ABISS

ADVANCED BATTLEFIELD INTEGRATED SCORING SYSTEM

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Nordic Radar Solutions

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Executive summary

This whitepaper describes the Advanced Battlefield Integrated Scoring System (ABISS) for weapons impact scoring. ABISS was created as a reaction to a market demand for precise, affordable, and complete weapon impact scoring systems. The technology has been co-developed with the Royal Danish Air Force.

The ABISS is a cost-effective detection system, which assures live and extremely accurate scoring data.

"Pilots need to fly. Maintainers need to maintain. Data can save lives — we need better data."

Retired Pilot, Army Gen. Dick Cody

Regardless of platform, there is always limited time and budget to train and refine the delivery of weapons. The time spent, should therefore be as informative and effective as possible. Having information readily available and delivered in real-time, allows the pilot to orient his or her attention towards decision making and improving skills.

Currently, weapon impact scoring is being performed with excessive human interaction on the ground. Visual identification of impact area, estimating impact effect, calculating angle of approach, counting fragmentation, and analyzing probability of kill – these are just a few of the time-consuming tasks which could be automated.

Meanwhile, the pilot is subject to long waiting times either in air using valuable time or forced to land and wait for results in order to receive feedback and try again.

The radar solution allows for fast and objective analysis of the weapon delivery, enabling the pilot and on-ground personnel to enhance their training patterns. The stand-alone system has been developed for the specific task of improving weapons scoring in close collaboration with the Royal Danish Air Force.

The problem in weapon impact scoring

System complexity and a failure to meet requirements for mission operations are the two main reasons why weapon impact scoring systems have been used insufficiently and with limited effect.

The desire to run complex missions with accurate scoring data, has historically required very complex systems, resulting in great cost for operators and equipment. The legacy systems currently installed at weapon impact scoring ranges throughout the world, are often outdated and do not match the weapons or weapon delivery platform. The delivery systems and weapons are constantly being improved and advanced, however the data collecting equipment supporting the development, enabling faster development and more accurate systems in the end, are often neglected.

The complexity of the system required to run advanced missions, involves people stationed at several positions, with different systems involved in order to collect sufficient data. Furthermore, several ranges still operate on a manual basis, with visual spotters and manual documentation. In the process of collecting the data, the pilots are often required to enter holding positions in air, or land and wait for results, resulting in added cost.

From these learnings, we derived two mission statements:

- The system needs to be able to operate complex missions in real-time and be able to export data in an easily read debrief format. It needs to support multiple simultaneous attacks, support multiple weapons and operation at night and in bad weather.
- The price of the system and the amount of personnel required to run the systems need to be reduced to improve cost effectiveness.

By understanding the problems and acknowledging the requirements, we were able to develop a system which meets the standards required and supports the operational patterns.

Concept of operations

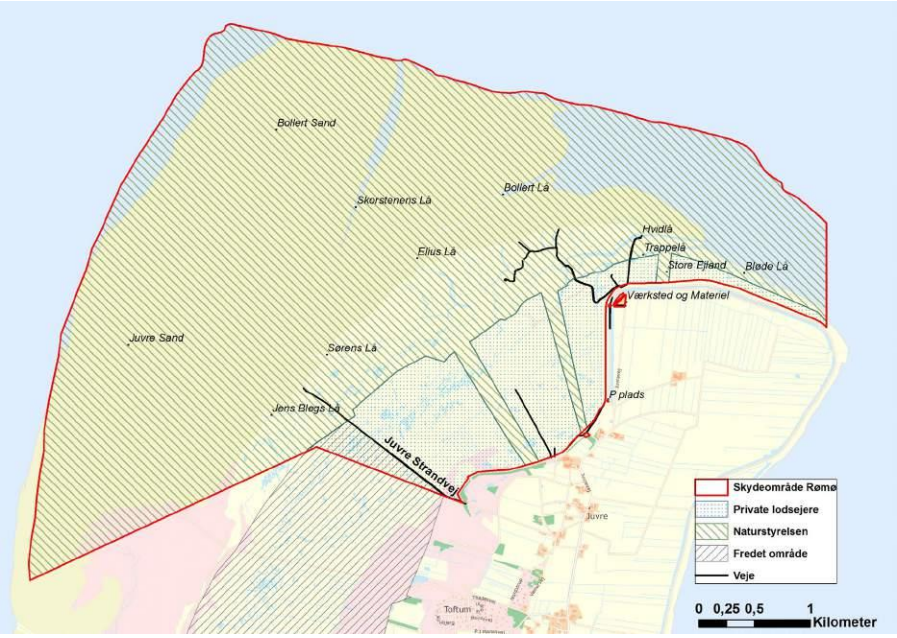
To illustrating the CONOPS, we will use the Danish Air Force proving range Rømø, located on the western shores of Denmark, next to the North Sea.

The 2.228 acres of proving grounds is a vital component in the training of Danish Air Force pilots, forward air controllers and sharp shooters. 75% of the area is sand beaches, dunes, and wetlands – making conventional instrumentation systems incapable of collecting precise data due to:

- Standoff range to impact area not far enough to protect data collection systems.
- The systems are not sufficiently mobile.

The geography makes it difficult to perform fast and objective data collection at a pace that satisfies the operational requirements of pilots and ensures that the weapon delivery artifacts are used effectively. There is a need for collection of data, association, and analysis to be automated and provided faster to the operators.

Rømø proving range
Denmark
Lat, long: 55.19561125380608, 8.502906408552462



The Royal Danish Air Force approved the development of a Ka-band radar from Nordic Radar Solutions in 2016, to reduce operating cost and have a stand-alone multifunctional scoring system available across the entire geography of the site.

Objective

Reduce the waiting time for pilots and on-ground personnel, while improving the data collection, association, analysis, and feedback for the ground personnel. Highlighted below, are a few examples of user scenarios.

Challenges for fixed wing aircraft

Both pilot and weapon platform are subject to constant change. Less training flying hours are available as more sophisticated and costly aircraft platforms are introduced. The result is less effective pilot training in special types of munitions and weapons - "Physical testing is at a premium".

Scoring of live firing of all types of munitions, in any terrain and condition is currently not an option.

Challenges for Unmanned Aerial Systems (UAS)

UAS assets and strategy are an ever growing and important part of the landscape.

The current UAS platforms, Future Combat Air Systems (FCAS) and drone swarms will still, and in the future, be required to operate alongside fixed wing platforms.

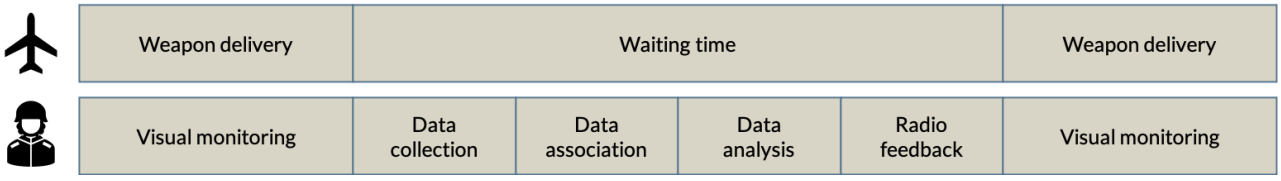
New ways of collaboration will have to be practiced, explored, and refined to harmonize the best delivery of weapon effect.

Challenges for forward air controllers / JTAC's

JTAC's who facilitate close air support in direct support of ground units is often limited by the availability of fixed wing aircraft.

Having the ability to 'prove' weapon accuracy faster, can have great effect on their skills and increase the number of training schemes within the designated time frame.

The following diagram shows the flow of data for the pilot and ground personnel. The waiting period displayed in the middle is a key pain for both operators and pilots.



By utilizing ABISS as an objective scoring system designed to support training for aviation gunnery, indirect fire missions and other instrumented ballistic measurement, we can reduce the waiting time for all involved personnel.

The solution

The core of the ABISS is made up of an advanced Ka-band staring radar, which illuminates the selected target with multiple beams, thus being able to accurately measure impact point, velocity, and angle of the incoming weapon in near real-time, during day and night and in all weather.

Ka-band is a shorter-range radar technology, with extremely short pulses of a few nanoseconds, providing unmatched range resolution. The most important technological feature of the Ka-band is the capability to minimize clutter, enabling high precision despite an array of other artifacts in its area of interest.

The proposed system is superior in terms of the overall quality, level of detection, enhanced detection volume and life expectancy compared to alternative systems.

For reference, please visit our website https://nordicradarsolutions.com, and view a brief (2:31min) introduction video of the technology.

Installation and training

NRS takes full responsibility for training and operations when physically present. On military sites, this requires close collaboration with a local team designated to the project, due to access restrictions and limitations to movements. A full project plan is scoped by NRS in the early stages, which entails all from the physical installation to communication protocols for subsystem integration.

Training

Initially, NRS will train the operators of the system (control software, setup etc.). Training is performed in three stages, from beginner to train-the-trainer.

Once trained, the setup personnel can be as little as:

- Physical inspection of ground (stability and visibility for the system) – 1 system operator.
- Positioning of the containerized system - 1 truck driver.
- Installation and setup of radar and camera – NRS recommend 1 system engineer/operator and 1 other due to weight.
- System initiation, setup, and Operations – 1 system engineer/operator.

Installation

The system is completely enclosed within a 20” container system, including radar, cameras, control station, office space and storage.

Prior to installation, an inspection of the ground where the system is to be positioned is performed. The ground should be able to carry the weight of the system, relatively level and the surroundings should be clear of obstacles, with line of sight to the target area.

Once a suitable location is found, the container is lifted into place by a crane.

The complete system sits in a self-contained 20ft ISO container for off-grid operations.
Ready to be air lifted

The original concept for the Royal Danish Navy, was to be used both on land and at sea, in any environment.
Ready for maritime operation's

Co-developed with the Royal Danish Air Force, to score all types of munitions and targets.
Ready for the F-35 JSF

Once power is supplied through the accompanying generator the setup can begin. A motorized mast lifts the radar up through an opening in the ceiling. Cables are placed in compartments close to where they are needed or enclosed in the system, minimizing cables clutter, and reducing the risk of misplacing items.

The radar electronics will correct and level the system during the system initiation and perform a system check, where motors, computers, cameras, and all system components are checked for functionality and operability.

Once systems checks have been performed and the radar is geographically aligned, the setup can begin. Map location is entered, a detailed RF map of the Ka-band and other equipment in the frequency range is mapped. Following this, NRS follows the procedures which defines the responsibilities and division of activities across organizations. The mission can begin, either locally or remote.

Operating the system

Once set up, the system is ready to collect data from the airborne weapon platforms. The system operates on two basic parameters; (target type and attack type), typically divided into small projectiles and large diameter weapons (bombs, missiles etc.). The projectile setup handles calibers from 5mm to 155mm at a rate of up to 6.000 rounds per minute. This enables the pilot, firing any secondary weapons, to receive instant feedback from the ground on accuracy, miss distance, spread, and burst length. The scoring delay (data collection, assembly, and analysis) is approximately one second.

The system collects the data, assembles the information, and analyzes it in near real-time. There is no human interaction on the ground near the target nor is visual confirmation needed.

The camera on the container records the impact for post-analysis and post-visual reporting but is not required in the feedback loop. Before the pilot exit's the target zone, he will be able to receive the information from the ground, making the second engagement information and corrections available instantly.

The large diameter weapon setup handles large projectiles, with the purpose of scoring as mentioned above and collecting valuable information for fragmentation analysis. The information gathered could be information from the impact of missiles, such as airburst fragmentation time, altitude, and angle in order to improve programming of the missiles or bombs in air.

Across the entire domain, the operator will be able to record:

- Lot numbers
- Time (hh:mm:ss:sss)
- Tail number
- Scoring accuracy
- Fragments
- Burst rate
- Terminal velocity
- Flight pattern
- Scoring delay

Being able to record the information and perform the analysis in near real-time, changes the engagement of targets and the general mission operation in training missions. Now, the training theatre will be able to provide more realistic training scenarios with multiple engagements. Attack helicopters, ships, fighter jets and other weapons systems will be able to engage the same target, with minimum delay and risk of collateral damage to each other, whilst collecting all the data and provide instant feedback.

Reducing the time

As described above, the data collection, association and analysis are bottlenecks in training missions. Reducing the time spent - and thus the waiting time for the pilot - is crucial.

	Weapon delivery	Waiting time	Weapon delivery
	Data collection, association and analysis	Data/Radio feedback	Data collection, association and analysis

Using the ABISS system, visual monitoring becomes unnecessary, as the data collection, association and analysis happens instantaneously and in near-real time. As the pilot banks off the engagement, the ground operator will be able to provide the necessary feedback to the pilot, who immediately will be able to engage the target a second time with corrections.

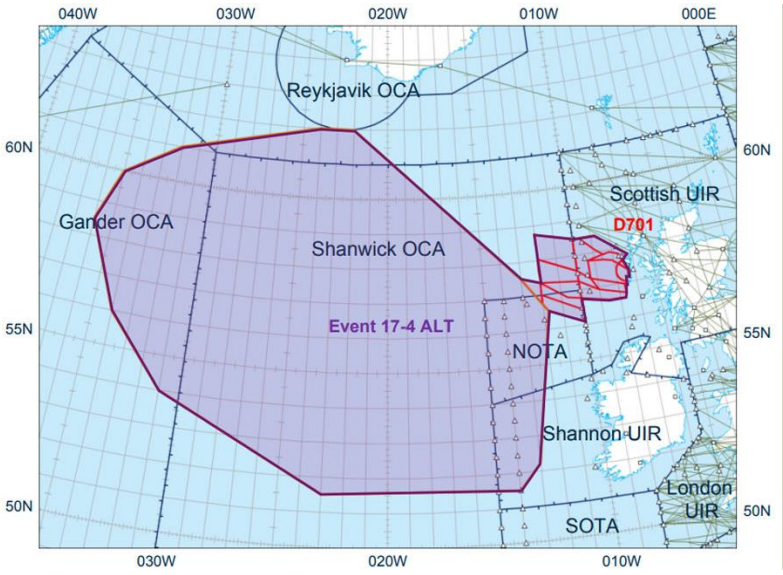
Meanwhile, the operator will be able to guide indirect fire, or secondary engagements from attack helicopters, which will increase the complexity of the training scenario and increase the value of the training for all mission personnel which is often in a Joint context.

Increasing the operational freedom

Weapons impact scoring is often restricted to the geography, as many systems are unable to relocate and be installed in remote locations with ease. Making the system fit in a 20" container, increases the operational freedom and flexibility to train anywhere for any mission.

The system can be airlifted to any location or placed on a barge and operate in remote locations at sea. This flexibility provides the possibility of target scoring in completely new mission scenarios, with new calibers and attack profiles, which in turn, does not need to be modified to fit the geography or the systems constraints. The system created by NRS, allows the pilot and others to perform realistic training missions.

The restricted airspace during the Formidable Shield exercise.



Maintenance and operation

The ABISS system consists of two compartments in the container, the ABISS system and the operator control room.

The ABISS system container has a foldable roof and a lifting mechanism, which allows the antenna and the antenna pedestal to be stowed inside the container when the system is not used. This further protects the entire system from the local environment. The container lift and roof are fully automated and requires no manual effort to exercise.

The operator control system provides control of the ABISS system through a multi-screen setup and a laptop for manual control and selection. The system can be operated by one trained operator either in the operator room or from a remote location.

The operator room and control system are connected through a dedicated ethernet cable between the two units. The system does not require additional equipment to be installed on the range and is flexible in operation with simple and rapid set-up.

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The ABISS system

The ABISS is a stand-alone commercial off the shelf (COTS) based radar system that delivers highly accurate and near real-time weapons scoring data to military customers while operating in a variety of environments.

Solution uniqueness

- Train more and create more complex and joint training schemes.
- Combine platforms and weapons engagement types.
- Train in remote locations due to small footprint of system and remote operability.
- Save time and reduce cost.

Technical uniqueness

- Ka-band radar with a wavelength of <1 cm, allowing detection of extremely small objects.
- 4D fully polarimetric radar; vertical and horizontal beams to capture small or flat objects.
- High gain antennas, allowing for the focused detection of weak signals from small targets.
- Realtime processing of signal providing instant detection of targets.
- User-friendly interface – Easy integration to airfield- or mobile systems such as laptops. tablets or smart phones for fast, accurate, and reliable decision making and risk assessment.

Technical specifications

Frequency	Ka-band	
Tx power (transmit)	50 Watt	
Transmission mode	FMCW	
Instrumented range	16.000 meters	
Elevation coverage	10 deg. electrical scan, up to 90 deg. mechanical	
Azimuth coverage	Up to 360 deg. mechanical scan	
Power in/out	230 VAC/ 16A	
Camera sensor	Wide selection of Pant Tilt cameras	
Interfaces	ASTERIX, Ethernet	
Projectile	Caliber	5 – 155 mm
	Burst rate	≤ 6.000 rounds/min.
	Max burst length	100 rounds
	Terminal velocity	≤ 300 – 1.200 m/s
Target	Ground speed	0 – 30 m/s
	Sea speed	0 – 20 m/s
	Air speed	0 – 500 m/s
Miss distance	Maximum range [a]	500 – 16.000 m
	Accuracy	≤ max (RØ, 30 cm)
	Scoring range	≥ 75 m
	Scoring delay	≤ 1s

Notes:
a) Depends on battlefield, scenario, caliber size, weather conditions etc.
Projectile: 7.62 mm up to 500 m, 12.7 mm up to 750 m, 20 mm up to 1000 m.
Shells/Bombs: Up to larger distances depending on size etc.

About Nordic Radar Solutions

Nordic Radar Solutions focuses on developing next-generation advanced radar-based systems dedicated to detection of small objects at relatively short range. Our radar has applications in Weapons Impact Scoring, Foreign Object Debris (FOD) detection, Drone Detection, Bird Detection and Warhead Fragmentation Analysis.

Our management team

Per Schmock (CEO and co-founder) – Pilot from the Royal Danish Air Force who advanced to become a Tactical Air Command Denmark Experimental Test Pilot on the F-16 Fighting Falcon. A Pilot/Test Pilot with Scandinavian Airlines, then an Experimental Test Pilot with Terma A/S. A strong commercial background and an MBA

Torsten Elmkjaer (CTO and co-founder) – M.Sc. In Antenna Theory and a Ph.D. in Active Noise Control, with 30 years of field experience in sensor system design and a specialist expert in radar systems, antennas, signal processing, tracking, control, microwaves, acoustics, tracking system design (including sensor fusion).

The roots of the company

Nordic Radar Solutions was founded on close collaboration with the Royal Danish Air Force to meet a need for a cutting-edge integrated system of radars and cameras for Weapons Impact Scoring. It has since been modified to detect Foreign Object Debris, Drones and Birds.

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Systems from Nordic Radar Solutions

WEAPONS IMPACT SCORING	TEST & EVALUATION	AIRPORT SAFETY
ABISS	T&E	FODDBASA
Advanced Battlefield Integrated Scoring System for Weapons Impact Scoring	Test & Evaluation Instrumentation Systems for fragmentation	Foreign Object Debris, Drone and Bird detection for Flight safety
		

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