology, to control a large area using only a few operators.

Building on the Rena experiment, a more complex experiment, protection of Ørland Air Force Base, was conducted in October 2017. The main differences were that the latter also included two stationary Remote Weapon Stations (RWS), a base protection force and a nano-UAV (Black Hornet). Also in this case all components were networked through the ICS. Both experiments comprised a Battlefield Management System (BMS) in support of the commander. As in the Rena experiment this experiment showed that a large area could be controlled by only a few operators. Moreover, new functionality (automatic detection and tracking) on the RWSs was successfully tested, and the possibility for one operator to operate several RWSs was confirmed.

Thus, when the opportunity for testing and demonstrating a base and force protection system in conjunction with TRJE18 turned up, a sound technological and procedural basis had been laid. An experiment in a TRJE18 context would take the Ørland experiment even one step further, including an autonomous surface vehicle (USV) and conducting the experiment in a large operational context. Moreover, it provided a possibility for having high ranking personnel (decision makers) visiting the demonstration and thus gain insight into the benefits of our force and base protection concept.

1.2 Objectives

The main goal was demonstrating to high level decision makers a force and base defence concept using unmanned systems. Our demonstrator system comprised networked unmanned ground, air and sea platforms, supplemented by networked sensor systems and effectors. The concept was conjectured to improve situational awareness for the base defence crew and reduce the number of personnel needed for adequate protection.

The transformational activity can broadly be divided into two parts, a demonstration part and an experimental part, with different sub-goals:

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[1] OLAV = Off-road Light Autonomous Vehicle, FFI’s experiment UGV

1. Demonstration
    1. Demonstrate to decision makers (visitors) the capabilities of the base defence concept
    2. Demonstrate unmanned platforms in support of situational awareness in force and base protection
2. Experiment
    1. Evaluate the operational value of unmanned platforms as guard force multiplier
    2. Gain experience in integration between unmanned platforms in different domains, and between manned and unmanned platforms

Our TACT was not integrated into the main scenario of the Trident Juncture exercise. It was in fact a benefit for us to be detached, as this gave sufficient room to set up and test the system for the experiment. The prime benefit of having the experiment in conjunction with Trident Juncture 2018 was the availability of high ranking officials who could visit our experiment to have a first-hand impression of the benefits of our base defence concept and the application of new technology.

2 Event planning and organization

The event was planned and coordinated as a Transformational Activity (TACT) within the NATO CD&E program. All TACTs proposed for execution during the NATO Exercise Trident Juncture ’18 were coordinated under the leadership of NATO Headquarters Allied Command Transformation (NATO ACT). This planning cycle was initiated 20 months prior to the exercise on site within the exercise. Under the leadership of dept. Operational Experimentation (OPEX) the Norwegian planning group took part in several video teleconferences – VTCs. Due to the ambition of interfacing the activities with the exercise, it was also mandatory for the TACT planners to take part in Ex Trident Juncture ’18 planning conferences (Initial Planning Conference – Stavanger Norway, Main Planning Conference – Naples Italy and Final Coordination Conference – Trondheim Norway). OPEX organized a dedicated TRJE 18 TACT Coordination Syndicate during IPC in Naples. In these syndicate sessions it was proposed and decided that three of the TACTs should federate and execute the experimentation at one common site. The TACTs *Autonomous Systems for Base Protection*, *Additive Manufacturing in the Field* and *Autonomous Transport* were consequently organized under the improvised umbrella “Enhanced Logistics Base Concept - ELB”. The TACTs Base Protection and Additive Manufacturing were organized by teams from the FFI, and Autonomous Transport was organized by a team from ACT/Capability Development – Logistics. The Teams agreed on the following organization; Conceptual Coordinator – LtCol Herve Jure, ACT, Operational Coordinator – LtCol Jens Inge Hyndøy, FFI, Technical Lead Base Protection – Senior Researcher Kim Mathiassen, FFI, Technical Lead AM Senior Engineer Guri A Nonsvik. This organization was established May 2017 at the IPC in Naples and was maintained throughout. It provided well defined roles and responsibilities and proved very useful allowing preparations within the respective areas of responsibility. Additionally members of the ELB planning group conducted a few site surveys to determine the optimal demonstration site and make arrangements with local suppliers.

The overwhelming planning burden fell on FFI, as the event was to be organized in Norway and leveraging Norwegian suppliers and military role players. The ACT, however, provided invaluable contributions for promotion and in attracting VIP visitors. FFI and ACT agreed to share the cost for common expenses equally.

All the three transformational activities partnered with industry from the NATO nations, and more than 20 separate companies were involved with their technologies and systems.

2.1 Manning

For the execution cycle in Oct and Nov 2018 the Base Protection Experimentation team was expanded. Each industry partner participated with personnel, this included FLIR, Kongsberg Defence Communication, Kongsberg Integrated Defence Systems, Kongsberg Protech Systems, Chess Dynamics and Teleplan. They were mainly responsible for their own subsystem, with the exception of Kongsberg Integrated Defence Systems. They provided the Integrated Combat

Solution (ICS) which was the main communication channel between the subsystems, and therefore they were involved in the overall integration.

FFI had five researchers on site to do the technical integration of the UGV, USV and the unattended ground sensors. They also rigged the demonstration venue and coordinated with the Home Guard. Another technical team of two researchers were at FFIs facility in Horten, to control the USV. In addition FFI had two researches for data collection and a media team of one reporter and one photographer.

The Norwegian Home guard provided ten soldiers to be role players at the demonstration. Three manned the operation centre, four of them were the Quick Reaction Force (QRF) and three played the part as intruders. Another ten soldiers comprised the guard force, and they were relieved by a new contingent during the exercise.

3 Base defence demonstration

The demonstration comprised two stationary remote weapon stations (RWS), an unmanned ground vehicle (UGV) equipped with an RWS, an unmanned surface vehicle (a USV operating at a different site), a nano-UAV, a number of unattended ground sensors, a counter-UAV (Unmanned Aerial Vehicle) system, a shot detection system, and a quick reaction force equipped with a soldier tracking system and a battlefield management system (BMS). Information from all these systems was available in the operation centre through a unified user interface. The operation centre had two soldiers operating the RWSs and one officer in charge of the operations. All military participants, including the quick reaction force and the “opposing force”, were from the Norwegian Home Guard. All main system components are shown in Figure 3.1.

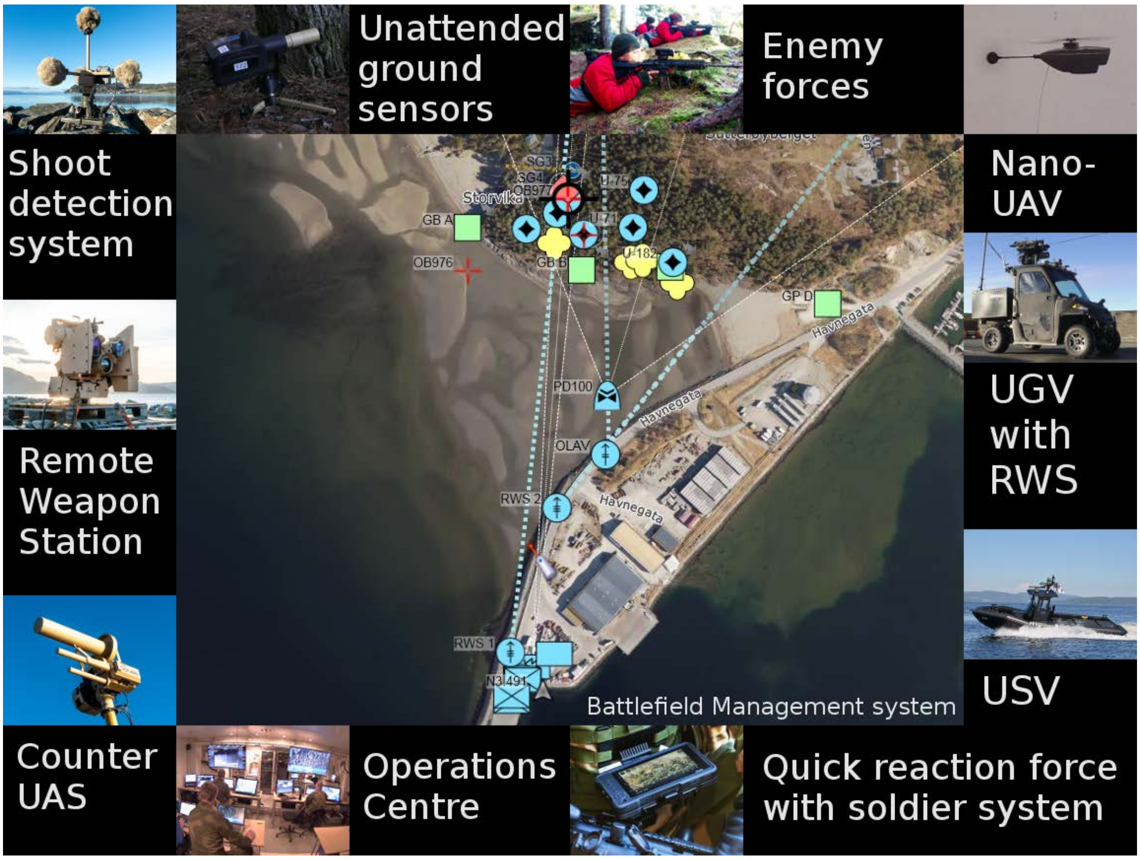


Figure 3.1 *All main components of the base defence system are shown along the figure border. The map in the centre shows the positions of all sensors and effectors. RWS1 and RWS2 are two stationary remote weapon stations, OLAV is a UGV with a remote weapon station, PD100 is a nano-UAV, and Odin is a USV patrolling the sea side (not shown in the map). The control centre is to the south of the map, and the unattended ground sensors are to the north.*

Most of the technology development is nowadays taking place in the civilian sector. It is accordingly important that the defence sector is offensive in incorporating civilian technologies, in particular technologies related to unmanned systems, computer vision and machine learning. This demonstration showed that using this technology can improve situational awareness for the soldiers protecting the base, and provides the commander with more options when facing possible intruders. This is relevant for all military leaders responsible for base protection.

The experiment was conducted in collaboration with our industry partners, Kongsberg Defence and Aerospace, Teleplan, FLIR and Chess Dynamics, who contributed with a wide range of products. The two major outcomes of the demonstration were a) bringing industry closer to the market, and b) forming a good basis for further collaboration and refinements of the system.

3.1 Overview

The activity was planned as a demonstration, which meant that emphasis on the tactical context and data collection plan was reduced. However, we endeavoured to create a tactical context as close to a real world mission as possible. This assured both a credible demonstration venue and a foundation for collection of relevant data.

The technical arrangement was designed off-site and tested at FFI's facilities at Kjeller before deployment. The equipment was shipped to the demo site 10 days prior to the demonstration. Set up was carried out 7 days prior to the demonstration, and testing was initiated after setting up the equipment. Operational role players started training as technical testing was winding down 5 days prior to the demonstration. The team then started rehearsing the scenario and adjusting timings and positions.

Rehearsals included test firing of blank ammunition from the weapon stations and the UGV. This had to be coordinated with local military authority and local police. The Home guard liaison provided excellent support on this point.

Parallel to training role players and adjusting network and software, the team completed set-up of the demonstration hall and stage. An introductory video clip lasting 4 mins was recorded on-site, edited and furnished with a pre-recorded narrator sound track. This effort was supported by the FFI media team.

The dress rehearsal was conducted 1 day prior to demonstrations. Role players had by then 7 or 8 rehearsal runs completed.

- **Day 1:** The team completed three full demonstration runs. We were visited by local companies and military leaders from Germany and France.

- **Day 2:** The team rehearsed the VIP demonstration and conducted a very successful live demonstration for NATO HQ Brussels (Military committee and North Atlantic Council).

- **Day 3:** The team conducted three live demonstration runs before dismantling and packing up the equipment.

- **Day 4:** A data collection session was conducted. Both interviews, notes and statistical data were collected for analysis

- **Day 5:** The last shipment took place, and team members left the demo site and returned to their home base.

3.2 System components

The base defence system comprised many components, which were all connected using various radio systems and Integrated Combat Solution (ICS) from Kongsberg. This section will focus on the individual components and their role. For further information on how they physically were connected and more technical details, please see Chapter 4.

Olav

Olav is a research unmanned ground vehicle (UGV) under development at FFI [2]. It is based on a Polaris Ranger all-terrain vehicle, prepared for autonomous operations. It is equipped with a navigation system based on Inertial Measurement Unit (IMU) and GPS, UHF radios, and a remote weapon station. In this experiment it can drive autonomously on a predefined network of traversable paths, and serves as a mobile, tele-operated RWS.

Odin

Odin is a research vessel under development at FFI. It is an RBB (Rigid Buoyant Boat) of length 10.5m equipped with maritime navigation radar, LiDAR, EO/IR cameras and VHF/UHF/SHF radios. In this experiment it can patrol a predefined area and relay video of objects detected inside that area.

Black Hornet

The Black Hornet nano-UAV is a commercial product from FLIR Systems. It is launched from a launch module (shown in the picture), and flown by an operator. Its main purpose is to scout once an alarm has been triggered.

Remote Weapon Station (RWS)

The RWSs used in the experiment were two Protector Nordic systems (on the ground) and one Protector Lite (mounted on Olav) system, all from Kongsberg Defence and Aerospace. The system had built-in experimental software for detection and tracking of vehicles. They had also been upgraded with multi-user capabilities, meaning that the two operators could choose which of the three stations they would like to control. The RWSs have daylight and infrared (thermal) cameras.

Unattended Ground Sensors (UGS)

The UGS is a subset of the UMRA system produced by Exensor. There are two types of UGS; one using a passive infrared sensor, and one using seismic and acoustic sensors. The infrared sensor creates an alarm when someone with higher temperature than the surroundings passes the sensor. The seismic and acoustic sensors process the data and trigger an alarm if the signal is classified as generated by a moving person. The sensors form a mesh network to communicate back to the base.

Wildlife Cameras

The Combat Lab at the Norwegian Army Weapons School has modified traditional wild life cameras to classify and alert of personnel within the field of view. The corresponding images are sent to the operation centre for assessment of the potential threat.

Counter UAS System (CUAS)

The counter UAS system was provided by Chess Dynamics. It consists of a detection system and a disruption system. The detection system applies radar, daylight camera and infrared camera to detect and track drones. The disruption part can emit a directed radiofrequency beam to jam the UAS' command and control link. The system was integrated with the Battlefield Management System, but not actively used under the demonstration.

Shot Detection System

The shot detection system used was the PILAR system from Metravib. When firing live ammunition, it can triangulate to find shooter's position, but when using blank ammunition, it can only find the direction towards the shooter. This system was not actively used under the demonstration, but was integrated into the overall base defence system.

Battlefield Management System (BMS)

NorBMS from Teleplan is the Norwegian Army's BMS. It displays the position of all sensors and effectors in the base defence system. The BMS features include alarms from the sensors that show up on the screen, the field of view of the RWS's will be displayed, and the commander can send target information to the soldiers. The information is accessed through the ICS.

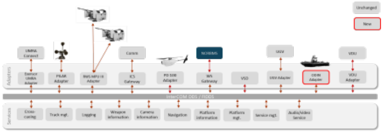
Tactical Operations Command

The operation centre was located in a command post container, and was the hub where information from all the sensors was received. It was manned by two soldiers operating the RWS stations, one commanding officer, two researchers controlling the unmanned systems, Olav and Odin, and one Black Hornet operator. The soldiers have the RWS screen and control unit in front of themselves, to their right is a NorBMS screen and to the left is a video monitor displaying all the video feeds available in the system. The commander has his own NorBMS interface, and his display is also shown on one of the large monitors in front of the soldiers. The other large monitors display available video feeds and the CUAS system screen. The command post container was provided by Combat Lab at the Norwegian Army Weapons School, and instrumented by FFI and its industry partners.

Quick reaction force with soldier system

The quick reaction force comprised four Norwegian Home Guard Soldiers and a light vehicle for transportation. The soldiers were equipped with a soldier command and control system consisting of a small PDA attached to their torso. The PDA could be flipped up or down (see picture to the left), and it was running FacNav Mobile (from Teleplan), and was connected to a soldier radio. The PDA had a built-in GPS, and the soldiers' positions were shown live in the operation centre, who in turn provided them with an updated situational picture.

Integrated Combat Solution (ICS)



The Integrated Combat Solution from Kongsberg Defence and Aerospace enabled communication between all sensors and effectors at a software level. It complies with the NATO Generic Vehicle Architecture (NGVA), and is used in the upgraded CV90 Vehicles of the Norwegian Army.

Network Communication

To enable communication between all the components of the system they were connected together in a computer network. To achieve this several network radios were used, from Kongsberg Defence Communications, Kongsberg Seatex, Persistent Systems and Harris, along with other network equipment. The overall network design was provided by Kongsberg Defence Communications.

3.3 Scenario

During the demonstration a predefined scenario was shown. The Home Guard's mission was to protect Værnes Airport against enemy infiltration or attack. For the demonstration only a small sector around the airport was covered, but it gave an impression of how the system could be used to cover larger areas. Just northwest of Værnes Airport lies Sutterøya, where the demonstration took place, as shown in Figure 3.2. This is a peninsula, and the mission was to protect the log base at the harbour from enemies coming by sea from west and northwest of the peninsula and from enemy ground forces coming from the north of the area. To serve this mission, the Home Guard unit had placed two remote weapon stations on the western side of the peninsula (marked RWS1 and RWS2 in Figure 3.2). They had additionally deployed a number of unattended ground sensors and wild life cameras in the wooded area north of the peninsula (marked Ground sensors in Figure 3.2). The operation centre (Tactical Operations Centre, TOC) was deployed to the south on the peninsula, co-located with the QRF, the UGV Olav and the nano-UAV Black Hornet. The USV Odin was not present at the demonstration site, but located outside the city of Horten, Norway, and patrolled the sea there. It simulated patrolling the sea area to the west of the peninsula.

Before the demonstration commenced, it was assumed that enemy forces had come by boat and landed on the shore north of the base. It was deemed likely that they would continue on foot into the wooded area north of the base and attempt to breach and attack the base from there. At the demonstration start the soldiers were scanning the area in search of enemy forces.

The enemy force moved from the staging area in the north along path A in Figure 3.2. Subsequently a wildlife camera triggers and alerts the commanding officer in the operations centre. He receives an alarm and an image of the scene in NorBMS. He notifies his soldiers about the incoming threat and activates the Black Hornet nano-UAV, which flies towards position 1 in Figure 3.2.

The enemy soldiers continue to move along path B in Figure 3.2 and trigger one of the unattended ground sensors. They also become visible from the remote weapon stations, and the commander orders his operators to fire at them. Next he dispatches Olav towards 2 in Figure 3.2, to have another angle of attack against the enemy.

The enemy starts taking casualties and moves along C in Figure 3.2 to have natural cover, but is still visible from the Black Hornet. The base commander dispatches the QRF to drive to point 3 in Figure 3.2, and the soldiers in the operation centre shift from using RWS1 and RWS2 to using RWS2 and the Olav RWS. They continue to suppress the enemy.

When the QRF is in position, the commander orders his soldiers to deploy and then engage the enemy. The soldiers in the operations centre can see the position of the QRF and ensure that they avoid fratricide. The QRF soldiers can see the field of view of the RWS’s and likely enemy positions, marked by the commander. The commander coordinates the counter attack so that the RWS fire stops when the QRF engages the enemy and neutralize them. With this the current demonstration run is completed.

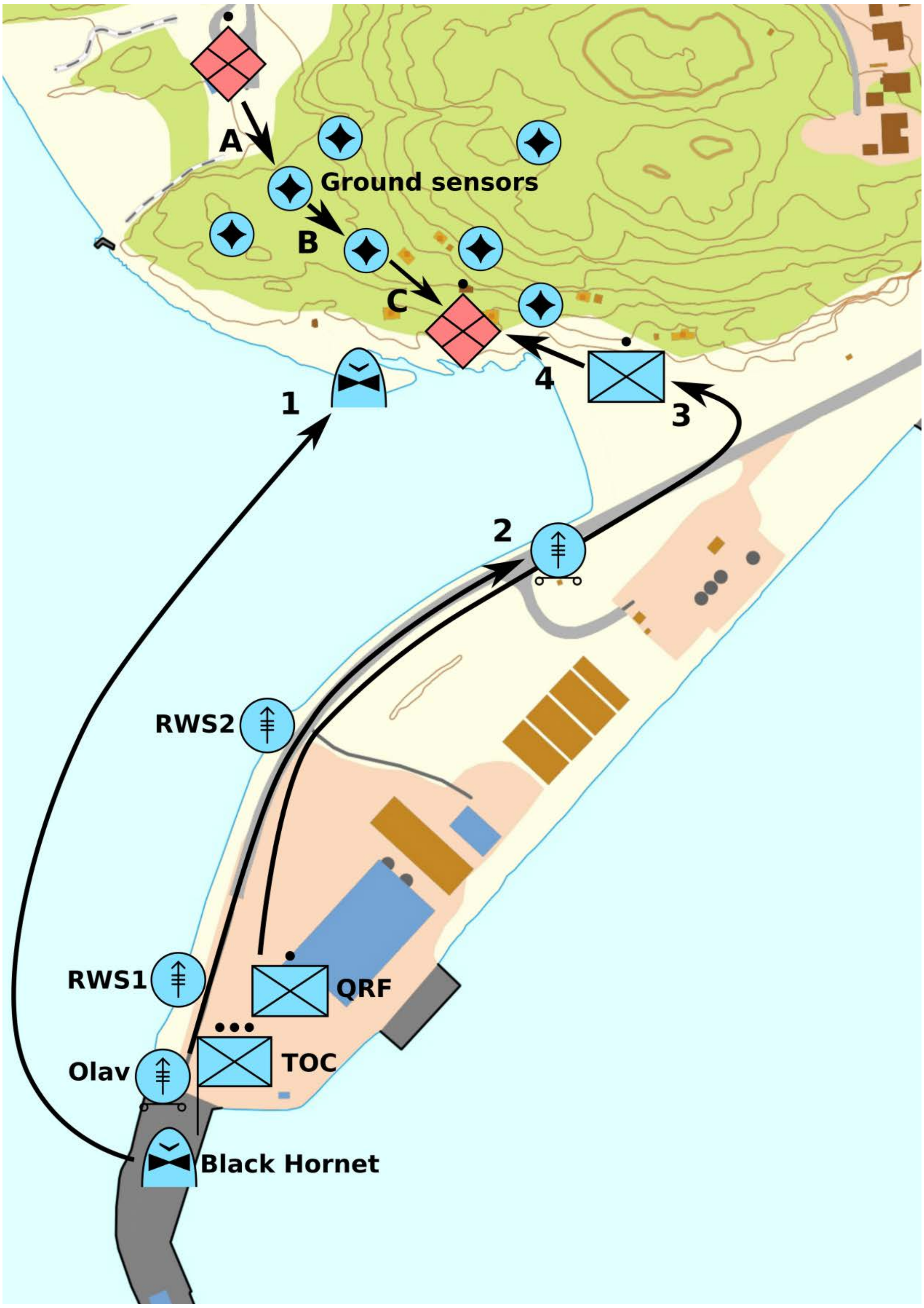


Figure 3.2 Battle map showing the scenario. Own movement is indicated with 1-4, enemy movement is indicated with A-C.

3.4 Venue

This demonstration was co-located with two other transformational activities (TACTs), Additive Manufacturing and Enhanced Logistics Base. Additive Manufacturing demonstrated in-field 3D printing of objects in plastic and metal. This was a collaboration between FFI and the company FieldMade. They deployed a container equipped with 3D printers.

The TACT Enhanced Logistics Base was responsible for the overall venue. A large tent was set up just south of the TOC in Figure 3.2. Inside the tent many companies, among them Teleplan, FLIR and Kongsberg Defence and Aerospace, set up stands to show their products. There were also companies with their products on display outside the tent.

In the rear end of the tent a small stage was set up with two monitors and loudspeakers. Here the live base defence demonstration (right monitor) and video with sound from the operation centre (left monitor) were presented to the visitors, as shown in Figure 3.3. The right monitor screen was divided into four parts; the upper left part showed the commander’s NorBMS screen, the two lower parts showed the stationary RWS screens, and the upper right part showed the screen of the Olav RWS. When the Black Hornet was deployed, its screen was placed on top of the RWS screen currently not in use. Jens Inge Hyndøy (FFI) introduced the experiment and guided the audience through the demonstration by noting the key events and explaining what was happening on the screens.

Figure 3.3 Jens Inge Hyndøy briefing the visitors during the base defence demonstration.

3.5 Visitors

The event attracted substantial interest and a large group of visitors over the three days it lasted. The most distinguished visitors were undoubtedly the group from NATO HQ in Brussels.

The demonstration was originally planned to take place the day prior to the Trident Juncture Distinguished Visitors (DV) day and last for three days. It was also important that the location was with immediate proximity to the Værnes airport, as this was the airport of entry for the distinguished visitors. This made it possible for both small VIP teams and large visitor groups to attend the demonstration. The NATO ACT team engaged early with the DV day planners, and this event was actively promoted both during planning conferences and by flyers and invitations prior to the event. This successfully attracted the international visitors. The FFI also promoted the demonstration to NOR military as well as to domestic industry. This also generated a fair amount of visitors.

The NATO HQ visitor group consisted of the North Atlantic Council – NAC and the NATO Military Committee – MC and numbered approximately 90 persons. This high level group also prompted Commander ACT to host this specific demonstration himself. In Figure 3.4 Commander ACT is receiving Deputy Sec Gen at the site.

Figure 3.4 Supreme Allied Commander Transformation André Lanata and Deputy Secretary General of NATO Rose Gottemoeller walking towards the demonstration.

The event attracted three Chief of Defence and both French and German military leadership. Norwegian visitors consisted of high ranking officers like Commander Cyber and Commander Airforce and several members of staff from most branches.

Industry was invited, and in all 30 to 40 companies attended the demonstration. Their interest was both to gain an insight into what type of technologies are in demand and also how to become a partner for future events.

Finally there was substantial press coverage from the event. The exercise international press center sent reporters all three days, and more than 50 agencies, domestic and international, reported from the demonstration. The FFI media team helped organize the press coverage and also reported the event themselves.

4 Technical description of systems

(This chapter may be skipped by non-technical personnel without loss of understanding the rest of the report.)

The base defence demonstration is a complex system with many sensors that produce data and has many consumers of the data. It required a good deal of planning and preparations to ensure that all necessary data were available to all consumers in a timely fashion. 7 different wireless connections tied the different sensors and players together and had to be checked for interference and range/coverage. We used ICS from Kongsberg as the information backbone in the system. ICS is a Kongsberg implementation of the NATO Generic Vehicle Architecture, STANAG 4754 [3], and it works as an information broker, collecting information from multiple sources, often in a proprietary format, and offer it through the ICS to its consumers in a standardized format. ICS handled all sensor data except the soldier C2 system which communicated directly with the BMS in the operation centre. The ICS has its own user interface for presentation of data, which was used for handling and viewing all the video streams, but ICS’ main role is to make the data available to other consumers. The BMS (NorBMS from Teleplan) was together with the video feeds, the main focus in the operation centre. The BMS is integrated with ICS and can show the position, orientation and field of view from the RWSs, location of ground sensors, alarms, blue force locations etc. Figure 4.1 is an illustration of how the different systems where integrated. Most of them integrate to ICS, but the wildlife cameras and the soldier C2 system integrate directly to the BMS. Figure 4.2 show what the operations centre looked like and what the different screens and positions were.

The following subchapters will go into more detail on the different systems and how the actual network was configured.

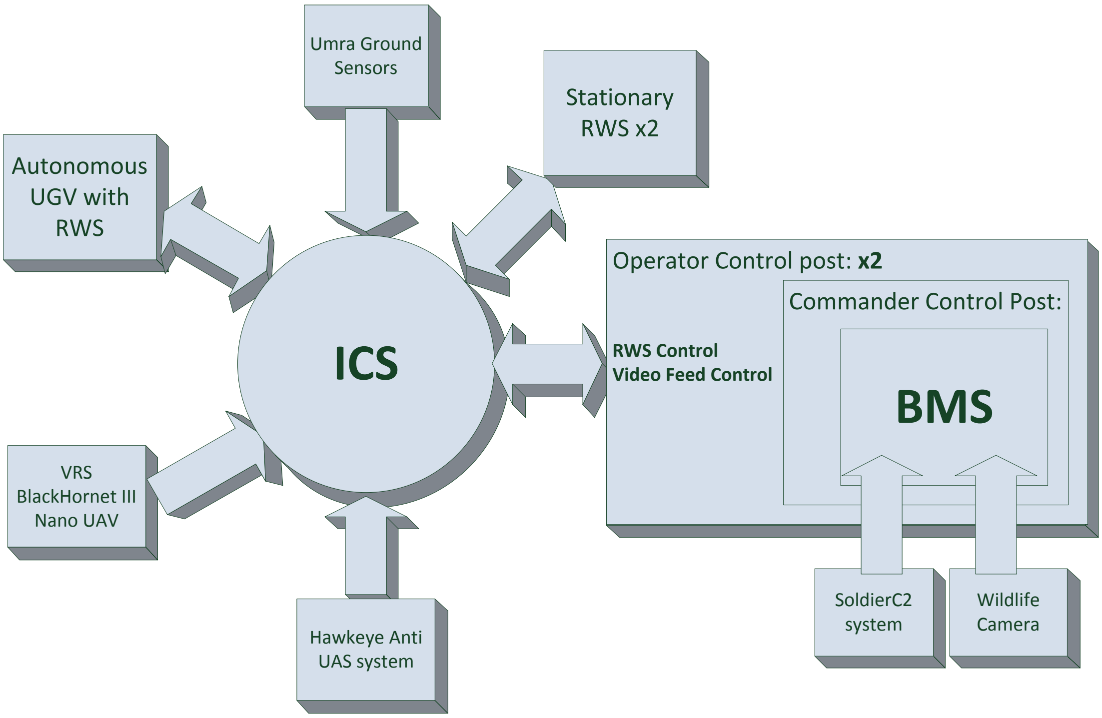


Figure 4.1 Technical overview of all the connected subsystems.

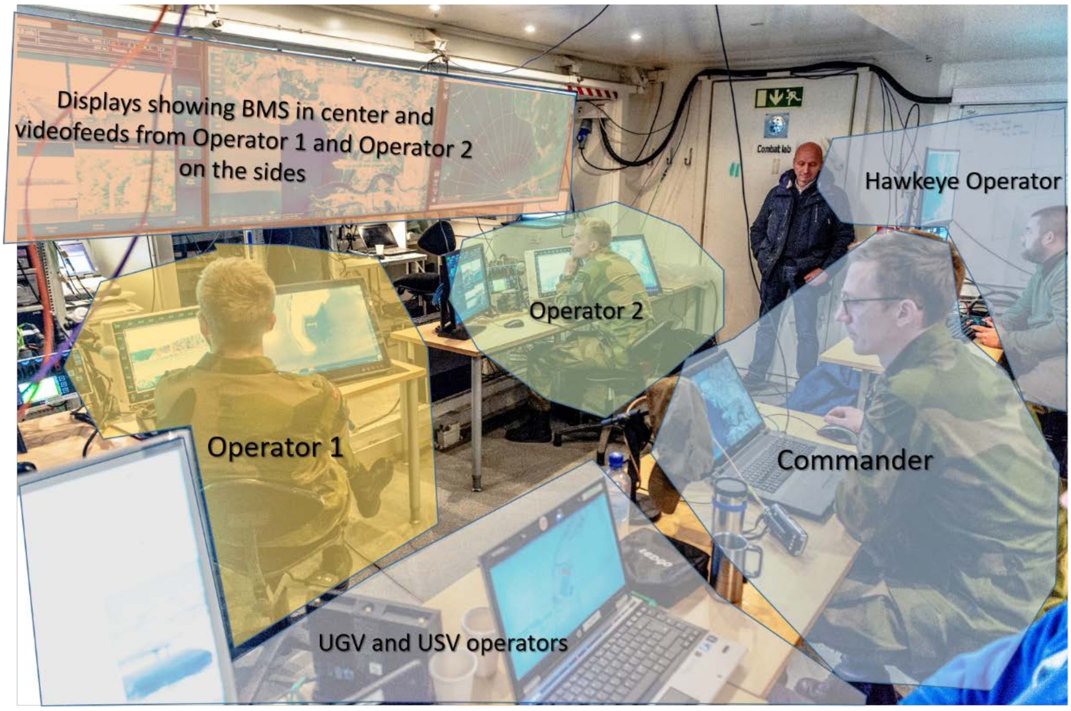


Figure 4.2 The operations centre inside command post container, showing the different manning positions and functions.

4.1 Network configuration

Kongsberg Defence Communications designed the network. The setup consists of three moving vehicles, the UGV Olav, the USV Odin and the UAV Black Hornet from FLIR. Figure 4.3 shows the network configuration. The colors indicate what organizations brought to the exercise. Table 4.1 contains descriptions of the components in Figure 4.3. New in this demonstration was the CC600. The CC600 is a Communications Controller that can connect multiple radio links in parallel.

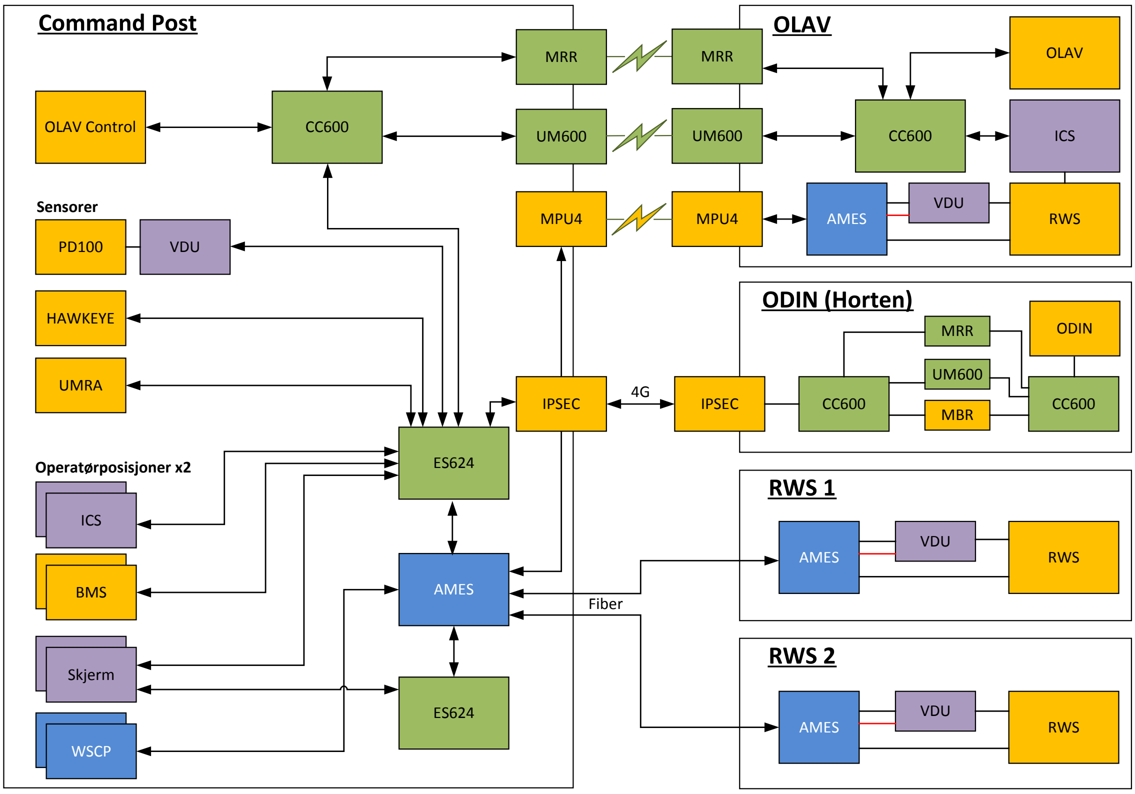


Figure 4.3 Network diagram showing the connected units during the Trident Juncture exercise. Yellow boxes indicate that the component is provided by FFI, green boxes by Kongsberg Defence Communications, blue boxes by Kongsberg Protech and violet boxes by Kongsberg Digital Vehicle Solutions. The illustration is provided by Kongsberg Defence & Aerospace, used with permission.

We used two radios for communication between Olav and its control station, namely the Multi Role Radio (MRR) and the UM600 radio, which use the VHF and UHF bands respectively. The MMR provides a better range at the cost of bandwidth compared to the UM600. The CC600 can route important but low bandwidth data to a long range, low bandwidth radio, i.e. telemetry and missions, and less important data like video to a higher bandwidth radio, but with shorter range. In this way the CC600 tries to utilize the best from abilities from the different radios. This demonstration did not cover a large geographical area, therefore only the UM600 was used. Beside the communication with the control station, we were also controlling an RWS on top of

Olav and streamed video back to the operation centre. For this purpose, we used the MPU4 radios from Persistent Systems. These are MESH radios and operate in the 2.4 GHz band. The original plan was to use the CC600 for these radios, but at this point the IP address requirements of the RWS meant that the RWS and the RWS control station had to share a common IP network. This in turn meant that use of CC600 for routing of the communication between the RWS and RWS control station would not be possible without advanced network configuration, and therefore the RWS was chosen to be directly connected to the operations centre IP network through the MPU4 only.

To get the best radio coverage possible, we used a 10 meters tall lift as an antenna mast. The MPU4, MRR and UM600 radio were placed on top of the lift. We also placed an MPU4 radio near the second RWS to improve the radio coverage.

During the demonstration, the USV was stationed in Horten. It streamed video and telemetry data to the operation centre via the 4G mobile network. At the operation centre, a dedicated PC running the USV control station was connected to the network in Horten via an IP tunnel. The setup was thus effectively duplicated with the operation centre receiving the same data as the operator in Horten. Due to the design of the connection set up by the USV control station, and the Real-Time Streaming Protocol (RTSP) we used for the video, the local radio link from the shore in Horten to the USV was duplicated. At times the increased network traffic put a heavy load on that link.

The radio setup in Horten and on Odin was similar to that on Olav in Stjørdal. The MRR, UM600 radios and CC600 Communications Controller were used. In addition, the Kongsberg Seatex MBR179 was used and interfaced through the CC600. The MBR179 operates in the SHF band featuring a bandwidth of up to 15Mbps and has a range of at least 50 km. It has low latency, which makes it suitable for video streaming. The MBR link was the main communications carrier in this setup, while the VHF and UHF radios duplicated some of the most critical telemetry. On the shore side, the MBR was located in a mast approximately 25m above ground, while the VHF and UHF antennas were mounted 2 meters above the ground.

The soldier C2 system used the Harris RF7800S SPR radio. We used one radio connected to the BMS system. It had an external antenna on a 3m tall mast outside the operations centre. All soldiers carried their own radio connected to their PDA and running the soldier C2 app (FacNav Mobile).

The UMRA sensors have a built-in radio operating in the open 868 MHz spectrum. The radios create a mesh network to find a communication route from the sensor to the sensor control node in the operations centre. The sensor control node is integrated with ICS. The UMRA ground sensors report their positions, battery status, and alarms. We used two different types of UMRA sensors during the exercise; one seismic and one acoustic sensor that detect personnel and vehicles through ground vibrations and noise, and one PIR (passive infrared) detector that detects if an object moves in front of it and reports movement and direction.

The Black Hornet VRS system integrates directly to ICS to which it streams UAV position and video. The video contains telemetry metadata allowing the video feed to be mapped to a geographic map.

The PILAR shot detection system can also be integrated to ICS. The PILAR system was not in use during TRJE18 because it works best when live ammunition is used and not blanks that was used in this case.

The stationary RWS's where placed approximately 50 meters and 150 meters from the HQ, and we used field fiber for communicating with them.

Table 4.1 Description of components in the network.

Name	**Description**
VDU	Video Decoder Unit
AMES	Managed switch made by Kongsberg
ES624	Managed switch made by Kongsberg
MRR	Kongsberg MRR VHF Radio
UM600	Kongsberg TacLAN UHF radio
CC600	Communications controller made by Kongsberg
MPU4	Radio system from Persistent Systems
MBR	Maritime Broadband Radio made by Kongsberg
IPSEC	Encrypted tunnel using IPSec
4G	4G internet modem
RWS	Remote Weapon Station from Kongsberg
ICS	Integrated Combat Solution node
WSCP	Weapon Station Control Panel
PD100	Black Hornet from FLIR
HAWKEYE	Hawkeye System from Chess Dynamics
UMRA	UMRA unattended ground sensors from Exensor
OLAV	Olav UGV experimental platform from FFI
ODIN	Odin USV experimental platform from FFI
OLAV Control	Control station for Olav
BMS	Battlefield Management System from Teleplan

4.2 UGV system description and integration

At the Norwegian Defence Research Establishment we are currently developing a platform for autonomous driving, Olav (Off-road Light Autonomous Vehicle) , based on a Polaris Ranger XP 900 EPS vehicle [2]. A subcontractor modified the Polaris vehicle to make it ready for autonomous operation. The vehicle is controlled by manipulating the:

- Throttle
- Brakes
- Steering
- Ignition (on/off)
- Gear change

For autonomous operations, Olav has been equipped with an IMU (Inertial Measurement Unit), GNSS (Global Navigation Satellite System), LiDAR and several cameras. The IMU and GNSS are used for navigation purposes, and the LiDAR and cameras are used for motion planning and driving.

For this task, Olav has been equipped with an RWS Protector Lite from Kongsberg Protech Systems. The BMS displays the RWS position, heading and field of view. To do this, Olav has its own onboard ICS node. ICS receives Olav's position and heading from Olav's on board navigation system. This enables the RWS operator to confirm the RWS' pointing direction and what he is aiming at. This again enables the operation centre commander to see in which direction every RWS in the system are pointing.

The main role of Olav in the demonstration was to act as an autonomous platform for the RWS. The stationary RWS's are the main tools for the operator to search for threats and engage them, but as their positions are fixed, their location might not always be the best, depending on where threats appear. A mobile weapon station can move between observation points, and can therefore cover different sectors depending on where it is most needed. Furthermore it can be moved closer to where a threat has been detected.

In the experiment, Olav had the capability of patrolling an area, or move to a specified position, all while an RWS operator had control of the RWS via a radio link. In the scenario demonstrated, Olav was in standby at a parking spot near the OPS, and moved along the main road to a position commanded from the OPS. Here it would serve as a forward observer, and the RWS operators could use Olav for engaging the enemy.

Figure 4.4 The route network where Olav was allowed to drive during the experiment.

Olav can be operated in two ways: either tele-operated by the RWS interface, or autonomously through a dedicated ground control station (GCS). While using the tele-operated mode, the RWS is fixed and pointing straight forward, and works as a driving camera. This means that the operator cannot control the RWS while driving Olav. The tele-operated mode is therefore best suited for small adjustments to the placement of Olav, and not continuous driving.

In autonomous mode, Olav can either drive to a commanded position, or patrol between several waypoints. Currently Olav can’t go everywhere, but is limited to positions on a predetermined route network. If this is designed so that it covers all points of interest around a base, this will be sufficient for most encountered missions in a base defence scenario. When Olav receives a route, the route is followed directly, which means that Olav will drive the same paths every time. In the experiment there was no obstacle avoidance used, as the path following was deemed satisfactory without it.

At the heart of the demonstrated autonomy, there was a route planning service running on Olav that was interfaced through Olav’s GCS. This route planner provides routes of high resolution, satisfactory for Olav for direct path following based on its navigation system. The route planner works by first having an operator manually driving around the operation area, and next a route network is generated from the recorded routes. This route network is then used for planning new paths. This approach has the advantage that the planner will never suggest routes that have not been driven before, and since all possible routes actually have been driven before, Olav is capable of following them. Another advantage is that this route planner is independent of any prior maps or data of the area, and can be established by manually driving around with a vehicle. The main disadvantage with this simplified approach is that Olav in the demonstrated setup is unable to move to a point outside the road network.

The route network used during the experiment is shown in Figure 4.4. The road is covered, and there are added turning spots at road intersections, because there was otherwise not enough room to make U-turns along the road. The route network could have been extended for example to allow for inspecting some of the buildings or the other side of the port, if the scenario was to be expanded.

4.3 USV system description and integration

As part of the mine counter measures (MCM) projects, FFI has acquired two USVs for technology development and demonstration. Basic autonomy, situational awareness and communication facilities have been implemented on-board. Both USVs are 10.5 m long RBB (Rigid Buoyant Boats) with twin waterjet installations and Volvo Penta engines. The boats are designed with a high load capacity and will be able to pull heavy equipment through the sea, making them very versatile platforms for MCM sweeping.

The USV Odin, which was utilized in this experiment, is equipped with maritime navigation radar, LiDAR, pan/tilt/zoom EO/IR cameras and VHF/UHF/SHF radios. A GNSS receiver and a navigation grade IMU is used for navigation purposes while the radar and LiDAR are used for path planning, including obstacle detection. In this particular experiment the EO/IR camera feeds were relayed to an operator over radio.

During TRJE18 Odin operated as a monitoring asset, but was actually located in Horten, The operator control station and real time video feeds were duplicated in the operations centre. Odin’s positioning data was sent to the ICS via a dedicated network port on the Control station in the operations centre. The data format and transmission protocol were the same as were used for Olav. RTSP camera video streams were sent directly from the vessel to the ICS through an IP-tunnel.

Odin’s main purpose was to monitor maritime activity in the bay area, and to transmit a video stream from the automatically and/or remotely controlled pan-tilt-zoom camera on-board. The result was that on-shore USV operators could monitor a movable camera located relatively close to any vessel that might be heading towards the base. Whether such incoming vessels constituted a threat or not, could thus be determined quickly by looking at the camera images.

Odin’s ground control station (GCS) was used for planning and monitoring of the vessel’s movements, see Figure 4.5. Camera images were streamed directly to the operations centre.

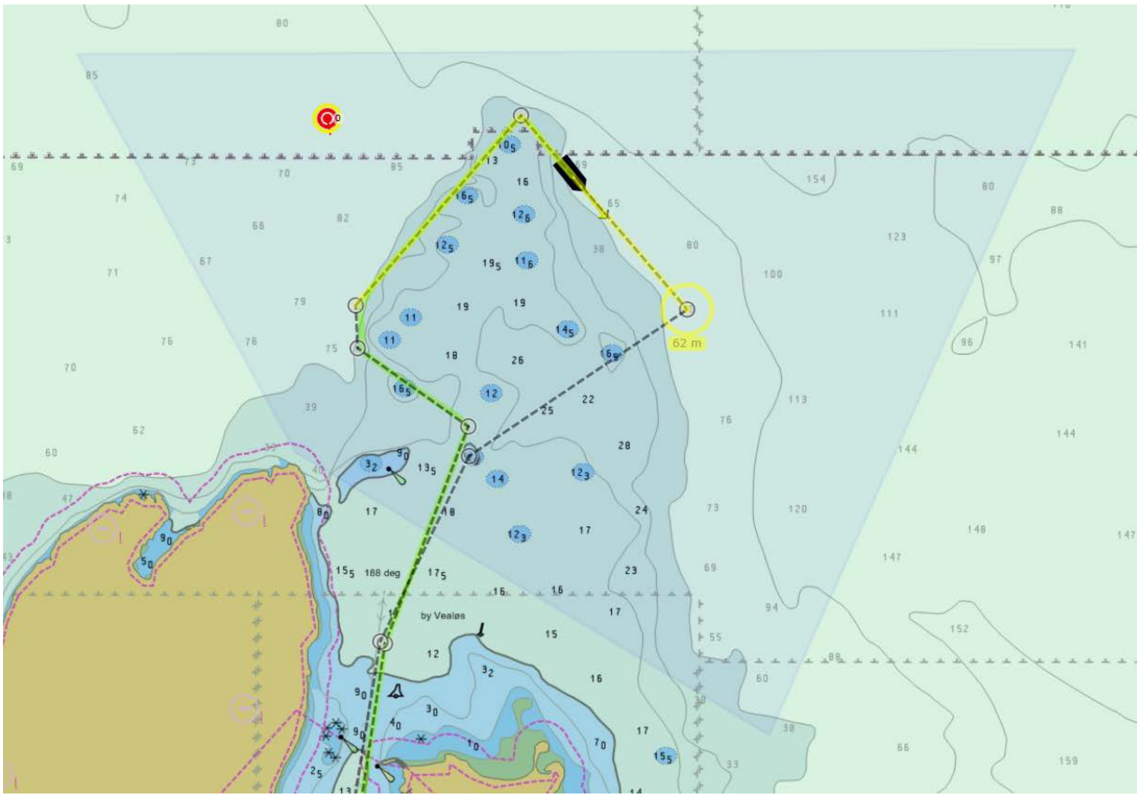


Figure 4.5 This is a screenshot of the GCS screen while monitoring Odin during a mission. Odin is patrolling along a route defined by three waypoints, indicated by a yellow line. The monitored area is defined by four global positions and is shown in blue. The red dot represents a moving object tracked by Odin's on-board radar.

Area surveillance was performed by letting Odin patrol a route planned by the GCS operator. Odin's autopilot is capable of following straight lines, and for that reason the planned route was defined by a few waypoints only. The monitored area was also defined by the operator and given as a polygon of global positions. By using the on-board radar, Odin detected and tracked objects within range, thus monitoring maritime activity inside the defined area. While patrolling, Odin slewed the on-board camera automatically in order to capture the most recent dynamic track inside the field of view. The tracks were also shown in the GCS, and it was possible for the operator to override the automatic camera control by selecting a track manually and thus make the camera pointing towards it.

Because Odin was patrolling while monitoring the area, the camera would occasionally have a poor view of the object it was tracking. Odin's capability of following a moving object was sometimes used in these situations to provide a better camera view of the object. When object following was no longer relevant, patrolling could be resumed by the operator.

4.4 UAV system description and integration

The Black Hornet VRS (Vehicle Reconnaissance System) from FLIR contains four nano-UAVs that can self-launch and fly either remotely controlled, a pre-planned route or to a pre-planned destination (see Figure 4.6). The nano-UAVs are very small (33 gram) and can operate covertly close to its targets. It brings BLOS (Beyond Line Of Sight) surveillance capabilities to the base defence operations centre. The VRS system integrates directly to the ICS and streams UAV position and video. The video contains telemetry metadata allowing the video feed to be mapped to a geographic map, making it much easier for an operator to orient and understand the information provided by the UAV. It can also send still images and “Cursor On Target” information (i.e. targeting information). The Black Hornet VRS system uses a dedicated UHF radio link from the control base to the nano-UAV.

Figure 4.6 Black Hornet VRS.

4.5 Soldier system description and integration

The QRF (Quick Reaction Force) soldiers carried a soldier C2 (Command and Control) system for blue force tracking and shared situational awareness between the soldiers and the operations centre. The soldier C2 systems consisted of a hand held PDA (Brand: Getac MX50) mounted to the soldiers’ load carrying vest (see Figure 4.7). The PDA ran an app named “FacNav mobile” from Teleplan Globe AS. The soldier C2 system used the Harris RF7800S SPR radio to communicate between the soldiers and to the BMS in the operations centre. The BMS in the operations centre sent all relevant situational data to the soldier C2 app keeping the soldiers updated on the current situation. This app enabled sharing positions between the soldiers and to the BMS. This was very important and useful for the operators using different camera systems and sensors to distinguish between own forces and other friendly/unknown/hostile personnel.

Figure 4.7 Soldier C2 system, PDA mounted to soldiers' load carrying vest.

4.6 Wildlife Cameras

The Combat Lab at the Norwegian Army Weapons School has developed a system for using standard commercial wild life cameras for area surveillance (see Figure 4.8). The wildlife camera has mobile data communication capability, and whenever an object triggers its infrared detector, it takes a picture and sends it to a predefined email address. The BMS in the operations centre monitors the email address, and whenever a new image appears, it is analyzed to detect and classify potential personnel, and if necessary, an alarm is triggered to alert the operators or commander in the operations centre.

Figure 4.8 Wildlife camera image to the left and wildlife camera to the right.

5 Results and discussion

During a three days event (October 29th – 31th) the base defence concept was demonstrated live 10 times. The different runs were streamed to a large monitor in the demonstration hall, where also products applying new relevant technology were on display. Nine of the runs were successful, while in the last demonstration the "opposing force" was not in correct position due to some communication error. We also had a few runs with minor problems streaming voice and sound.

Overall the demonstration was a big success, and the visitors (both military personnel and media) clearly expressed their interest. At the second day we had a very successful demonstration for distinguished visitors from the North Atlantic Council and the NATO Military Committee.

The main goal was to demonstrate our base defence concept for key decision makers. Attracting the North Atlantic Council and the NATO Military committee, along with other high ranking officials made this activity a big success.

5.1 Demonstration

There were several factors decisive in attracting so many and so high ranking officials to the demonstration. Firstly, the open dialogue with the DV day committee at the planning conference was crucial, because that made the right people aware of our demonstration. Secondly, the closeness to Værnes airport made it possible for the VIPs to visit the demonstration without having to make a time consuming detour.

Another important issue was the successful integration of all subsystems prior to the demonstration. Many industry partners were involved, and that made the integration work complex. Although we have had two previous demonstrations with similar concepts and many of the same partners, the integration proved to be challenging. Integration of all subsystems was successfully completed only one week prior to departure for Trident Juncture.

Another issue that arose was the availability of the necessary equipment for the demonstration. We had some unforeseen issues pertaining permissions according to International Traffic in Arms Regulations (ITAR) that delayed the handover of the remote weapon stations that we borrowed from the Norwegian Procurement Agency. We managed to resolve this issue, but it inflicted some delay in the integration work.

The operational coordinator, who was instrumental in the preparations for and execution of the experiment, was forced to work too much alone. This resulted in a massive workload and high risk of uncoordinated activity. In case of illness or other unforeseen situations, the experimentation activity would have been severely hampered. An assistant/ stand-in should have been appointed at the outset to reduce the risk.

Extensive personal experience made it possible to put together the activity without meticulous planning. Connecting with the right parties just in time saved us in the sense that we acquired the necessary resources and had the work organized and coordinated well enough, though the risk was high.

5.2 Assessment of Operational Value

The second objective was to evaluate the operational value of the system. Since the demonstration was our main goal, this part had some shortcomings. The main one was that all use of the system followed a predefined sequence of events. The opposing force did not have the opportunity to free play their engagement, as there was no time to do this. This makes it hard to draw definite conclusions, but we had valuable feedback on how the system works in practice and on the soldiers' impression of the system.

The soldiers from the Norwegian Home Guard had only four days of training prior to the TACT demonstration. However this verified the 'simplicity' of the user interface. Operating the technology in the base defence system must be intuitive and not require long, intensive training of personnel. In order to evaluate the concept for an after action review, we collected data before, during, and after the demonstration. The Home Guard personnel in the operation centre were asked to take notes from start of training and throughout the entire experiment. After the experiment we had a debriefing session with the soldiers to learn from their experiences using the system. Additionally we video recorded all the demonstration runs. The 10 runs were scripted – they use the same scenario. This gave the Home Guard soldiers valuable training and a very good understanding of the base defence system.

The soldiers' interactions were based on the use of traditional Tactics, Techniques and Procedures (TTP), Rules Of Engagement (ROE) and Standard Operating Procedures (SOP). The familiarity with TTP, ROE and SOP improved during rehearsals and the demonstration. In order to accomplish this in a short time, it was crucial that personnel were selected due to their skills in handling the different tasks and roles, and were trained by experienced personnel.

To gain shared situational awareness the soldiers emphasized that the commander (located in the operation centre) is crucial in summarizing information about the enemy from sensors and conveying this information to the quick reaction force (QRF).

The battle management system (BMS) provided information from all sensors and the QRF personnel. The sensors detected the enemy positions, and the BMS provided a safe and secure way to coordinate the response and avoid blue-on-blue situations (fratricide). However, the soldiers emphasized that voice communication over radio is still important, as well as vital for backup if the BMS fails. Several possible additions to the BMS to make it more suitable for this setting were suggested by the Home Guard soldiers, such as quick menus for sending enemy positions and automatic update of enemy positions. The different sensors of the remote weapon stations and nano-UAV contributed to good situational awareness and were enablers for accomplishing the mission effectively and avoiding own casualties. The sensor coverage and BMS made it easier and faster to designate enemy positions.

Overall the soldiers deemed the system to be effective and that it provided additional benefits. The commander commented that “When the system runs without problems, it gives a formidable situational awareness” and also “If my platoon in the Home Guard had been tasked with this mission … then it would clearly have gone better when using this system.” They also felt that using unmanned systems could give them some advantages in regular operations, the most important one being reduced risk for own and fellow soldiers’ life.

This was our most complicated test so far. Although there were some minor technical problems and loss of connectivity, the test gave a good indication that our base defence concept – sensors, effectors and unmanned systems connected through a network – works according to our hypothesis and can meet our operational needs. This concept can increase the effectiveness of the base protection force, improve situational awareness for the personnel protecting the base, and reduce the need for manpower. It also enables personnel to be more effective by using new, disruptive technology.

5.3 Lessons learned

Having the demonstration as a Transformational Activity (TACT) at ACT was important. First of all this enabled us to establish contact with persons within the Trident Juncture 2018 planning team who could help us attract high ranking officials and officers. Secondly, it was a success to team up with other TACTs and co-locate with them. We believe that this created a package that was more attractive for visitors.

The industry was heavily involved in the demonstration. The integration done by the industry was contracted and paid for by the Norwegian Defence Research Establishment (FFI), but their participation in the actual demonstration was funded by the industry partners themselves. It is important for FFI to cooperate with the defence industry to drive new ideas forward, that later can be made into products usable for the Norwegian Defence. During this demonstration we had many interested visitors, and hopefully this system can be used by Norwegian or NATO forces in the future.

The Home Guard soldiers using the system had some suggestions for improvements of the system. One point they made was the instability of the radio communication. In some situations the link to the RWS mounted on the UGV fell out. In a real situation this could be critical. Furthermore it was hard to know where in the map an alarm was triggered and which sensor had triggered it.

6 Conclusion and recommendations

Our base defence concept using unmanned systems was successfully demonstrated for numerous high ranking officials. Thus we achieved our main goal. Our secondary goal, which was evaluation of the operational value of the system, was only partially achieved. The main reason for this was that the time constraints didn’t allow for trials with an opposing force free to operate the way they wanted. All our demonstration runs were scripted.

However, the soldiers using the system deemed it valuable in the sense that it provided them with much improved situational awareness, which is one reason why such systems can increase the effectiveness of the base protection force. With this in mind we think it important to continue experimenting and fielding this type of system.

The team behind this TACT has engaged with the NOR Airforce to form a partnership for developing a concept for protection of air force bases, based on the demonstrated solution. Industry will also be a key partner, and a complete system will undergo sustained trials at a NOR air force base.

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About FFI

The Norwegian Defence Research Establishment (FFI) was founded 11th of April 1946. It is organised as an administrative agency subordinate to the Ministry of Defence.

FFI's MISSION

FFI is the prime institution responsible for defence related research in Norway. Its principal mission is to carry out research and development to meet the requirements of the Armed Forces. FFI has the role of chief adviser to the political and military leadership. In particular, the institute shall focus on aspects of the development in science and technology that can influence our security policy or defence planning.

FFI's VISION

FFI turns knowledge and ideas into an efficient defence.

FFI's CHARACTERISTICS

Creative, daring, broad-minded and responsible.

Om FFI

Forsvarets forskningsinstitutt ble etablert 11. april 1946. Instituttet er organisert som et forvaltningsorgan med særskilte fullmakter underlagt Forsvarsdepartementet.

FFIs FORMÅL

Forsvarets forskningsinstitutt er Forsvarets sentrale forskningsinstitusjon og har som formål å drive forskning og utvikling for Forsvarets behov. Videre er FFI rådgiver overfor Forsvarets strategiske ledelse. Spesielt skal instituttet følge opp trekk ved vitenskapelig og militærteknisk utvikling som kan påvirke forutsetningene for sikkerhetspolitikken eller forsvarsplanleggingen.

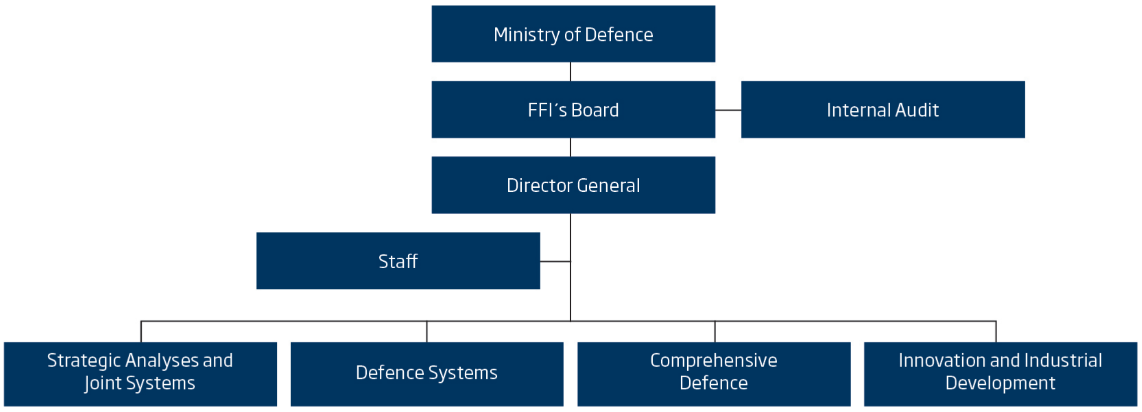
FFIs VISJON

FFI gjør kunnskap og ideer til et effektivt forsvar.

FFIs VERDIER

Skapende, drivende, vidsynt og ansvarlig.

FFI's organisation



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