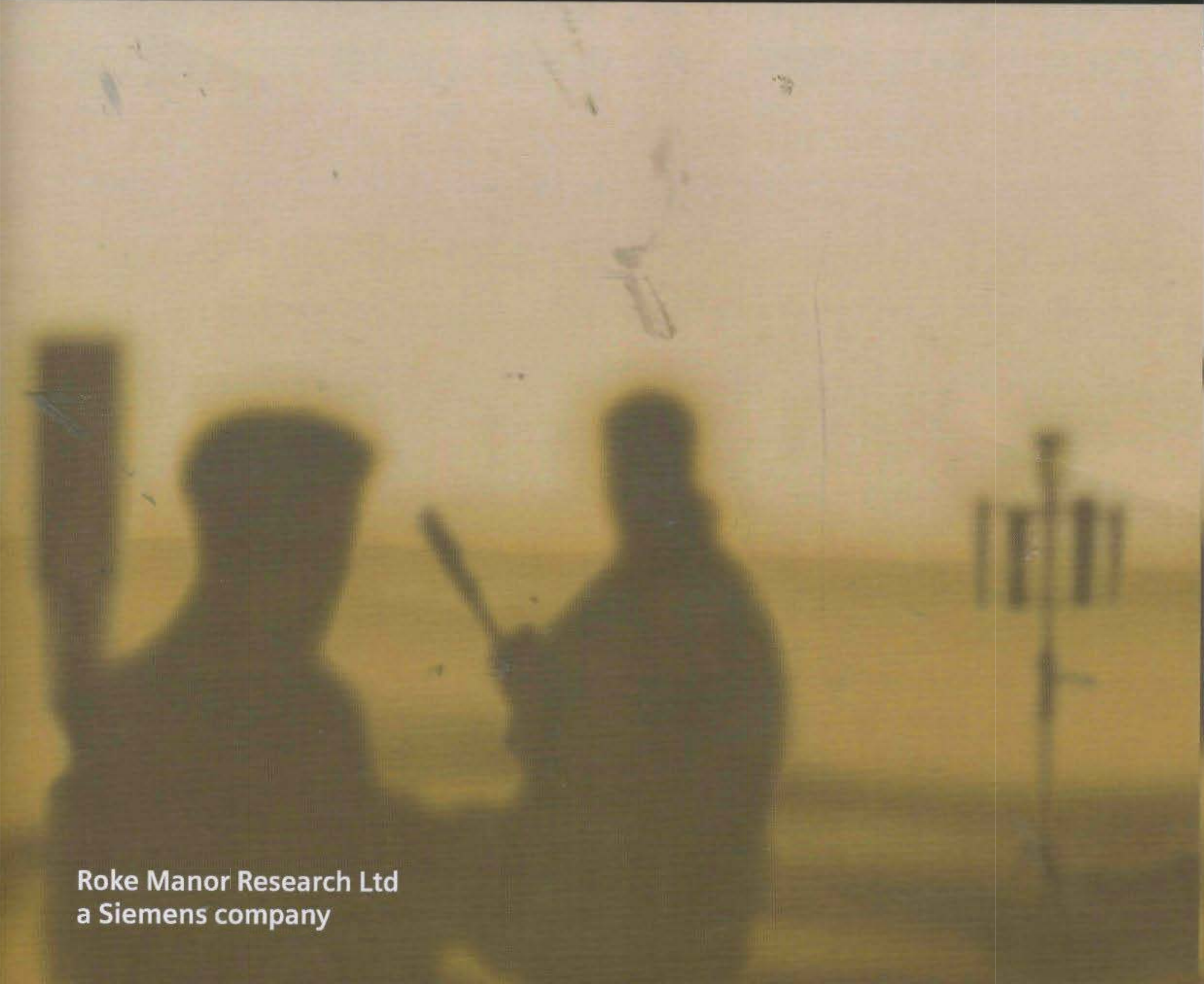
Support to Operations



Roke Manor Research Ltd
a Siemens company

Roke Manor Research Ltd
Roke Manor, Romsey
Hampshire, SO51 0ZN, UK

T: +44 (0)1794 833000
F: +44 (0)1794 833433
defence@roke.co.uk
www.roke.co.uk/defence

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Defence

Turning technology into military advantage

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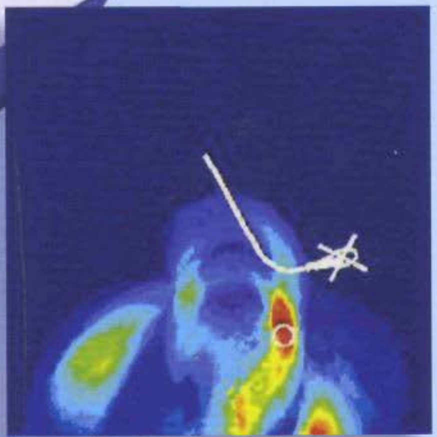


Defence solutions from Roke

From our List X site in Hampshire, Roke has been working as a trusted partner of the MoD for over 50 years

In this time the world has seen significant changes in the nature of conflict and the defence market continues to evolve. In uncertain times we need solutions which have the flexibility and agility to meet the needs of future operations.

Roke is a technology company which has experience and understanding across defence lines of development (DLODs). This, together with a background of working in commercial markets, provides a powerful combination which can rapidly deliver battle winning defence solutions.

Roke's system engineering skills and defence domain knowledge ensure that customer requirements are comprehensively captured and analysed to produce solutions that are optimised for performance, cost and timescales. Combining COTS/MOTS components with selective bespoke hardware and software development produces rapid solutions to challenging customer requirements – backed up by Roke's ability to provide in-service support.

Whether you need cutting edge products, a customer friend or a development partner – our business is helping you to solve your difficult problems – quickly and efficiently.

Our focus remains on the development, exploitation, and through life support of battle winning defence technology through the following key areas:

Support to operations	Delivering rapid responses to address urgent operational requirements
MOTS products portfolio	In-use around the world: from Electronic Warfare, to radar modelling
Product development	Full product development from a concept through to field ready product design
Production and in-service support	On-site manufacturing & test facility. Deployment preparation and training with in-service support
Quantifying military benefit	Tools to rapidly determine military benefit highlighting risks relating to operational effectiveness and technology insertion
Enabling Future Capability	Future capability research and development programs

Support to operations

Delivering solutions to meet urgent requirements in current operations

MoD needs dependable suppliers that can rapidly close capability gaps by fully understanding the challenges of delivering military capability to meet current operations. This includes:

- Rapidly engineered systems that optimise the balance between reliable functionality and time to deliver
- The need to minimise pre-deployment training to realise full operational capability
- Full awareness of and design to minimise the logistics footprint

Rapid engineering solutions – Roke is an R&D organisation with a significant portfolio of products that can form the basis of enhanced military capability. Solutions can be rapidly designed and implemented using Roke's highly skilled engineering sovereign workforce using robust but flexible processes.

Minimising training requirements – Through, for example, extensive use of graphical user interfaces, Roke solutions minimise pre-deployment training, which is an essential prerequisite for achieving full operational capability in current operations. Roke offers full pre-deployment training with system delivery.

Minimised logistics footprint – With extensive background in the design of civil communications technology Roke is able to take advantage of compact power-efficient design know-how which results in systems that have highly favourable size, weight and power characteristics, leading to more sustainable military capability.

Roke has a proven track record of successful UOR and Force Protection delivery into the MoD.

Case study: Urgent Operational Requirement for a 'Ceasefire Violation Monitoring' system

Customer	British Army
Challenge	Provide the British Army deployed in a peace keeping role with the capability to detect any ceasefire violation within 6 months
Approach	Our world class expertise in acoustics enabled us to deliver an operational solution called 'HALO' (Hostile Artillery Locator) with the ability to detect any hostile fire up to 30km away
Benefits	HALO provided the British Army with a cost effective, flexible system that can be used 24 hours a day in all weather conditions, in any location to detect ceasefire violation, developed and delivered to timescales in 6 months

Defence products

Enhanced military capability in-use around the world: from modelling and surveillance, to front-line deployment

Roke has combined patented technology, high volume, high density design skills and proven processes with multi-million pound investment to build up a product portfolio that underpins our customers' operations; operations that may last for decades.

Combining these state of the art products with the most suitable COTS/MOTS equipment enables us to meet our military customers' requirements, providing enhanced capability in Defence and Aerospace.

This capability is available now; off the shelf from Roke and our worldwide resellers.

To fulfil unique requirements, products are customisable, through the retention of ownership and design within Roke. Customers gain access to rapid-prototypes to provide early concept and trials equipment through use of our in-house production facility.

Roke has tailored solutions for many major international organisations and this experience enables us to create innovative, world leading, reliable products. These are backed up by our full life-cycle support structure, there when you need it, 24/7.

Electronic Warfare

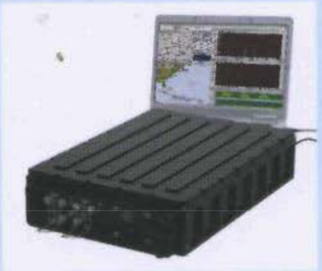
resolve
Integrated tactical electronic warfare system

The Resolve system offers a modular, scalable and integrated capability for the intercept, geolocation and further exploit of tactical communications signals within the HF to SHF bands

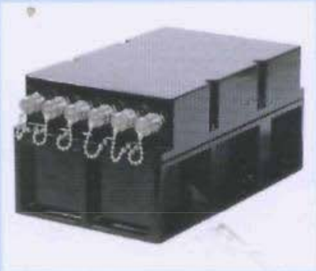
QuadTac
Tactical direction finding antenna

Quadrant
Broadband HF receive antenna system

N-Channel AGS
Acquisition and geolocation sensor



AGS
Acquisition and geolocation sensor



Electronic surveillance
Superresolution Direction Finding, Wideband HF Receivers, and Tactical HF DF Antennas

A range of electronic surveillance products ranging from specialist antennas, arrays, wideband tuners, wideband digital receivers, and N-Channel wideband digital receiver systems

Compact Crossed Loop Antenna

DWR16

MCDWR16

Defence solutions

HALO™
Acoustic weapon location system

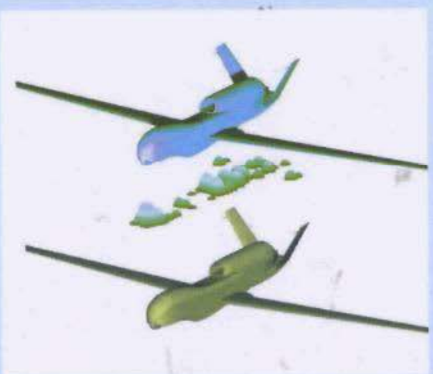
Leading acoustic weapon location system, developed under UOR for British Army peace keeping operations. In-service for over 10 years, it is deployed in-theatre by several nations'.

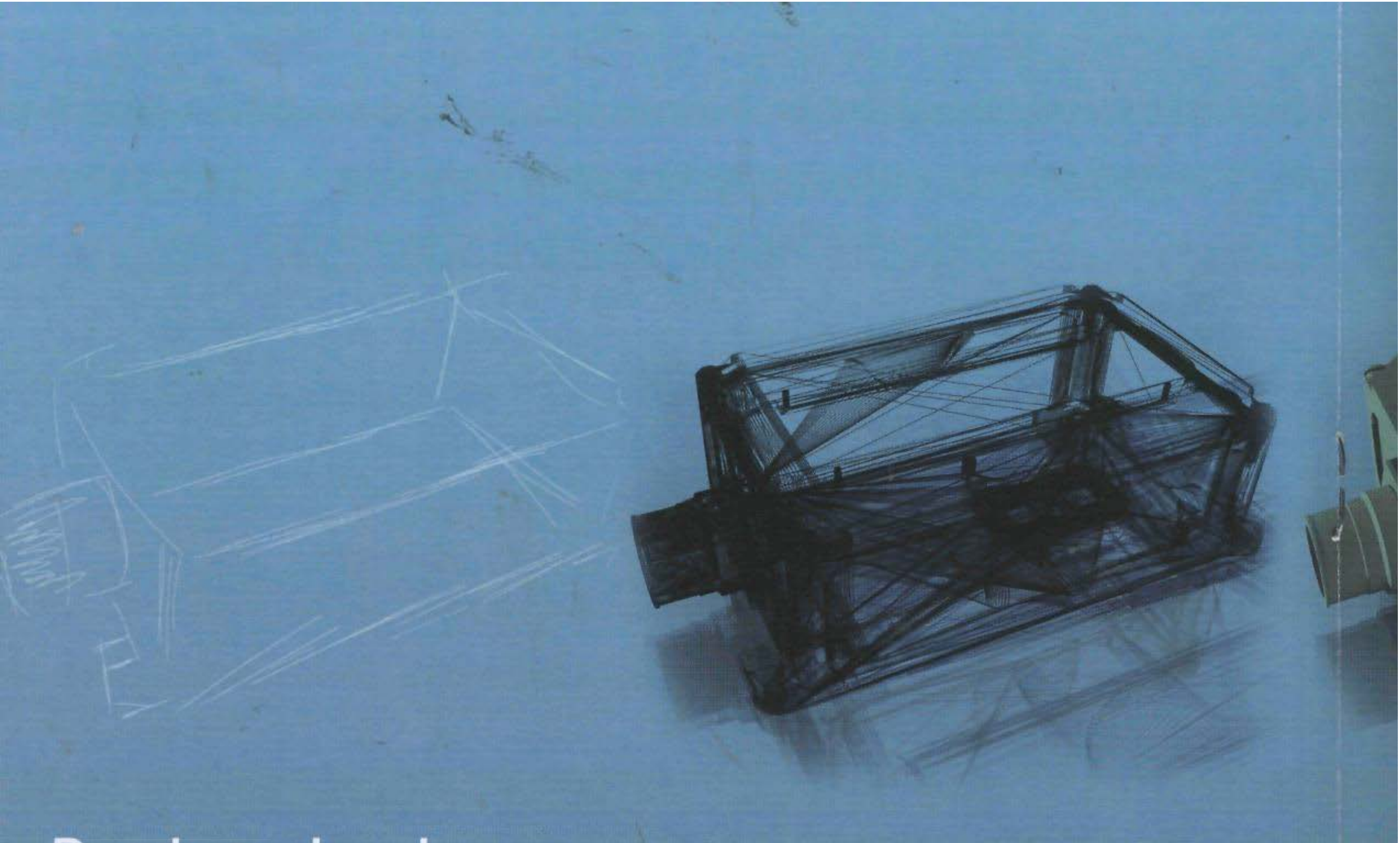
Miniature Radar Altimeter
The world's smallest radar solution for UAVs and aerial targets

Provides robust, precise performance with 'plug & play' installation into all major UAV platforms and aerial targets

Epsilon™
Radar cross section modelling

Windows software to predict the Radar Cross Section (RCS) of targets such as aircraft, ships, and tanks. Highly versatile and proven it is the most rigorous and accurate RCS solver in its class.





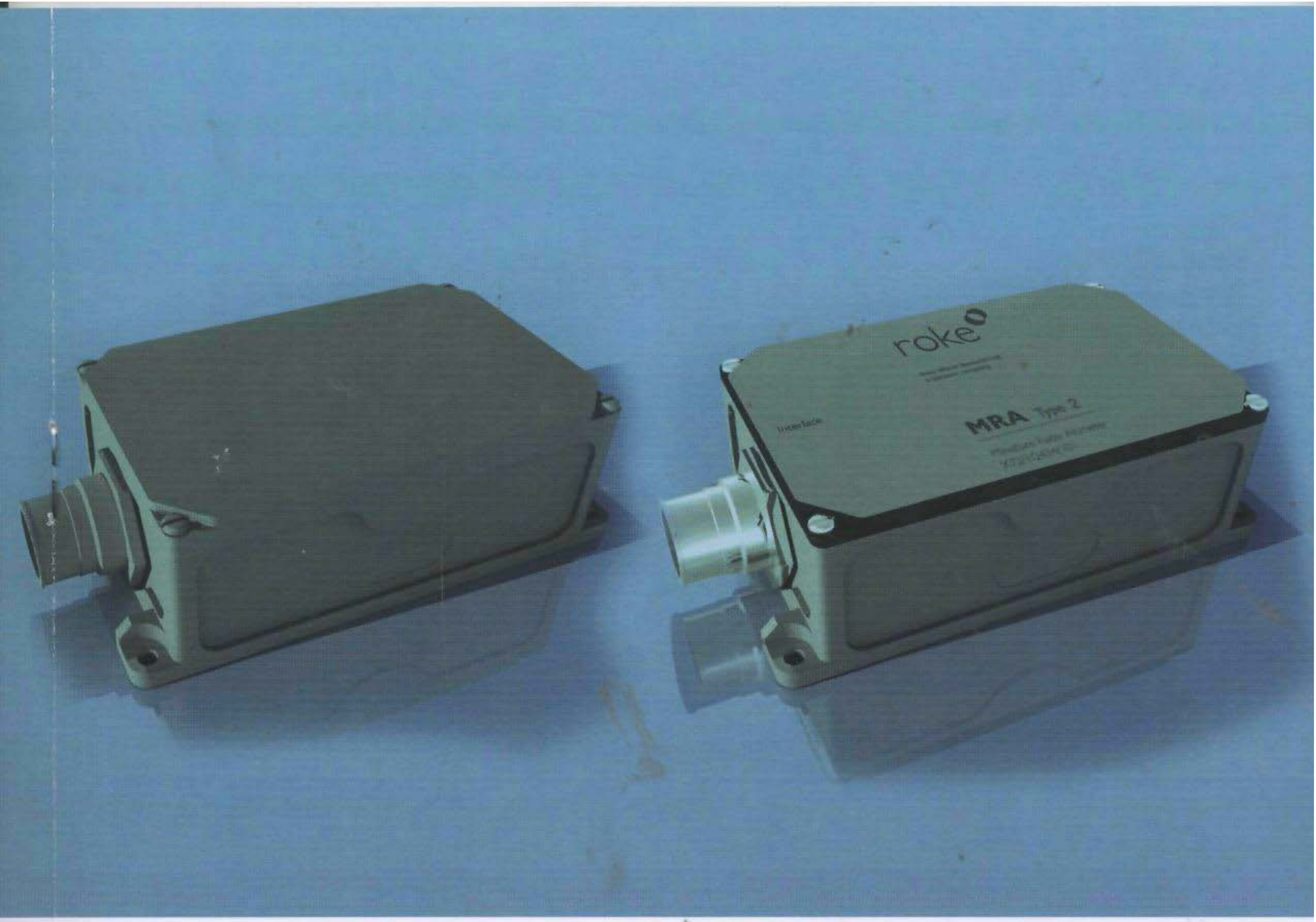
Product development

Full lifecycle development and production support

By tapping into decades of critical product development experience, and benefiting from Roke's product development processes, customers can significantly lower the risks normally associated with product development; securing a rapid and flexible response to the technical and schedule challenges of urgent requirements, and managing fully scaled-up, higher volume, product development where factory and subcontractor risks become a major factor.

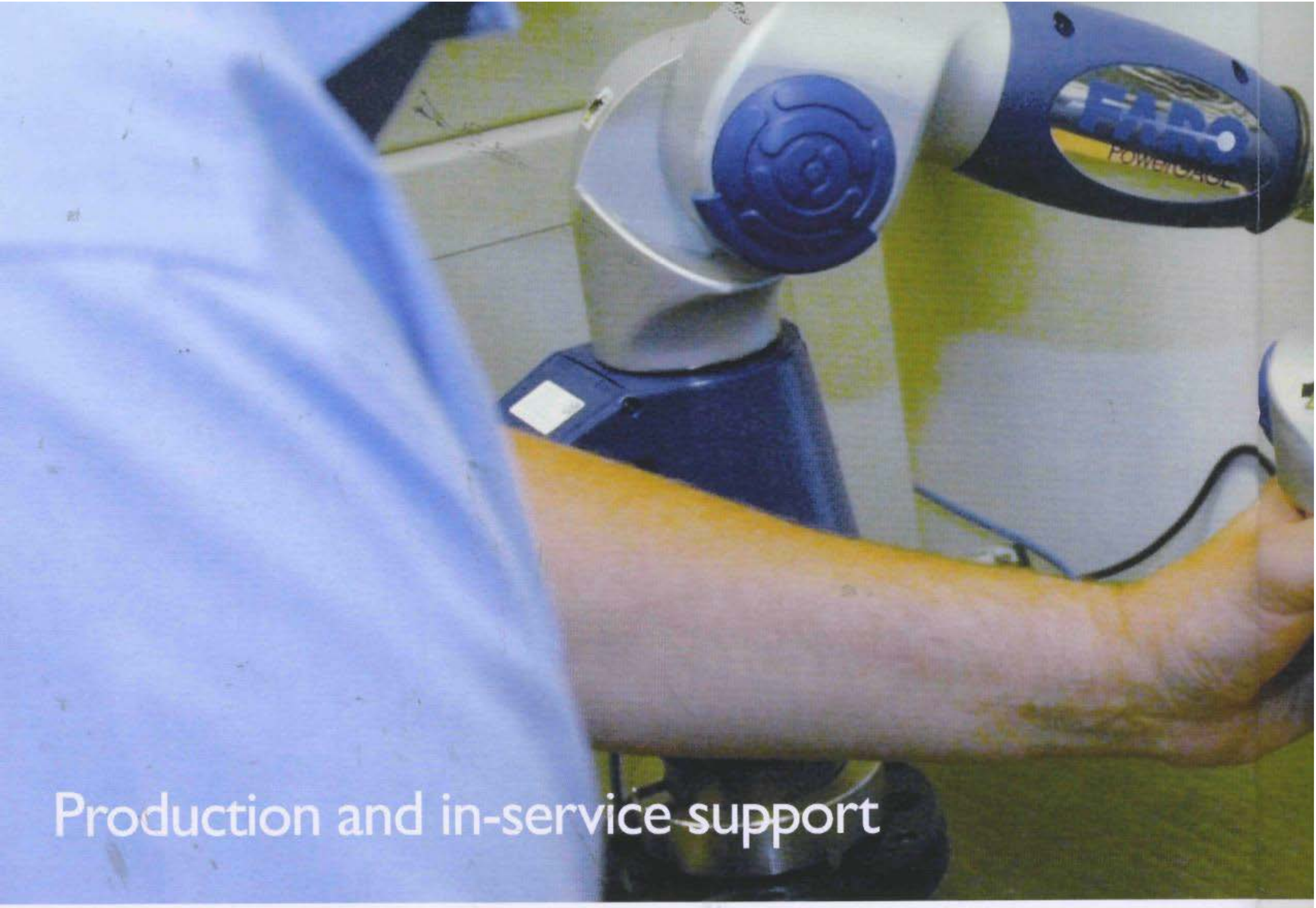
For the majority of Roke's customers, size, weight, reliability, scalability, schedule and cost are critical, so determining the optimal cost/performance/schedule trade-offs is paramount to our approach. In addition, Roke's experience within the commercial sector allows us to take the best (often cutting-edge) commercially available technology and production methods and re-apply them into the defence arena.

We offer a complete, in-house, service covering everything from hardware, software and mechanical design to manufacture and factory support including associated approvals and compliance testing (including the provision of thermal, mechanical, environmental and reliability analysis).



Case study: Personal Locator Beacon development

Customer	Signature Industries (SI)
Challenge	Looking to build on their excellent reputation in the search and rescue beacon market, Signature Industries were looking for a development partner to deliver the next generation Personal Locator Beacon (PLB)
Approach	Initially we were asked to quote for the electronics development of the new PLB but after a few meetings SI were convinced that we were capable of developing the entire product. We undertook the entire product development which included concept, development, electronics, mechanics, software and development testing. Production Automated Test Equipment (ATE) was also developed for SI at their request.
Benefits delivered	The resulting Personal Locator Beacon not only ensured that Signature Industries secured their lead customers, but also set new standards at a global level for functionality and performance versus weight. The PLB ensured that Signature Industries remain in a dominant market position.



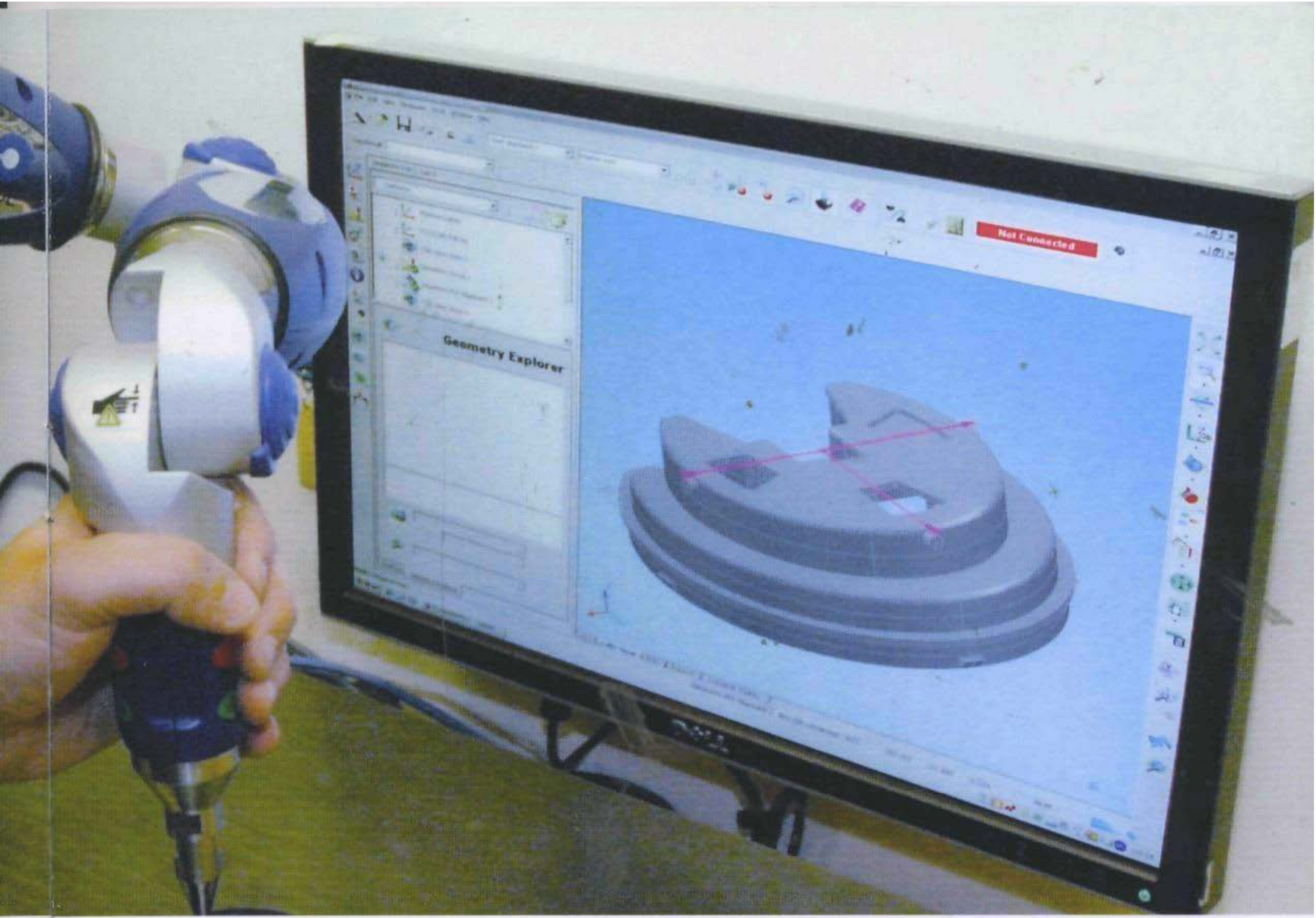
Production and in-service support

Commercial expertise applied to military product manufacture

At Roke we have developed an integrated and flexible approach to the development of products that allows us to undertake both in-house development and design for large volume production. Our integrated in-house design and production facilities include both electronic and mechanical CAD and surface mount assembly equipment supported by a comprehensive test and inspection capability. Our machine shop has both rapid prototyping and CNC machining equipment that are fully integrated with our design tools.

This capability, augmented by a reliable and trusted supply chain, allows us to offer a complete bespoke concept to product service to our customers.

The established core team of service delivery managers and field technical specialists deliver support of COTS/MOTS hardware, Roke developed applications and infrastructure in high-security environments utilising methodologies such as IT Infrastructure Library® (ITIL) and Integrated Logistic Support (ILS) to efficiently manage incidents, problems, configuration changes, obsolescence management and system upgrades. Delivering added business benefits to the Whole Life Costs (WLC) of the operations of systems by maximising availability and reliability.



Overview

Challenge	Fast development of both electronic and mechanical hardware to support short timescale prototype/product lifecycles
Approach	Our integrated approach seamlessly links electronics design from concept to schematic capture through to PCB layout and build with our mechanical CAD and production facilities. Our mechanical CAD tools are also fully integrated with CNC milling and turning, and fast prototyping facilities within our model shop.
Benefits	This integrated approach to low volume prototype and product development allows us to respond to customer requirements with very short timescales. It also gives great flexibility throughout the entire product development lifecycle, enabling design changes to be implemented in an efficient, timely and cost effective manner.

Quantifying military benefit

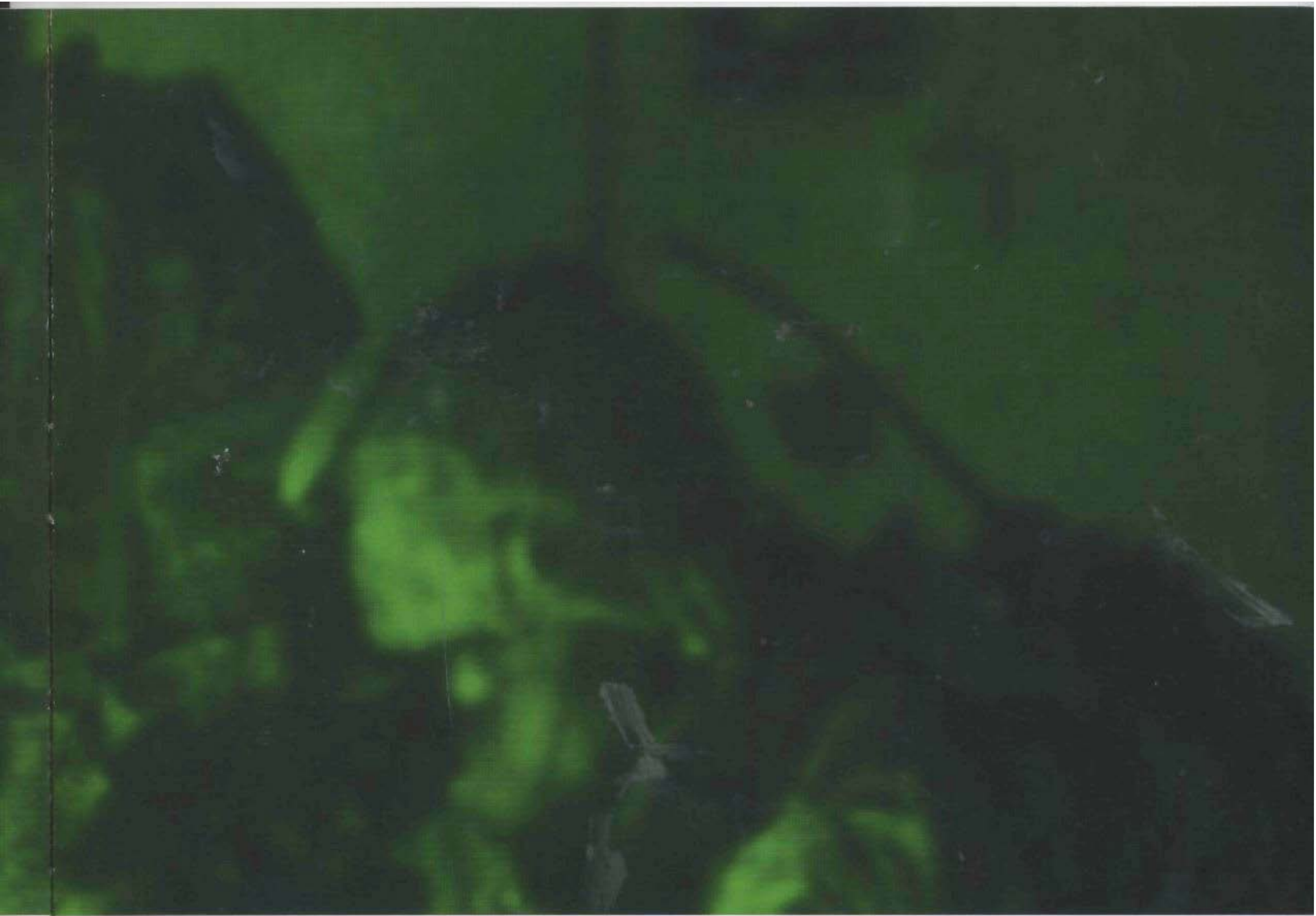
Analysing benefits against cost versus risk

Quantifying military benefit requires an understanding of how a portfolio of technological or non-technological investment options is likely to enhance military capability.

Traditionally military benefit has been determined through qualitative means, typically presented in the form of a benefits map that has been constructed through workshops or brainstorming sessions. Whilst this approach offers a good insight into the capability under investigation, most time thereafter is spent justifying the existence of relationships within the map and locating interventions to build up the business case. What is not understood so well is the complexity and inter-dependency that exists between the technical performance and military effectiveness space to have confidence that operational benefits will be realised.

Roke has developed a comprehensive methodology which models the capability under investigation through representation of key information needs and flows and derives a benefits map from it. The methodology extends the role of the benefits map to provide an understanding of where the greatest gains from investment in the benefits chain can be made and what the nature of those investments should be.

The methodology has most recently been applied to measure the benefits associated with C4I interventions determined from the NEC for Close Combat research programme. This work has drawn on the guidance provided from JSP777 to provide a framework for benefits analysis that can compare the relative benefit of radically different interventions, from across the DLODs, in terms of quantified measures of C2 effectiveness.



Case study: Providing advice-based research to the Ministry of Defence

Customer	Ministry of Defence (MoD)
Challenge	The MoD needed advice on how networked communications systems could enhance the performance of their front-line troops
Approach	With Roke acting as prime, we constructed and led a consortium of 13 companies. This included academia, human factors and logistics specialists, large system integrators, operational analysts and military experts to address all aspects of the research.
Benefits delivered	Roke was able to analyse and solve complex issues using the different strengths of the consortium members. The advice derived from the research has now been used by MoD to steer the communications needs of the major equipment programmes such as Bowman and Future Integrated Soldier Technology (FIST). The MoD has also been able to capitalise on the combined abilities of the consortium to address other difficult challenges in related areas of work.

Enabling future capability

Innovation and technological development are critical to maintaining military advantage against ever evolving threats

One key aspect of our success is our ability to identify future technologies and map them to known future capability gaps.

Working at the forefront of technology allows us to identify forthcoming technologies that have the potential to address future military requirements. We can then, where appropriate, undertake initial de-risking work through the development of white papers, software simulations and laboratory demonstrations of concepts. This work helps inform technology roadmaps and develop the requirements for future military systems.

We are a key contributor in the UK Defence Technology Centre (DTC) community with top table membership in 2 of the DTCs:

- Systems Engineering for Autonomous Systems (SEAS) DTC
- Electro Magnetic Remote Sensing (EMRS) DTC

Recent work in autonomous systems includes mission planning, data gathering, data analysis, vehicle control and vehicle recovery.

Case study: STARTLE – Biologically inspired threat assessment

Customer	SEAS DTC
Challenge	Provide autonomous systems with effective and efficient situational awareness, threat detection and threat assessment
Approach	Emulating the mammalian conditioned-fear response mechanism, STARTLE uses a low overhead detection component that utilises existing sensor output streams to identify threats. Once identified, a rule-based system tasks sensor reassignment and algorithm processing to rapidly confirm the nature and immediacy of the threat.
Benefits	STARTLE can be used to provide high-speed, low processing overhead threat detection for autonomous systems with minimal processing/memory overhead. This provides autonomous systems with rapid, accurate and reproducible reactions to potential threats.

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Roke Manor Research Ltd
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www.roke.co.uk/defence
defence@roke.co.uk

Roke Manor Research Ltd
Roke Manor, Romsey
Hampshire, SO51 0ZN, UK

T: +44 (0)1794 833000
F: +44 (0)1794 833433
defence@roke.co.uk
www.roke.co.uk/defence

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Cover photo of SAMPSON Multi-Function Radar on T45 courtesy of AMS Limited

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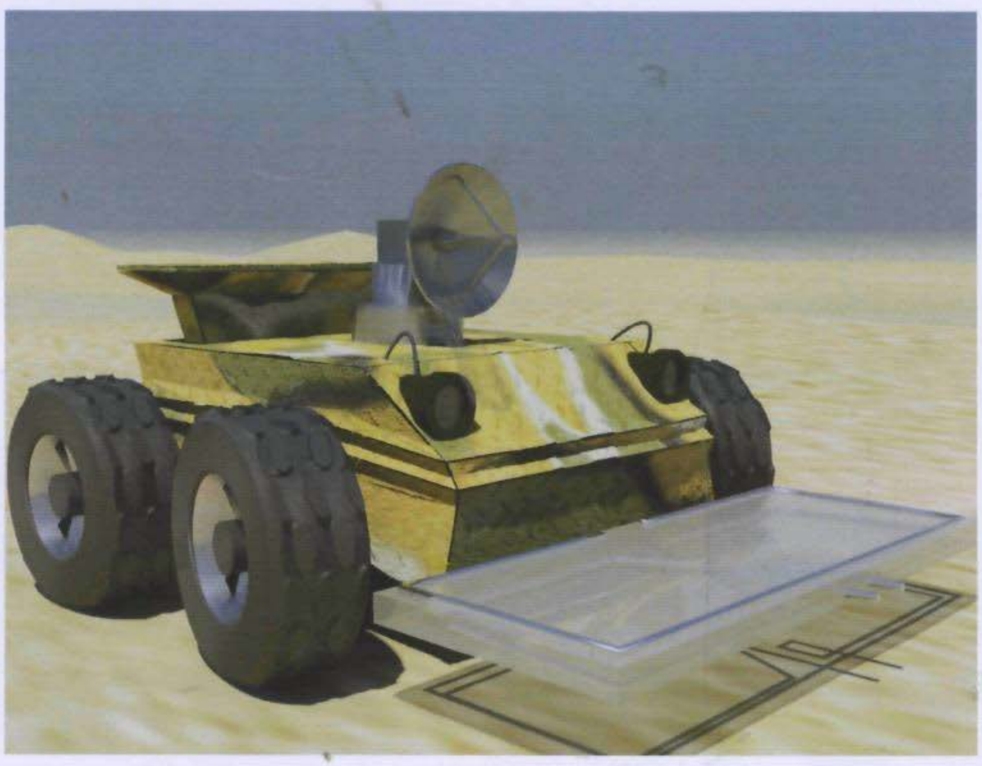
STARTLE

STARTLE is a software architecture for efficient situation awareness and threat assessment for autonomous platforms.

STARTLE is applicable to:

- External threat monitoring for UxVs
- Internal system status monitoring of UxVs
- External threat monitoring for manned vehicles as a mid-life enhancement, using existing or enhanced sensors



What is STARTLE?

STARTLE is a bio-inspired software architecture for efficient situation awareness, / threat detection and threat assessment for autonomous platforms. The STARTLE architecture emulates the mammalian conditioned-fear response mechanism to provide an efficient threat detection solution. STARTLE offers enhanced threat detection and assessment with reduced processing and memory overheads when compared with conventional techniques. It does not require sensor duplication and the approach simplifies the certification task, whilst offering potential savings in size and power demand.

STARTLE can be used to monitor internal status parameters as well as external threat indicators.
The approach can also be used to provide additional automatic situation monitoring for existing manned vehicles, piggybacking on data from existing sensor fits.

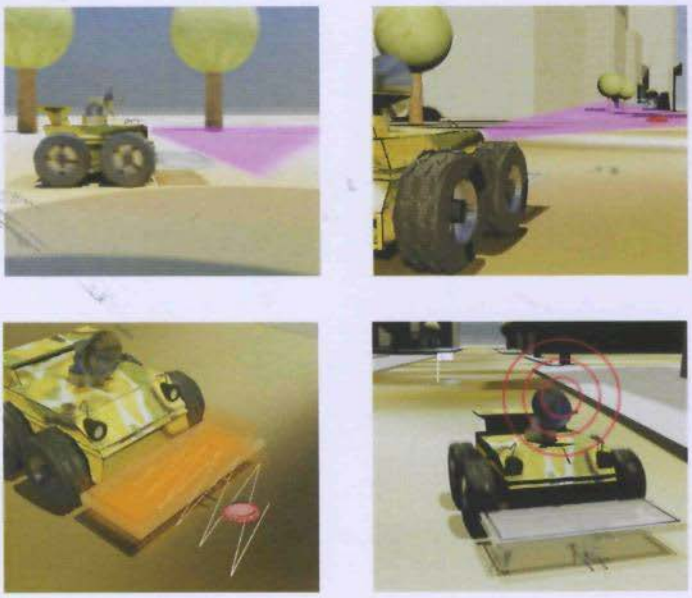
Early threat warning can cue power management changes, e.g. starting up a gas turbine in readiness for increased power demands for sensing and propulsion.

How does STARTLE work?

STARTLE employs a low processing overhead threat-detection component which makes use of the existing sensor output streams to detect possible threats exploiting the sensor data which is already being collected for primary task sensor processing (such as imaging for vehicle navigation).

STARTLE can exploit just the existing primary-task sensor fit, or it can be supplied with additional threat detection sensors.
Once a potential threat has been identified, a rule-system is invoked to assess whether a threat is really a threat to the local platform.
The rule-system in turn tasks sensor re-assignment and sensor processing algorithm selection in order to best assess the threat.

The combination of high-speed, very light-weight threat detection cueing more detailed threat analysis allows for efficient operation, requiring reduced processing/memory and sensor fits compared with standard sensor fusion techniques based on the conventional JDL/DFS data fusion process model.

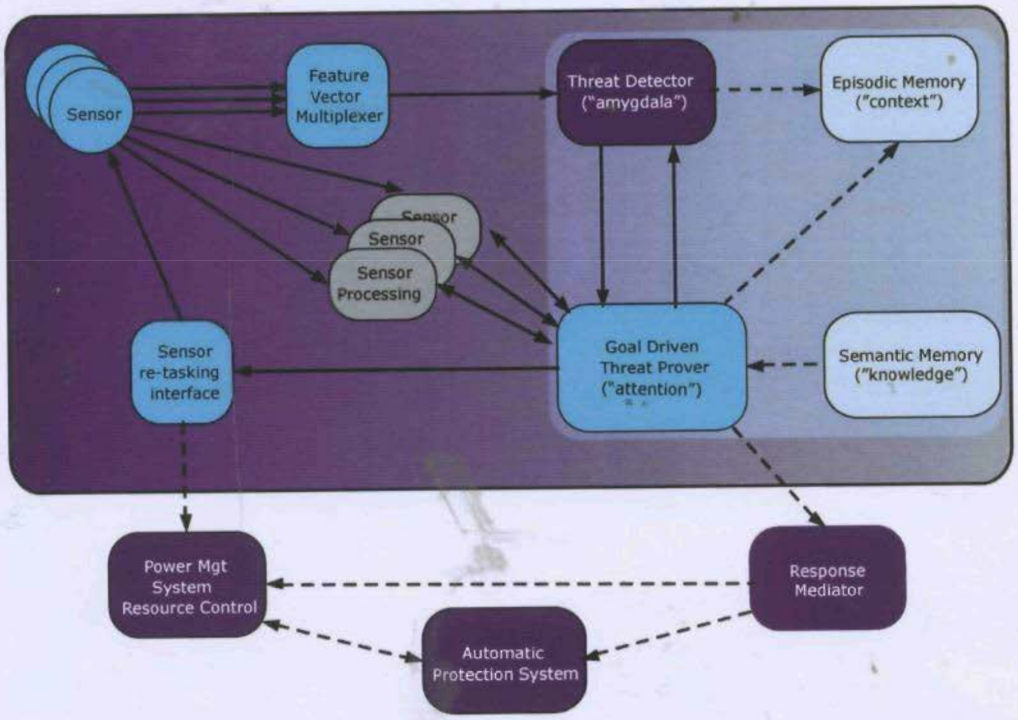


STARTLE in a fast-time simulation of a UGV undertaking a route clearance task

The development of STARTLE has been supported by the Ministry of Defence within the Sensor Exploitation theme of the Systems Engineering for Autonomous Systems Defence Technology Centre (SEAS DTC).

STARTLE uses a **fast threat detector** and a **goal-proving threat assessor** to **direct sensor assets** and select processing algorithms, emulating the mammalian brain's amygdala and sensory cortical areas, to **efficiently assess possible threats.** This allows for **more efficient and more focused use of available processing power.**

STARTLE Architecture:



STARTLE key components:

Feed forward threat detection

- Typically a trained classifier eg an Artificial Neural Network
- Makes use of existing sensor data streams
- Fast throughput monitoring and alerting
- Triggers the rule system to assess potential threats
- Trained under supervision

Goal proving threat assessor

- Typically a rule-based system
- Intelligently assesses a perceived threat to own platform
- Provides cued sensor re-tasking (rules explicitly request additional data to be collected from a particular sensor / processing algorithm)
- Gives traceability allowing reasoning to be validated

Deploying STARTLE

Threat detector training can be based on real or synthetic environment derived data, allowing a wide range of potential operational scenarios to be investigated.

The rule system is compiled by domain experts and allows the system to request the most appropriate sensor data to confirm potential threats. The use of a 'signed-off' rule system will assist in gaining system deployment certification.

STARTLE has the potential to accommodate on-the-job learning in future systems.

DSEI 2009

For further information please contact:

Mike Hook
T +44 (0)1794 833303
F +44 (0)1794 833616
mike.hook@roke.co.uk

Marketing department

T +44 (0)1794 833455
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

Roke Manor Research Limited

Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

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Compact HF Crossed Loop Antenna

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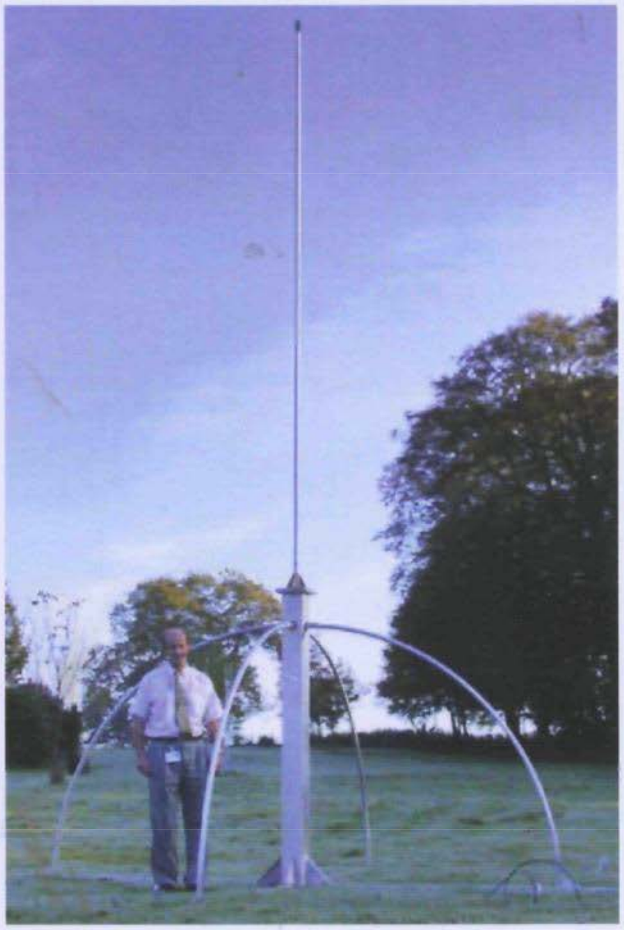
Features and benefits

- Simultaneous vertical monopole and cross loop outputs
- Ideal for use in multi element arrays for beam forming or direction finding
- Robust and self supporting-no guying required
- Designed to withstand a wind of 165km/hr, when loaded with 6.5mm of ice and/or 20.3 cm of snow
- Total shipping weight <200kg
- Operating temperature -40°C to +55°C
- Extremely low field-maintenance requirement
- DC grounded and protected against lightning induced transients
- Highly cost effective DF antenna solution
- One year full warranty



General description

The Compact Crossed Loop Antenna is a broadband omnidirectional High Frequency (HF) receive-only antenna.

It comprises both a vertical monopole antenna and a cosited crossed loop antenna, and is suited to fixed land based installations. Together, the two antennas allow reception of HF signals over the entire range of take-off angles (TOAs) from the horizon to overhead. Both antennas are passive (no built-in amplifiers) to allow the best possible dynamic range, and have built-in matching transformers to suit 50- ohm systems.

Mechanical description

The antenna consists of a 6.1m high central elevated feed monopole, combined with two tubular half-loops connected to a lower mesh ground mat. The square section lower column of the monopole is 2m high, and the tubular upper section is 4.1m high. The upper section of the monopole is of fibreglass construction. The rest of the antenna is constructed of galvanised steel.

Four arms extend from near the top of the monopole lower column down to the ground mat, forming two loops each with an effective diameter of 3.6m. The RF connections and associated electronics are encased in a fully waterproof aluminium box housed inside the hollow column, with a cable exit hole near ground level.

The 5m diameter ground mat is manufactured in four prefabricated sections to aid transportation. The antenna is provided with a set of eight 5m long ground radials. Each radial connects to the ground mat at its inner end and to a 2m long ground stake at its far end.

Electrical description

Vertical Monopole Antenna

The vertical monopole antenna is designed to respond to vertically polarized signals, primarily from 5 degrees to 45 degrees TOA, corresponding to long to medium range skywave propagation. The antenna also responds to shortrange surface-wave signals arriving at low angles.

The azimuth pattern is circular at all TOAs. The height and feedpoint location are chosen such that the elevation pattern is consistent over the entire frequency range.

Figure 1 shows the space wave gain in dBi at 10 MHz over good ground, as a function of TOA. Maximum gain occurs at a TOA of 25 degrees.

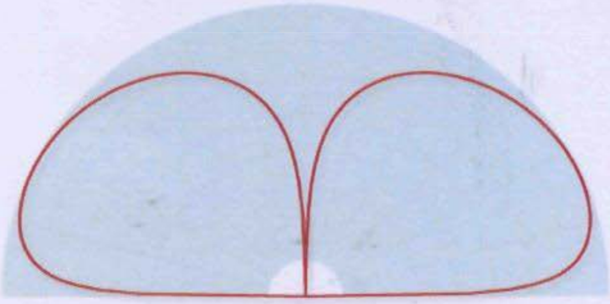


Figure 1 – Vertical Antenna Space-Wave Gain Versus TOA at 10MHz

Figure 2 shows the space-wave gain in dBi versus frequency, for TOAs of 5, 20 and 45 degrees when erected over good ground. The falling gain at low frequencies is typical of broadband matched HF antennas optimised for receive-only applications. The surface-wave gain is also shown.

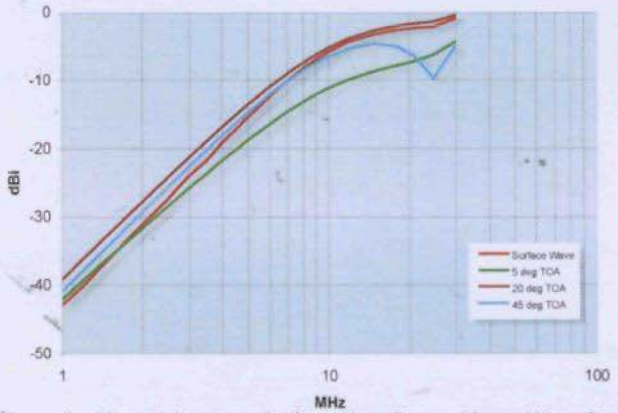


Figure 2 – Vertical Antenna – Surface-Wave Gain and Space-Wave Gain

Figure 3 shows the equivalent noise field (ENF). This is the external noise field strength, which would yield an antenna noise output equal to the receiver's internal noise. Figure 3 also shows the standard ITU-R external noise models for "Rural", and "Quiet Rural" locations. In nearly all cases the external noise dominates over the receiver's internal noise, i.e. reception is external noise limited even at the quietest sites.

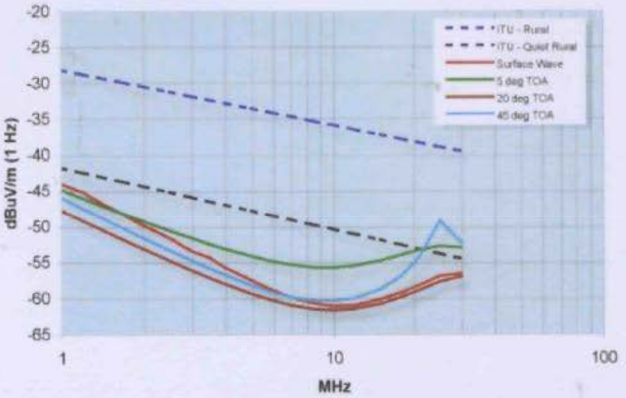


Figure 3 – Vertical Antenna ITU External Noise and ENF

Crossed Loop Antenna

The crossed loop antenna is optimised to respond to circularly polarized signals, primarily for TOAs from 25 degrees to 90 degrees (overhead), corresponding to medium range to short range / NVIS skywave propagation. The individual loop outputs are combined in a broadband quadrature hybrid network, to yield two possible RF outputs. These two outputs are matched to incoming Right and Left hand circularly polarized signals (RHCP / LHCP) respectively. For each output, the suppression of signals of mismatched (opposite handed) polarization is typically 10 dB or more over this TOA range. The antenna offers enhanced discrimination to circularly polarized signals, which are encountered under certain skywave propagation conditions.

The crossed loop antenna also responds well to both linear vertical and linear horizontal polarized signals in the 25 to 90 degree TOA range. Signals with slowly varying linear polarization will exhibit reduced fading with this type of antenna. Below 25 degrees TOA the response is primarily to vertically polarized signals, though the monopole would normally be used for these due to its enhanced sensitivity.

Figure 4 shows the space-wave gain in dBiC (dBi circular) at 10 MHz over good ground, as a function of TOA. The azimuth pattern is circular at all TOAs. The loop size is chosen to allow consistent pattern shape over the entire HF band.

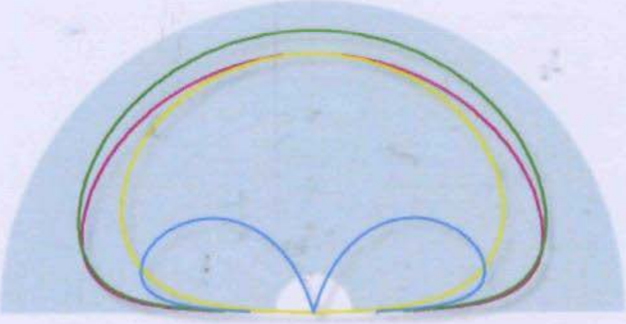


Figure 4 – Crossed Loop Antenna (RHCP output)

Space-Wave Gain Versus TOA at 10MHz

Green Trace - RHCP (matched polarization)
Blue Trace - LHCP (mismatched polarization)
Purple Trace - Vertical Polarization
Yellow Trace - Horizontal Polarization

Figure 5 shows the antenna space wave gain to matched circular polarization versus frequency, for TOAs of 20, 45 and 90 degrees when erected over good ground.

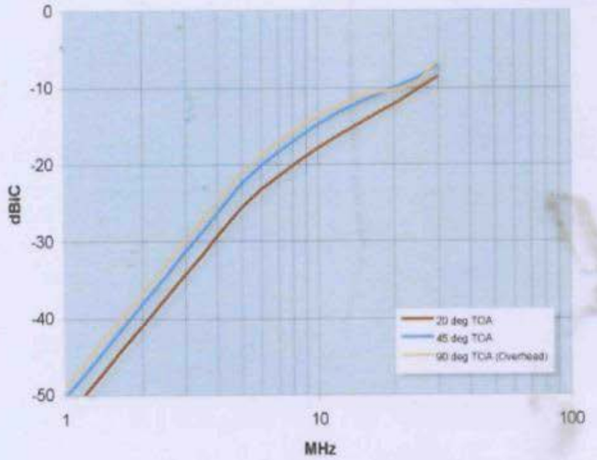


Figure 5 – Crossed Loop Antenna Space-Wave Gain

Sensitivity to vertical polarization is typically 9 dB less than the monopole, but this is still adequate to allow external noise limited reception at most sites. Figure 6 shows the ENF for vertical polarization.

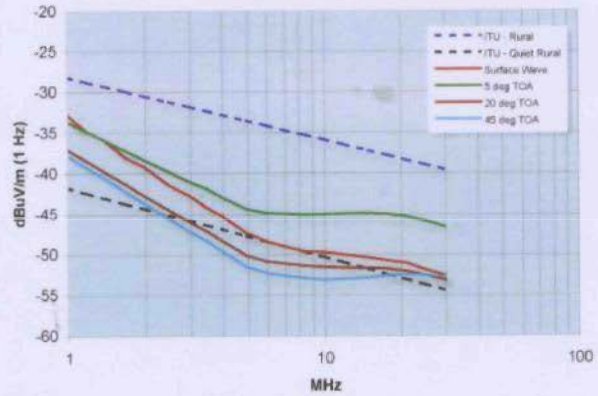


Figure 6 – Loop Antenna ITU External Noise and ENF

Operating mode

There is a single RF output connector designed for a 50-ohm load. Selection of this RF output between Crossed Loop RHCP, Crossed Loop LHCP and Vertical Monopole is performed by internal relays, according to the bias voltage conveyed via the RF feeder centre conductor:

Bias voltage	Operating mode
+8V	RHCP
-8V	LHCP
0V	Monopole

Electrical summary – Vertical Monopole

- Passive antenna with broadband internal matching
- Frequency range 1 to 30 MHz
- Omni-directional VP response for all takeoff angles below 30 degrees

Frequency	Vertically polarized gain	Antenna ENF (RX NF = 10db) @ 20deg TOA @20deg TOA
MHz	dbi	dBuV/m (1 Hz)
3	-22	-56
6	-11	-60
10	-6	-62
20	-2	-59
30	-1	-57

Field deployed Roke HF Crossed Loop Antenna (static location - Eurasia)

DSG 2009

Electrical summary – Crossed Loops

- Passive antenna with broadband internal balanced matching
- Inbuilt quadrature hybrid combiner
- Frequency range 3 to 30 MHz
- Omni-directional CP response for all take-off angles above 30 degrees
- Response also to linear vertical and linear horizontal polarization
- Switched RHCP/LHCP, activated by ±8V DC bias on RF centre conductor
- Switching time <20ms
- Delay matched between RHCP/LHCP

Frequency	Circularly Polarized gain @ 45deg	Vertically Polarized gain @ 45deg TOA	Antenna ENF (RX NF = 10 dB) @ 45deg TOA
MHz	dBiC	dBi	dBuV/m (1 Hz)
3	-32	-30	-47
6	-20	-19	-52
10	-15	-14	-53
20	-10	-8	-53
30	-7	-5	-53

Options

- Monopole and dual RHCP/LHCP loop outputs – simultaneous, no switching
- Loops only – no Monopole
- Monopole only – no Loops

For further information please contact:

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
es@roke.co.uk
www.roke.co.uk

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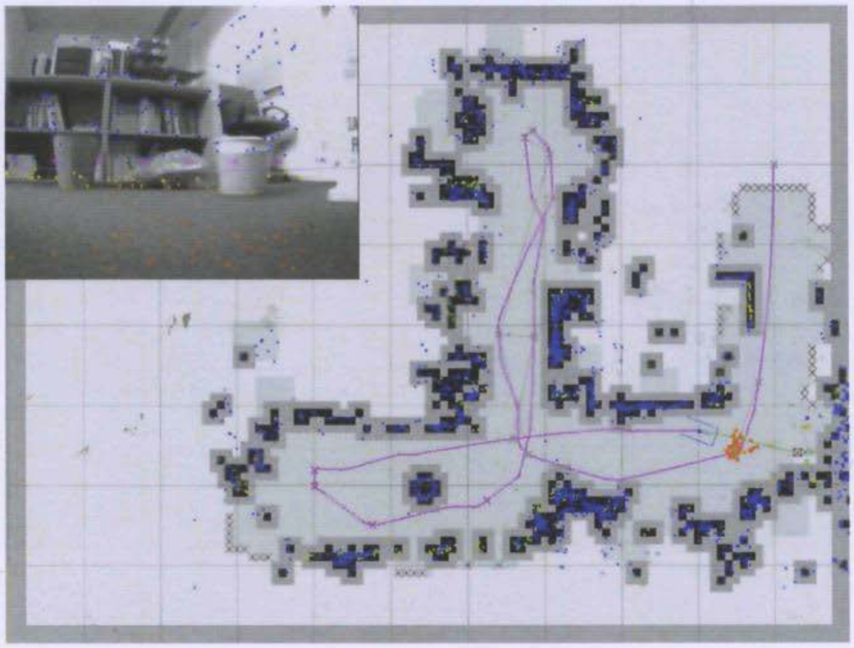
Vision Processing

Roke's Vision Processing group has remained at the leading edge of image processing technology over the last 25 years. With over 250 man-years of investment the team has demonstrated success in developing a wide range of industry-leading applications, ranging from simple image capture and retrieval systems through to complex image processing solutions. The group's work ranges from small studies, to innovative development projects, to full system and product developments.

The solutions we offer build on our core capabilities:

- Extraction of **3D information** from images – which builds on our ability to understand the complex mathematics required within this area.
- Development of techniques that can be used in **unstructured environments** – meaning that the user needs little prior knowledge of environment and does not need to spend time training the system.
- **Real time** solutions – our solutions are efficient and optimised, making intelligent use of computing resources
- Extraction of information from **video** and **image sequences** – which allows us to make intelligent use of the extra temporal dimension, giving greater understanding.

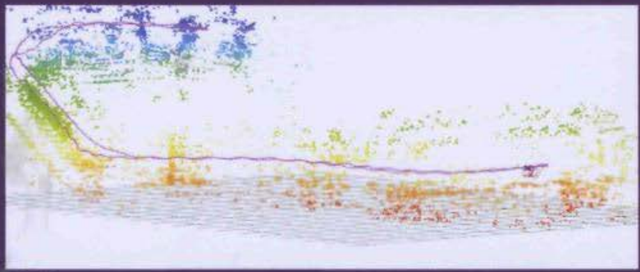


GeViS (Geometric Vision System)

GeViS performs a geometric analysis of video imagery taken from a moving platform. A real-time Structure-from-Motion algorithm is used to determine the motion of the camera and produce a 3D point-cloud model of the explored environment, which can be post-processed to generate a 3D surface model. GeViS has a wide variety of applications, including exploration of dangerous environments such as caves and unsafe buildings and 3D modelling for mission planning. It can support a wide range of configurations, including human-carried, robot-mounted and aerial camera systems and single (monocular) or paired (stereo) cameras.

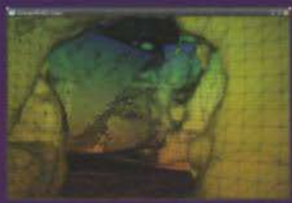
Right:
DORA robot – DORA (Demonstration of Robot Autonomy) explores buildings using 3D maps generated by GeViS to plan routes and avoid obstacles.

House



3D Point-map

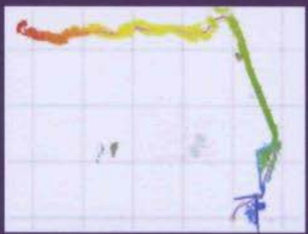
Surfaces



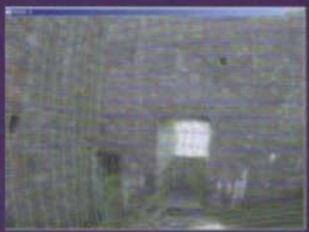
Surfaces with lines

The 3D point cloud produced by GeViS can be processed to generate a 3D surface model of the explored region.

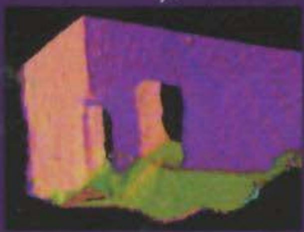
Cave



3D Point-map



Contours



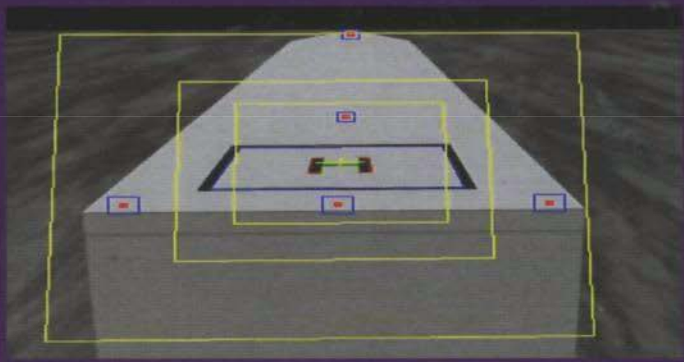
Surfaces

GeViS working in a difficult environment (castle with cave-like passageways)

Autolanding

Roke has developed autolanding capability for both fixed-wing and rotary-wing UAVs. Our system uses RAPiD, Roke's model-based visual tracking software, to identify and track the landing area. The relative position of the UAV is then calculated and the flight path from the current position to the landing point is passed to the UAV's autopilot or flight control system, allowing it to land autonomously. Integration with the GeViS system would enable detection of obstacles in the landing area. This visual autolanding system will require no ground infrastructure and will be capable of landing on a moving platform such as an aircraft carrier or a UGV.

Landing Aids



Landing on ship

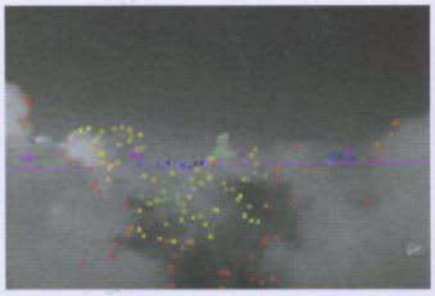
Detect landing site

Detecting obstacles

Cloud Detection

Roke's cloud monitoring algorithms detect and classify areas of cloud using video from ground-based or aerial cameras, enabling a UAV to identify risky areas and take advantage of rising thermals for auto-soaring, saving fuel and increasing the UAV's range. Our 3D structure-from-motion algorithms can then be used to create a depth model of the cloud cover and plan the most advantageous flight path.

Detection of clouds, ground and sky. White areas of cloud are classified as risky, black areas are safe.



Depth modelling (red is near, blue far)

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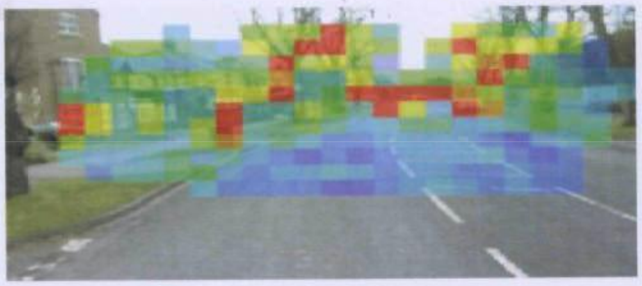
Change Detection

Roke has developed experimental algorithms to detect changes along a route travelled by a vehicle by comparing live video with data captured on a previous occasion. This is a challenging task as the scene may be affected by changes in camera position and speed, route, illumination and weather conditions. Change detection would assist soldiers who are unfamiliar with a route to spot changes which could indicate a threat, such as a hidden IED, and would also be applicable to automated surveillance tasks such as perimeter monitoring.



Red highlights areas where changes have occurred

VMAD (Video Motion Anomaly Detector)

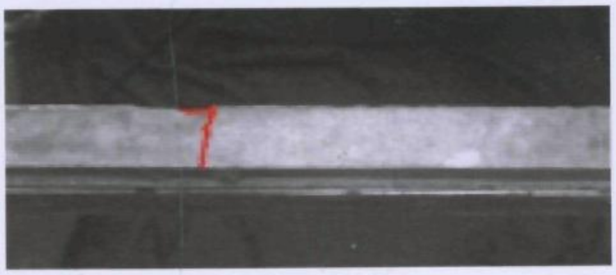
Roke's Video Motion Anomaly Detector learns normal patterns of behaviour in a scene by statistical analysis of the motion of features in a video feed. Abnormal or anomalous behaviour within the scene is then detected by comparison with this statistical picture. The learning process is completely automated, so there is no need for manual training of the system by the user. Originally developed to process video from static cameras (such as standard CCTV), VMAD can be combined with Roke's 3D motion analysis tools to process video from moving sources such as panning and tilting cameras and cameras mounted on UAVs.

Detection of abandoned bag

VMAD monitors traffic and detects anomalous behaviour

Visual Inspection and Fault Detection

Roke's vision processing algorithms have been applied to the automation of inspection and fault detection tasks in the processes of manufacturing and operating machine parts. Our expertise in 3D modelling from video enables detection of faults in complex 3D objects and comparison with computer models. Working closely with our customers we develop bespoke solutions in order to deliver improved speed, accuracy and reliability and reduced costs in the manufacturing process.



Detection of crack in a train pantograph (the device connecting a train to an overhead wire carrying electrical current).

For further information please contact:

Emma Brassington
T +44 (0)1794 833288
F +44 (0)1794 833433
emma.brassington@roke.co.uk

Marketing department
T +44 (0)1794 833455
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

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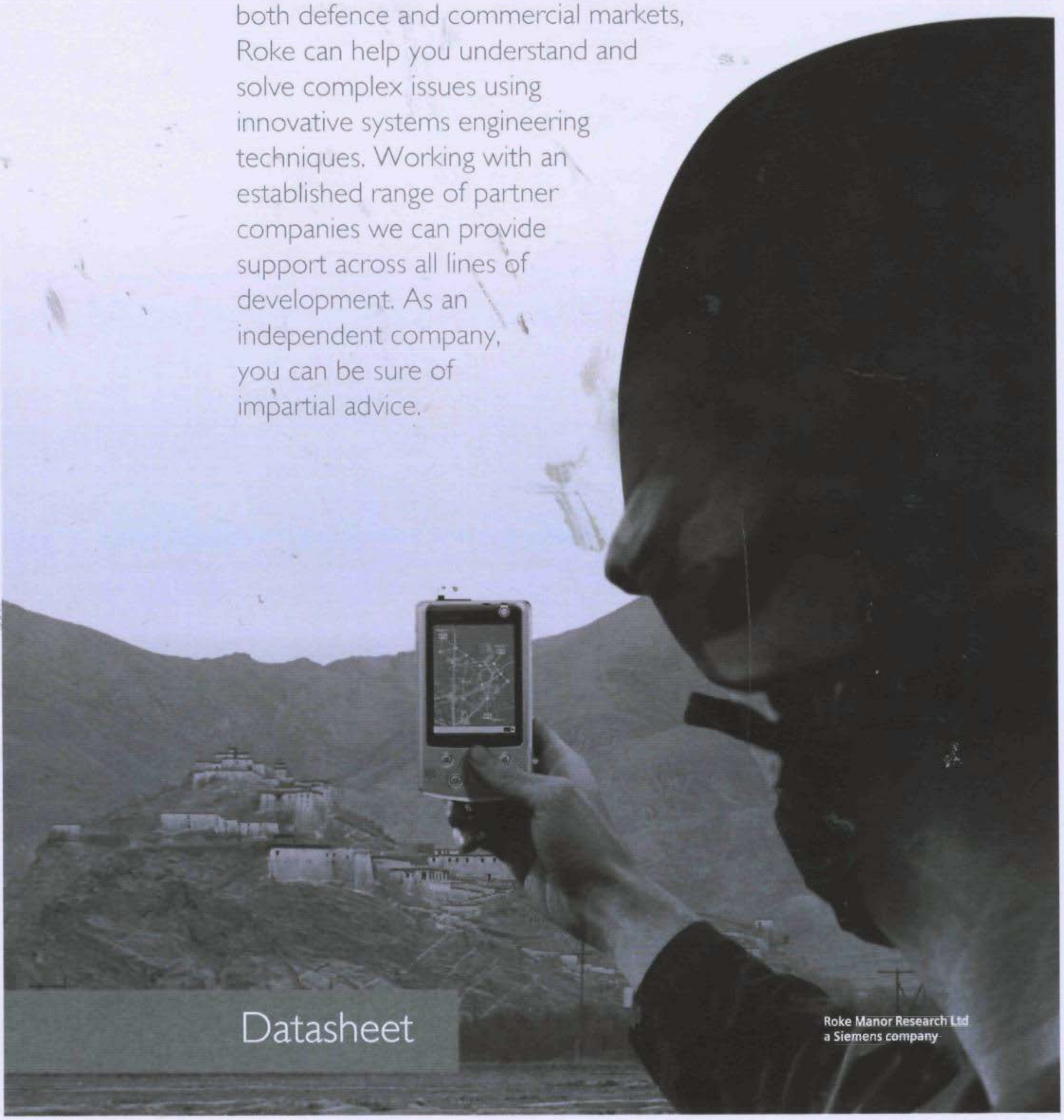
Capability research and consultancy

With extensive experience in communications systems, networks and electronic sensors in both defence and commercial markets, Roke can help you understand and solve complex issues using innovative systems engineering techniques. Working with an established range of partner companies we can provide support across all lines of development. As an independent company, you can be sure of impartial advice.



Datasheet

Roke Manor Research Ltd
a Siemens company

a. Photograph by: LA(PHOT)HUSBANDS; © Crown Copyright/ MOD, image from www.photos.mod.uk

Roke's involvement in capability research and consultancy includes:

- Prime Contractor of the TeamREACH consortium – for the NEC for close combat research programme for DEC Ground Manoeuvre
- C4ISTAR theme leader within the future Dismounted Close Combat (DCC) research programme for DEC Ground Manoeuvre
- C4I studies in support of FIST for the DCC IPT
- IP over Tactical Data Link (TDL) study for the TDL IPT.

Modern battlespace systems are characterised by the need for increased connectivity, improved interoperability and the extensive use of Commercial Off The Shelf (COTS) equipment.

To realise the benefits of Network Enabled Capability (NEC) the link between network architectures and technologies, and operational benefits must be understood. Roke and our partner companies have developed techniques that allow this link to be made and quantified. Systems modelling is undertaken with straightforward visualisation techniques so that stakeholders are able to contribute to and validate the process.

We are able to help you quantify the benefits of NEC and identify the impact across all lines of development.

The use of the Internet Protocol (IP) is revolutionising the ability to improve connectivity and interoperability. Roke can advise on, and model, all aspects of IP networks and gateways, and provide solutions to overlay IPv6 networks on legacy systems.

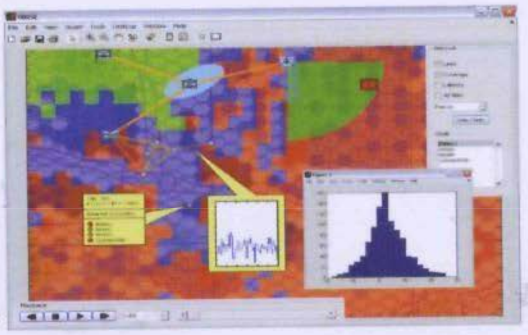
The acceptance of COTS equipment in defence systems increases the scope for the rapid introduction of commercial technologies such as civil telecommunications networks. However the pace of development in many areas is extremely rapid and technology will change many times within the lifecycle of a defence system. The opportunities afforded by these technology advances and the obsolescence vulnerabilities need to be tracked closely. Operating independently in the commercial and defence domains in equal measure; Roke is ideally placed to undertake technology road mapping and horizon scanning activities.

Key areas of support for defence customers:

- NEC benefits analysis
  - Answering the question "What can NEC do for you?"
- Soldier systems research
  - Soldier system C4ISTAR
  - Addressing mounted/dismounted infantry interoperability issues
- IP networking consultancy
  - Resilient networking, IP gateways to military and commercial communications networks
- Technology road mapping
  - Commercial and defence technologies.

b. Network connectivity/activity modelling.

c. Urban 3D radio coverage model.


b.


c.

Modelling the impact of Network Enabled Capability (NEC)

Roke and our partners have created a suite of tools for modelling networked systems to quantify the benefits of NEC. These tools can be used to:

- Evaluate the potential benefits of different technology, configuration and process interventions for C4ISTAR systems
- Visualise and compare a variety of communications, logistics, human factors and process performance parameters
- Aid intervention and requirements definition and support decision making.

The ability to link technology and architectural designs to measures of operational effectiveness allows audit trails to be created. This helps to justify system solutions for Main Gate business cases.

Example 1 (figure b): Network connectivity/activity modelling

This element of the toolset provides high levels of visualisation to simplify very complex problems including time-varying status, such as connectivity and activity. This can be used to calculate and compare metrics, and discuss problem definitions with subject matter experts.

Example 2 (figure c): Communications modelling

This element can be used to estimate communications connectivity in real urban environments. It can also evaluate information transfer performance for complex, large scale networks in representative scenarios. This can be used to provide data on:

- Radio coverage for specific individuals
- Probability of successful transmission
- Time to transfer information
- Network utilisation/throughput
- Spare network capacity
- Power consumption.

Developed in support of research in the close combat domain, these techniques are applicable wherever you need to assess the impact of NEC.

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For further information please contact:

Bob Dalgleish
T +44 (0)1794 833170
F +44 (0)1794 833589
info@roke.co.uk

Marketing department
T +44 (0)1794 833455
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

0065

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For immediate release.

News Release

7 September 2009

MoD Selects Roke for Advanced Manpack Electronic Warfare Programme

The UK MoD has awarded the Project SEER UOR contract to Roke Manor Research Ltd (Roke) to provide the next-generation Land Electronic Warfare (EW) manpack programme for British Land Forces.

The Roke solution is based on its state-of-the-art MOTS, 'RESOLVE' EW manpack product, which incorporates a fully integrated range of Roke sensors, antennas and software applications. This integrated approach enables the system to be configured to meet specific operational requirements as part of MoD's ongoing commitment to enhancing ISTAR support for UK Forces.

Upon delivery during the first quarter of 2010, Project SEER will provide integrated Electronic Surveillance (ES) and Electronic Attack (EA) capability for the UK armed forces. The scalable and networked manpack system will exploit many types of enemy communications in real-time, and provides UK Forces with enhanced Land EW capabilities.

Chris Tarran, Roke's Electronic Warfare Business Sector Manager, said: *"The RESOLVE system and its subsequent selection for Project SEER illustrates Roke's continued commitment to the enhancement of UK Forces' capabilities within the ISTAR domain."*

Teaming partners with Roke include: Thales UK supporting the NEC requirements, Selex UK supporting the Electronic Attack hardware and Frazer Nash Consultants providing ILS expertise.

About Roke www.roke.co.uk

Roke is behind some of the most innovative technology in the defence sector. Working in collaboration with government agencies, consortia and industrial partners, it has a long track record of responding to changing operational requirements by developing and delivering battle-winning defence solutions. Roke is situated in Hampshire, UK and employs over 450 people with an annual turnover of approximately £45 million.

ENDS

For further information please contact:

Russell Hardy
Business Marketing Manager
T: +44 (0)1794 833474
M: +44 (0)7921 245460
F: +44 (0)1794 833433
E: russell.hardy@roke.co.uk

Roke Manor Research Limited
T: +44 (0)1794 833000
F: +44 (0)1794 833433
E: es@roke.co.uk

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resolve

N-Channel AGS

Acquisition & Geolocation Sensor

roke

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Features and benefits

- N receiver configurations for spectrum monitoring and geolocation applications (4 or 5 channels as standard)
- Direction Finding and TDOA
- Optimised for modern commercial waveforms
- HF/VHF/UHF/SHF operation is continuously tuned from 1-3000MHz
- 37.5MHz 'Wideband Stepped Stare' architecture
- Simultaneous monitoring and display of four tuned channels (Narrowband Digital Drop Receivers)
- Standard demodulation modes include: AM,FM,SSB,CW
- Enhanced modes include GSM and CDMA (WCDMA with DSP module option)
- Low power (<20W) with 9 to 36v supply - ideal for man portable and vehicular applications
- Optional 19" rack mounts for security or rough terrain
- Standard USB2 interface for data and control
- Windows®-based GUI and API
- Integrated GPS provides location, clock conditioning and time stamping
- Single and Dual channel AGS units also available (alternate casings)
- 11 litres rectilinear volume
- 300mm x 450mm x 90mm dimensions

Description

Acquisition and Geolocation Sensor (AGS) is an N-channel, wideband receiver, optimised for intercept and geolocation of modern commercial waveforms i.e. PMR, GSM, WCDMA and Sat-phones. It provides continuous coverage from 1-3000 MHz.

Due to the wideband nature of the receiver, it can support up to 37.5 MHz instantaneous bandwidth per receiver channel; providing capability against frequency hopping signals such as GSM as well as supporting other modern wideband waveforms.

The N receiver channels can be software configured as N coherent receivers for direction finding or as one independent wideband receiver, plus N-1 coherent receivers for DF.

When used as N coherent receivers they can be employed directly for advanced N channel algorithms such as super-resolution DF.

The wideband digitiser in AGS employs the latest generation of 16 bit, high dynamic range, wideband ADC's.

In addition to the inherent wideband digitisation, each receiver offers 4 digital down converter (DDC) channels. There is also a powerful onboard FPGA if, for example, FFT processing is required.

A small integral GPS module provides for three functions: 1) position location of the AGS unit 2) local oscillator/clock conditioning and 3) precision time stamping of the data to a few ns. The time stamping feature is employed when TDOA geolocation is being employed from multiple AGS units.

The AGS units are designed to interconnect on a standard IP network. For position fixing at least 2 AGS units are required with DF algorithms and at least 3 AGS units for TDOA applications.

The IP network backbone can be provided either by a wired system or via a wireless mesh network employing say Wimax or satellite links.

For ease of use, AGS provides a standard USB2 interface for control and data transfer to a local PC. The PC is used for standard signal processing, digital filtering, DF, TDOA, demodulation and control. For specialist signal processing an additional DSP solution is available.

AGS is both high performance and low power. The low power is achieved in part by the switched down-converter architecture such that only the required circuitry specific to a band is powered up. The total AGS unit requires only 20 watts from a 9 to 36 volt supply when fully operating; however, a sleep mode is also available.

The 37.5MHz instantaneous bandwidth allows for a wideband stare across a band to capture short duration hopping signals.

In the GSM application, one receiver can be set to listen to downlink signals for queuing the remaining N-1 channels to provide DF on the uplink.

AGS is equally suited to narrowband operation for PTT intercept and geolocation. In this instance initial intercept can be provided by a 4K point FFT in the internal FPGA. Multiple signals can then be handed off to the 4 DDC's and processed simultaneously.

AGS is also available in a single channel version with a commensurate reduction in size and power consumption. This unit is suitable if only signal monitoring is required or if a single receiver channel geolocation technique such as TDOA or FDOA is employed.

Wideband Capture

The receivers employ the latest 16 bit ADCs and are able to digitise 37.5 MHz of spectrum at high resolution. This IQ data can be transferred via USB2. The wideband capture enables advanced surveillance monitoring and capture of transient or frequency hopping signals. Stored IQ data can be replayed and post processed using any of the filter bandwidths or demodulators.

Control Interfaces

Control of all receiver and down-converter settings is via a USB2 interface on the motherboard.

Windows® GUI

A Windows® based application is available which is designed to run on an external computer connecting to the USB2 interface on the AGS. It provides a user-interface for a single receiver configuration. It allows control and signal processing of the received signals. The following functions are available:

37.5 MHz Wideband channel

- Attenuator: automatic or manual mode (0dB to –31dB in 1dB steps)
- Signal level.

Narrowband channels

- Maximum 4 channels available concurrently, each tuneable anywhere within wideband channel
- 1Hz tuning resolution
- Bandwidths: 32kHz to 56Hz with 74 bandwidths
- Demodulation: I/Q, AM, USB, LSB, ISB, CW, NBFM
- Gain control: automatic (fast medium slow) and manual (6dB steps)
- Signal level
- Audio output level control: automatic or fixed (2 settings)
- Audio output
- Recording: I/Q or demodulated signal in .wav format.

The spectra of the wideband and four narrowband channels are displayed with pan, zoom and cursor-driven signal level measurement functions. A wideband waterfall display allows users to see the longer term trend.

The application permits tuning of the narrowband channels by numerical entry, using the virtual-wheel, keyboard up/down, mouse-wheel or by clicking on a signal of interest in the wideband display and handing-off to the selected narrowband channel.

Additional signal types supported

The four tuned channels support all common modulation schemes including AM, NBFM, SSB, and CW. The digitiser receiver cards can, however, also be programmed to support a much wider bandwidth e.g (200 kHz) to support GSM, and higher still (4 MHz) for WCDMA.

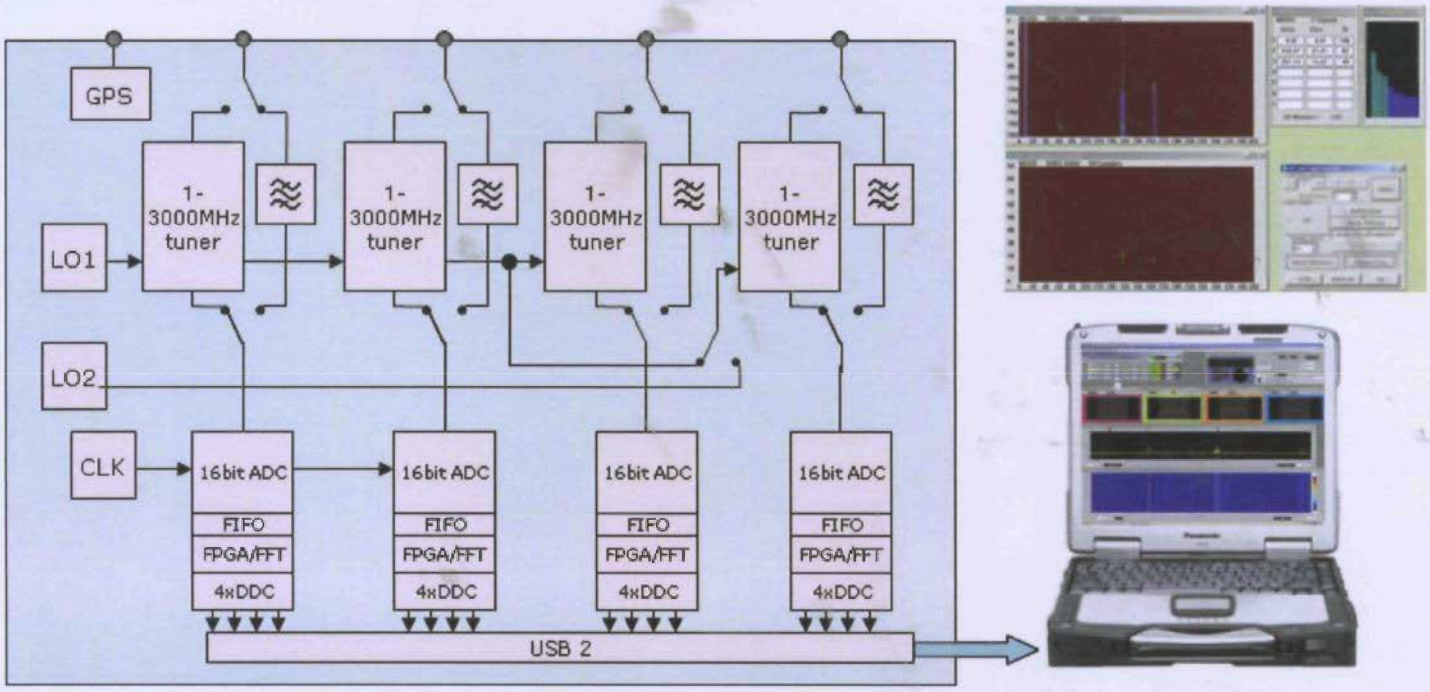
Receiver API

A Windows® DLL is available which can be linked with a customer application allowing control of and data access from the AGS. The DLL can operate the equipment with one or both receiver and down-converters present.

LAN network options

A MATLAB interface is available allowing full control and intermittent real time processing. The AGS can be connected to any standard IP network either wired or via mesh network employing for example, WiMAX or satellite links.

Block Diagram



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For further information please contact:

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
es@roke.co.uk
www.roke.co.uk

resolve

QuadTac

Tactical Direction Finding Antenna

roke

Roke Manor Research Ltd
a Siemens company

Features and benefits

- Ideal for use in deployed situations where tactical use of a Direction-Finding antenna is required
- Low visual signature - 'compressed' when body worn, but maintaining limited DF capability
- Frequency range 30MHz – 3GHz
- Optimised for PMR & GSM bands
- Rapidly deployable within seconds
- Compact folding design
- Lightweight antenna <600 grammes
- Body-worn, tripod or vehicle mounted
- Operating temperature -40°C to +55°C
- Cost effective – semi-consumable item

General description

Designed for 2 or 3-channel Monitoring and Direction Finding systems, the Roke Manor Research 'QuadTac' Antenna is designed for tactical applications where Direction Finding is required for conventional, LPI or complex transmissions within the VHF to SHF portion of the RF spectrum.

Compact enough to be integrated as part of a body-worn man-portable, man-pack or vehicular tactical Electronic Surveillance solution, the antenna can be rapidly deployed as either a Direction Finding or 'monitoring only' resource as required.

Mechanical description

The antenna is used to provide DF relative from the User to a target. Alternately, the QuadTac can be deployed as part of a wider Position-Fixing system. A mounting kit is supplied, allowing the antenna to be mounted on a tripod or vehicle as necessary. Alternatively, bespoke rapid-deployment and man-portable tripods are available as MOTS.

Electrical description

2 bands, each comprising. 4-element dipoles are provided, covering the range of 30MHz to 500MHz (low-band) and 500MHz to 3GHz (high-band).

During normal operations (see larger image above), the antenna is used to perform DF and monitoring of signals between 30MHz & 3GHz.

When in 'compressed' mode (see smaller images above), the antenna retains the ability to be used as a monitoring antenna with limited (i.e. lower LoB accuracy) DF capability, thus decreasing the visual signature during, for example, patrols on foot.

Future QuadTac developments

Future 'QuadTac' developments include the exposure of the high-band arrays when in 'compressed' mode to extend the Monitoring and Direction Finding capabilities to 3GHz, but maintaining the low visual signature.

Options are in development to provide a 3-element high-band array and an additional integrated 3-element 3-6GHz array.

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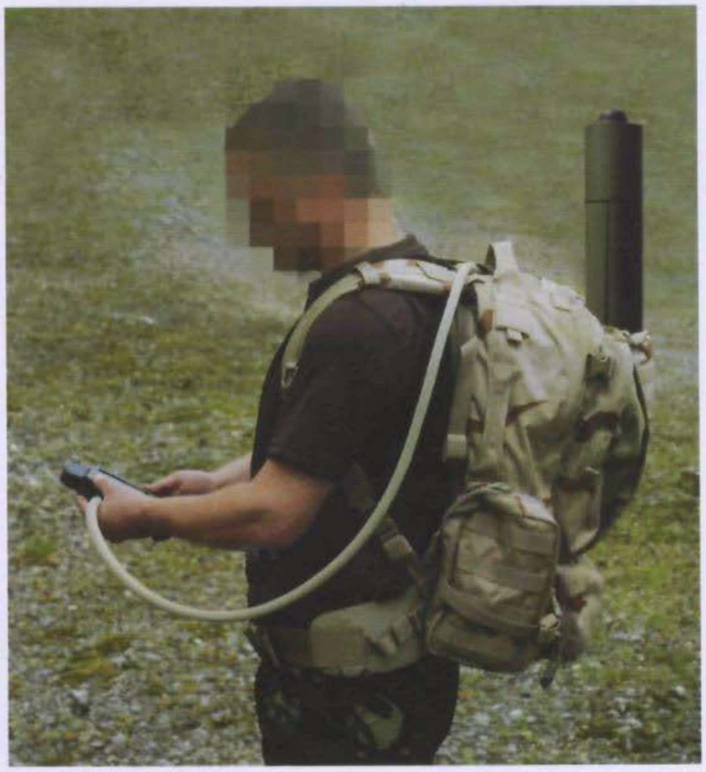


For further information please contact:

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
es@roke.co.uk
www.roke.co.uk

resolve

roke

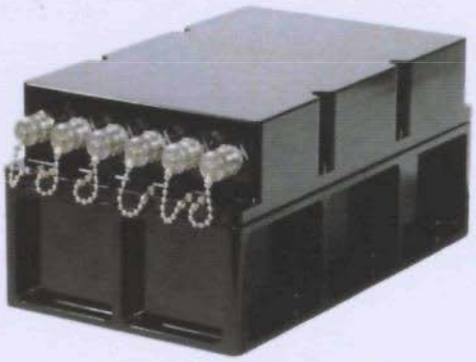
Roke Manor Research Ltd
a Siemens company

AGS (continuous tuned variant)

Acquisition & Geolocation Sensor

Features and benefits

- Dual receiver configurations for spectrum monitoring and Geolocation applications
- Direction Finding and TDoA
- Optimised for modern commercial waveforms
- HF/VHF/UHF/SHF operation is continuously tuned from 1-3000MHz
- 37.5MHz 'Wideband Stepped Stare' architecture
- Simultaneous monitoring and display of four tuned channels (Narrowband Digital Drop Receivers)
- Standard demodulation modes include: AM, FM, SSB, CW
- Enhanced modes include GSM and WCDMA (WCDMA with DSP module option)
- Low power (<10W) with single 12v supply for dual channel AGS – ideal for man-portable & vehicular based applications
- Standard USB2.0 interface for data and control
- Windows®-based GUI and API
- Integrated GPS provides location, clock conditioning and time stamping
- Optional single board micro PC for autonomous operation and control via network interface
- Single Channel version also available
- Small size 160x130x270 mm
- AGS weighs 3.9kg



Front view - DF/Monitoring, GPS & auxiliary antenna inputs

Example AGS Sensor operator GUI

Description

Acquisition and Geolocation Sensor (AGS) is a dual channel, wideband receiver, optimised for intercept and geolocation of modern commercial waveforms i.e. PMR, GSM, WCDMA and Sat-phones. It provides continuous coverage from 1-3000MHz.

Due to the wideband nature of the receiver, it can support up to 37.5MHz instantaneous bandwidth per receiver channel; providing capability against frequency hopping signals such as GSM as well as supporting other modern wideband waveforms.

The two receiver channels can be software configured as two coherent receivers for direction finding or as two independent wideband receivers.

When used as two coherent receivers they can be employed directly for two channel DF algorithms, such as 2 modes from a Butler Matrix network. Alternatively AGS provides a solid state antenna commutating switch that enables up to 5 antenna DF to be employed such as Correlative DF algorithms.

Description (cont.)

The wideband digitiser in AGS employs the latest generation of 16 bit, high dynamic range, wideband ADC's.

In addition to the inherent wideband digitisation, each receiver offers 4 digital down converter (DDC) channels. There is also a powerful onboard FPGA if, for example, FFT processing is required.

A small integral GPS module provides for three functions: 1) position location of the AGS unit 2) local oscillator/clock conditioning and 3) precision time stamping of the data to a few ns. The time stamping feature is employed when TDOA geolocation is being employed from multiple AGS units.

The AGS units are designed to interconnect on a standard IP network. For position fixing at least 2 AGS units are required with DF algorithms and at least 3 AGS units for TDOA applications.

The IP network backbone can be provided either by a wired system or via a wireless mesh network employing say Wimax or satellite links.

For ease of use, AGS provides a standard USB 2 interface for control and data transfer to say a local PC. In addition AGS can be fitted with an internal micro PC running full Windows XP operating system. In either case the PC is used for the standard signal processing, digital filtering, DF, TDOA, demodulation and control. For specialist signal processing an additional DSP solution is available.

AGS is both high performance and low power. The total AGS unit requires only 10 watts from a 12 volt supply when fully operating, however, a sleep mode is also available.

The 37.5MHz instantaneous bandwidth allows for a wideband stare across a band to capture short duration hopping signals.

An example application for GSM is to employ the two receivers as two independent receivers A and B covering a total of 75MHz downlink bandwidth. This configuration will rapidly identify all the broadcast channels which can then be 'handed off' to a DDC channels, set at 200KHz bandwidth, to provide a more in depth analysis.

Alternatively the two receivers can be configured as wideband, dual channel, coherent receivers to provide capability (with suitable DSP) for GSM DF.

Finally the receivers can be configured with one covering 37.5MHz of GSM uplink bandwidth and the other covering 37.5MHz of down-link bandwidth.

AGS is equally suited to narrowband operation for PTT intercept and geolocation. In this instance initial intercept can be provided by a 4K point FFT in the internal FPGA. Multiple signals can then be handed off to the 4 DDC's and processed simultaneously.

AGS is also available in a single channel version with a commensurate reduction in size and power consumption. This unit is suitable if only signal monitoring is required or if a single receiver channel geolocation technique such as TDOA or FDOA is employed.

Antenna Switch

The antenna switch matrix offers the following possibilities:

- Selection or commutation of up to 4 antennas between 1 receiver, and 1 monitor antenna for the second. (DF applications)
- Selection between 2 antennas for each receiver.
- GPS antenna input and routing.
- Selection of external calibration source

Wideband Capture

The receivers employ the latest 16 bit ADCs and are able to digitise 37.5MHz of spectrum at high resolution. This IQ data can be transferred via USB2 or Ethernet. The wideband capture enables advanced surveillance monitoring and capture of transient, frequency hopping or other LPI transmissions.

Stored IQ data can be replayed and post processed using any of the filter bandwidths or demodulators. With the Dual receiver two 37.5 MHz slices of spectrum can be captured simultaneously in the same or different frequency bands.

Single / Dual Receiver

The single receiver can be operated in the following ways:

- Monitoring of 4 different frequencies within a single band
- Capture of a 37.5MHz segment within same band
- TDOA when part of a network of AGS units

The dual receiver supplements the above:

- Monitoring of 8 different frequencies within two bands
- Capture of two different 37.5MHz segments of spectrum in the same or different bands
- 2 channel DF via an external Butler matrix 3 channel Adcock with switching or 5 channel correlative DF with commutating antenna switching

The AGS has a high quality internal TCXO frequency reference but the option to use an external 80MHz input is also provided. The TCXO can be locked to GPS for high accuracy applications.

Control Interfaces

Control of all receiver and down-converter settings is via a USB2 interface on the motherboard. The single board computer, if fitted, also uses this USB2 interface, and may communicate outside the AGS box via an Ethernet LAN connection.

Windows® GUI

A Windows® based application is available which is designed to run on an external computer connecting to the USB2 interface on the AGS. It provides a user-interface for a single receiver configuration. It allows control and signal processing of the received signals. The following functions are available:

37.5MHz Wideband channel

- Attenuator: automatic or manual mode (0dB to –31dB in 1dB steps)
- Signal level reporting

Narrowband channels

- Maximum 4 channels available concurrently, each tuneable anywhere within wideband channel
- 1Hz tuning resolution
- Bandwidths: 32kHz to 56Hz with 74 bandwidths
- Demodulation: I/Q, AM, USB, LSB, ISB, CW, NBFM
- Gain control: automatic (fast medium slow) and manual (6dB steps)
- Signal level
- Audio output level control: automatic or fixed (2 settings)
- Audio output
- Recording: I/Q or demodulated signal in .wav format.

The spectra of the wideband and four narrowband channels are displayed with pan, zoom and cursor-driven signal level measurement functions. A wideband waterfall display allows users to see the longer term trend.

The application permits tuning of the narrowband channels by numerical entry, using the virtual-wheel, keyboard up/down, mouse-wheel or by clicking on a signal of interest in the wideband display and handing-off to the selected narrowband channel.

Additional signal types supported

The four tuned channels support all common modulation schemes including AM, NBFM, SSB, CW. The digitiser receiver cards can, however, also be programmed to support a much wider bandwidth e.g (200kHz) to support GSM, and higher still (4MHz) for WCDMA.

Receiver API

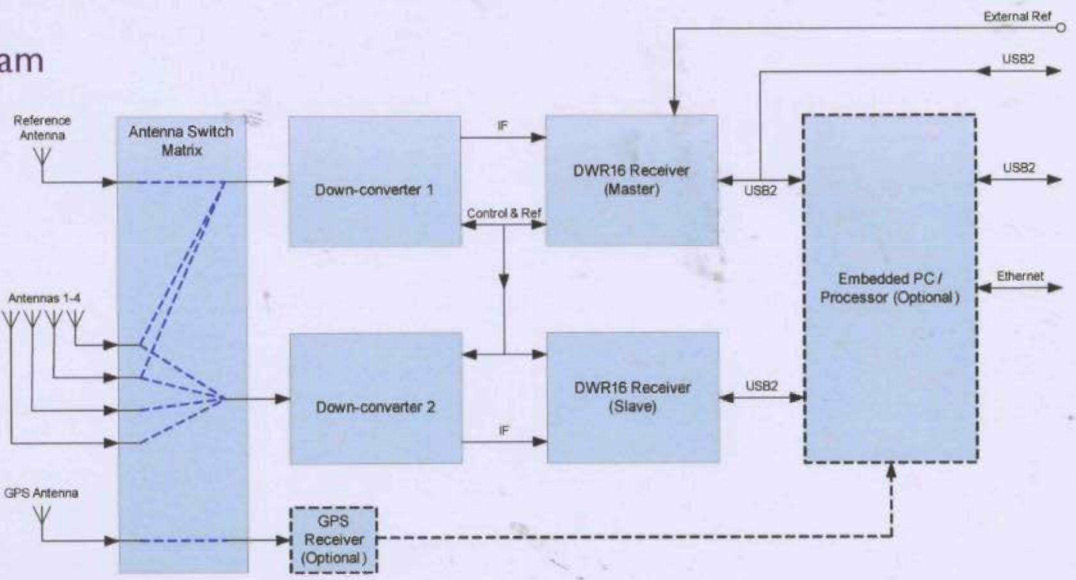
A Windows® DLL is available which can be linked with a customer application allowing control of and data access from the AGS. The DLL can operate the equipment with one or both receiver and down-converters present.

LAN network options

When the micro PC is fitted to the AGS, a data collecting program can be run which allows control of and presents raw data from both receivers over the standard Ethernet interface. This network format data can be saved to disk or connected to the single receiver GUI remotely. A MATLAB interface is also available allowing full control and intermittent real time processing. The AGS can be connected to any standard IP network either wired or via mesh network employing for example, WiMAX or satellite links.

For use with low data rate networks, e.g. GPRS or Satellite), the AGS unit when fitted with the SBC can be commanded to collect data, analyse and present results in order to reduce network loading.

Block Diagram



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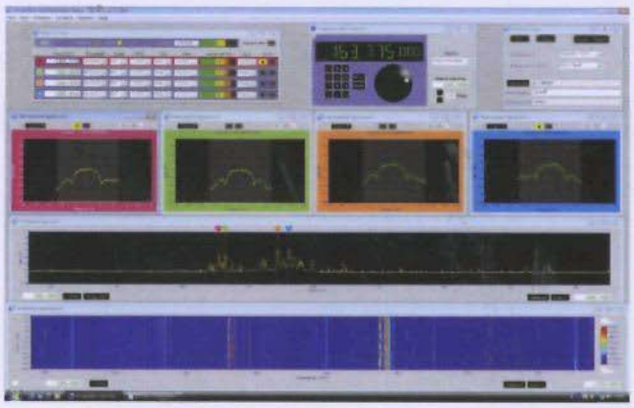
AGS Graphical User Interface examples

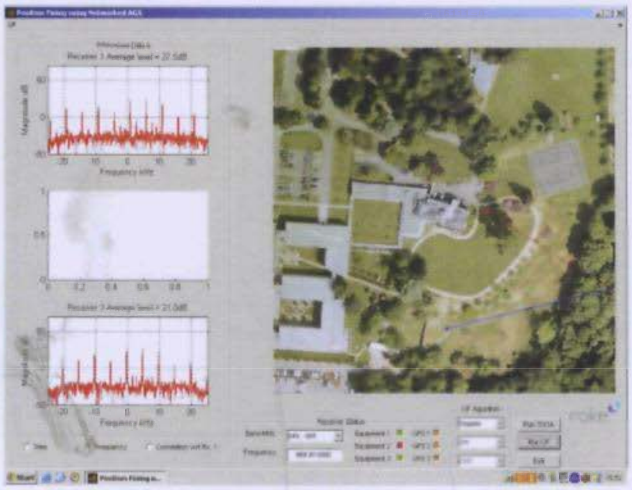
- 4x Digital Drop Receiver (DDR) controls including live audio and recording handoff
- Frequency/Band entry & Virtual Tuning Wheel - USB controlled ergonomic tuning wheel available
- Intuitive .WAV recorder with 'auto-record'
- Wideband spectral & waterfall displays c/w 4x Narrowband DDR channel FFT displays



Example - Wideband V/UHF spectral survey with DDR & DF handoff

Example - Monitoring and handoff of UHF FM channels (note 'zoomed' spectral display)

GSM survey (further details on application)



Networked AGS Nodes performing DF & Geolocation

For further information please contact:

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
es@roke.co.uk
www.roke.co.uk

locate

MCDWR16

Multi-channel Digital Wideband HF Receiver System

roke

Roke Manor Research Ltd
a Siemens company

Features and benefits

- Up to 9 Digital Wideband Receiver cards packaged in a small form-factor, 19" 2U high case
- Simultaneous monitoring of up to 36 HF channels
- Supports 4 frequency channel simultaneous DF using up to 9 antennas
- External clock input
- Fully synchronous operation
- Two units may be linked together
- USB2.0 control
- Windows®-based GUI and API

Description

The unit can be configured for different roles. When operating as a bank of 36 independent HF receivers, the 9 receiver cards are tuned independently. When operating as an "N-Channel" DF receiver, the 9 receivers are tuned phase coherently for use in adaptive array applications, allowing up to 4 simultaneous frequency channels.

The individual Digital Wideband Receiver cards digitise the 500 kHz to 30 MHz band of spectrum from separate RF inputs and subsequently down-convert 4 programmable narrowband channels to complex base-band.

Two multi-channel receiver units may be connected together to form systems with up to 72 independent narrowband channels or 18 coherently tuned receivers (with 4 separate narrowband frequency channels per receiver).

The multichannel receiver is designed to be controlled by software running on a Windows® PC. Receiver control commands to and data from the unit are transferred via an industry-standard USB 2.0 interface. The digitised signal data from each receiver card is multiplexed onto a single data stream and transferred to a PC.

Applications of the multi-channel receiver include standard HF receivers and direction-finding and beamforming applications.

Receiver Functions

The features of the receiver cards are covered in the DWR16 datasheet. Features specific to the multichannel system are:

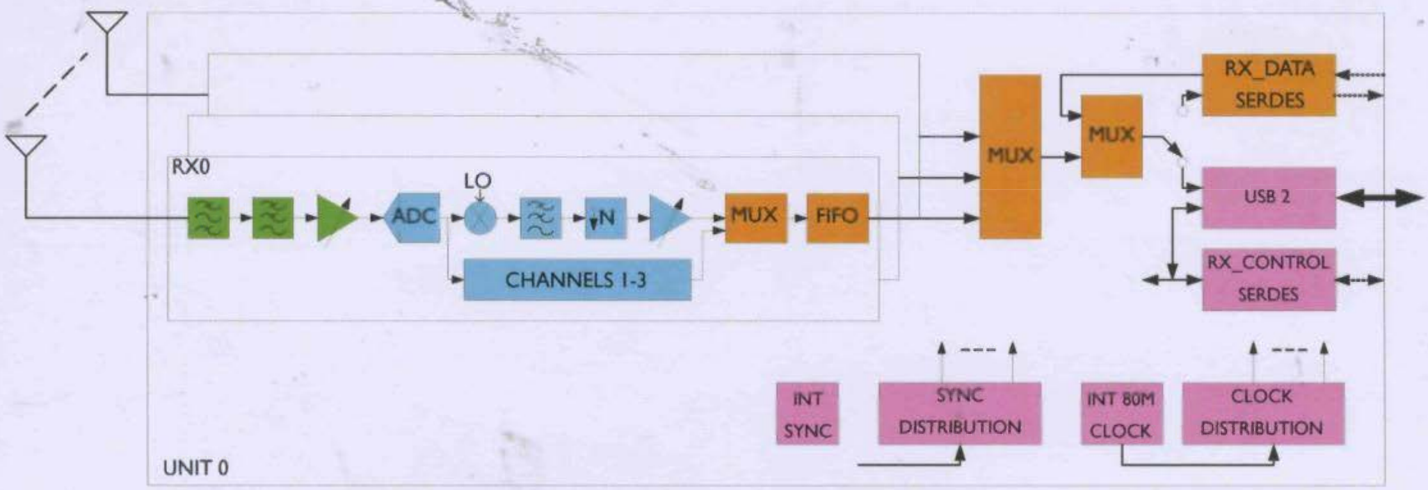
- Coherently sampled receivers permit either independent or coherent tuning.
- Internal or external clock options.
- External synchronisation input for GPS 1pps signal or other hardware sync signal.
- Clock and sync distribution extendable to support second multi-channel receiver unit.
- Control and data channels to/from second multi-channel receiver unit.
- Ganged or independent analogue gain control of the receiver input signals.
- Ganged or independent digital gain control of the narrowband signals.

Software

The MCDWR16 is supplied with Windows® software to operate the unit as 36 independent receivers. This allows full control of all receiver settings and provides narrowband filters together with demodulation support for AM, FM, CW, USB, LSB, ISB and I/Q. I/Q mode allows third party demodulators to operate on the data. Audio output to PC soundcard or WAV file is supported. All 36 channels may be recorded at the same time. All 36 channels are represented by frequency and level, whilst 4 channels at any one time are also presented as narrowband spectrum plots.

DSG 2009

Block Diagram



Example Graphical User Interface

Example GUI displaying four of the 36 simultaneous 'live' channels

Customisation

An optional high speed interface card provides two 2.5 Gbits/s serial links to a DSP board for processing received signal data. This allows the receiver cards to be operated at bandwidths up to 1.25 MHz. Thus it is possible to digitise 5 MHz blocks of spectrum on each receiver. Configuring the unit with 8 such cards would offer 40 MHz of spectrum coverage. A 9th card could be operated independently in single DWR16 mode with its own USB2 stream to allow wideband spectrum monitoring.

An Application Programmer's Interface (API) is available, allowing full control of the multichannel receiver and extraction of the demultiplexed and filtered data.

This unit is used as part of Roke's N-Channel Superresolution DF system.

This unit, together with the high speed interface, is used as part of Roke's High Speed Wideband Superresolution DF system.

Specifications

Detailed specifications of the receiver cards appear in the DWR16 datasheet. Specifications specific to the multichannel system appear below.

Internal clock:	80MHz
External clock:	10MHz, 0 dBm into 50Ω
Signal inputs:	1 RF input per receiver, 50 Ω
Configuration:	9 receivers, 4 narrowband channels per receiver, 37 kHz complex base-band (16bit I, 16bit Q) from hardware, additional filtering in the control software provide bandwidths from 56 Hz to 32 kHz
Dimensions:	448mm x 90mm x 315mm (19", 2U high)
Power:	110 – 240VAC, 35W

For further information please contact:

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
es@roke.co.uk
www.roke.co.uk

resolve

AGS (single channel)

Acquisition & Geolocation Sensor

roke

Roke Manor Research Ltd
a Siemens company

Features and benefits

- Receiver configuration for spectrum monitoring
- Optimised for modern commercial waveforms
- HF/VHF/UHF/SHF operation is continuously tuned from 1-3000MHz
- 37.5MHz 'Wideband Stepped Stare' architecture
- Simultaneous monitoring and display of four tuned channels (Narrowband Digital Drop Receivers)
- Standard demodulation modes include: AM, FM, SSB, CW
- Enhanced modes include GSM and WCDMA (WCDMA with DSP module option)
- Low power (<6W) with single 12v supply – ideal for man-portable & vehicular based applications
- Standard USB2.0 interface for data and control
- Windows®-based GUI and API
- Integrated GPS provides location, clock conditioning and time stamping
- Optional single board micro PC for autonomous operation and control via network interface
- Small size 60x180x260 mm
- AGS weighs 3.9kg

Front view - DF/Monitoring, GPS & auxiliary antenna input

Example AGS Sensor operator GUI

Description

Acquisition and Geolocation Sensor (AGS) is a single channel, wideband receiver, optimised for intercept of modern commercial waveforms i.e. PMR, GSM, WCDMA and Sat-phones. It provides continuous coverage from 1-3000MHz.

Due to the wideband nature of the receiver, it can support up to 37.5MHz instantaneous bandwidth providing capability against frequency hopping signals such as GSM as well as supporting other modern wideband waveforms.

Description (cont.)

The wideband digitiser in AGS employs the latest generation of 16 bit, high dynamic range, wideband ADC's.

In addition to the inherent wideband digitisation, the receiver offers 4 digital down converter (DDC) channels. There is also a powerful onboard FPGA if, for example, FFT processing is required.

A small integral GPS module provides for three functions: 1) position location of the AGS unit 2) local oscillator/clock conditioning and 3) precision time stamping of the data to a few ns. The time stamping feature is employed when TDOA geolocation is being employed from multiple AGS units.

The AGS units are designed to interconnect on a standard IP network.

The IP network backbone can be provided either by a wired system or via a wireless mesh network employing say Wimax or satellite links.

AGS units can perform single receiver channel geolocation techniques such as TDOA and FDOA.

For ease of use, AGS provides a standard USB 2 interface for control and data transfer to say a local PC. In addition AGS can be fitted with an internal micro PC running full Windows XP operating system. In either case the PC is used for the standard signal processing, digital filtering, TDOA, demodulation and control. For specialist signal processing an additional DSP solution is available.

AGS is both high performance and low power. The total AGS unit requires only 6 watts from a 12 volt supply when fully operating, however, a sleep mode is also available.

The 37.5MHz instantaneous bandwidth allows for a wideband stare across a band to capture short duration hopping signals.

AGS is ideally suited to narrowband operation for PTT intercept and geolocation. In this instance initial intercept can be provided by a 4K point FFT in the internal FPGA. Multiple signals can then be handed off to the 4 DDC's and processed simultaneously.

Wideband Capture

The receiver employs the latest 16 bit ADCs and is able to digitise 37.5MHz of spectrum at high resolution. This IQ data can be transferred via USB2 or Ethernet. The wideband capture enables advanced surveillance monitoring and capture of transient, frequency hopping or other LPI transmissions.

Stored IQ data can be replayed and post processed using any of the filter bandwidths or demodulators.

Receiver Operation

The single receiver can be operated in the following ways:

- Monitoring of 4 different frequencies within a single band
- Capture of a 37.5MHz segment within same band
- TDOA when part of a network of AGS units

The AGS has a high quality internal TCXO frequency reference but the option to use an external 80MHz input is also provided. The TCXO can be locked to GPS for high accuracy applications.

Control Interfaces

Control of all receiver and down-converter settings is via a USB2 interface on the motherboard. The single board computer, if fitted, also uses this USB2 interface, and may communicate outside the AGS box via an Ethernet LAN connection.

Windows® GUI

A Windows® based application is available which is designed to run on an external computer connecting to the USB2 interface on the AGS. It provides a user-interface for a single receiver configuration. It allows control and signal processing of the received signals. The following functions are available:

37.5MHz Wideband channel

- Attenuator: automatic or manual mode (0dB to –31dB in 1dB steps)
- Signal level reporting

Narrowband channels

- Maximum 4 channels available concurrently, each tuneable anywhere within wideband channel
- 1Hz tuning resolution
- Bandwidths: 32kHz to 56Hz with 74 bandwidths
- Demodulation: I/Q, AM, USB, LSB, ISB, CW, NBFM
- Gain control: automatic (fast medium slow) and manual (6dB steps)
- Signal level
- Audio output level control: automatic or fixed (2 settings)
- Audio output
- Recording: I/Q or demodulated signal in .wav format.

The spectra of the wideband and four narrowband channels are displayed with pan, zoom and cursor-driven signal level measurement functions. A wideband waterfall display allows users to see the longer term trend.

The application permits tuning of the narrowband channels by numerical entry, using the virtual-wheel, keyboard up/down, mouse-wheel or by clicking on a signal of interest in the wideband display and handing-off to the selected narrowband channel.

Additional signal types supported

The four tuned channels support all common modulation schemes including AM, NBFM, SSB, CW. The digitiser receiver cards can, however, also be programmed to support a much wider bandwidth e.g (200kHz) to support GSM, and higher still (4MHz) for WCDMA.

Receiver API

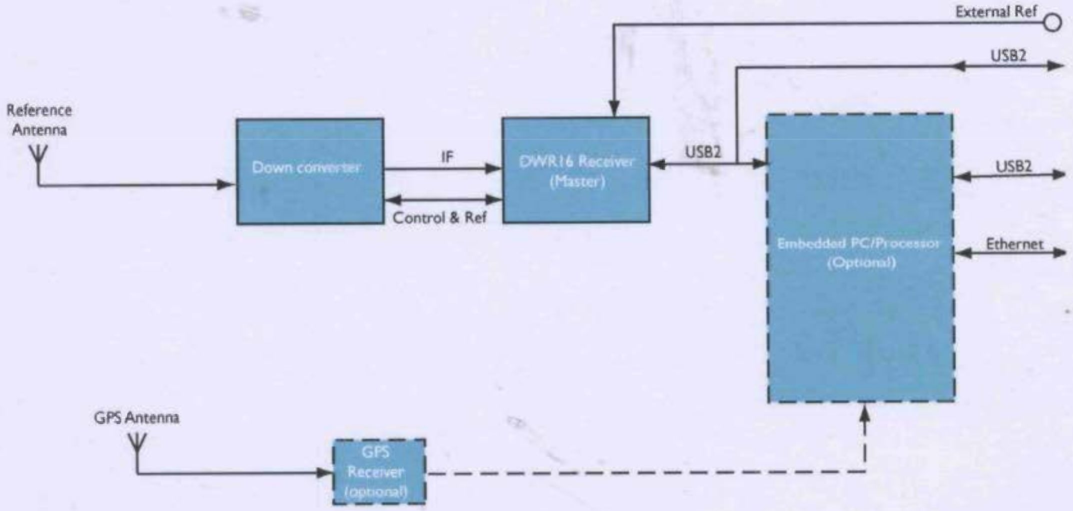
A Windows® DLL is available which can be linked with a customer application allowing control of and data access from the AGS. The DLL can operate the equipment with one or both receiver and down-converters present.

LAN network options

When the micro PC is fitted to the AGS, a data collecting program can be run which allows control of and presents raw data from both receivers over the standard Ethernet interface. This network format data can be saved to disk or connected to the single receiver GUI remotely. A MATLAB interface is also available allowing full control and intermittent real time processing. The AGS can be connected to any standard IP network either wired or via mesh network employing for example, WiMAX or satellite links.

For use with low data rate networks, e.g. GPRS or Satellite), the AGS unit when fitted with the SBC can be commanded to collect data, analyse and present results in order to reduce network loading.

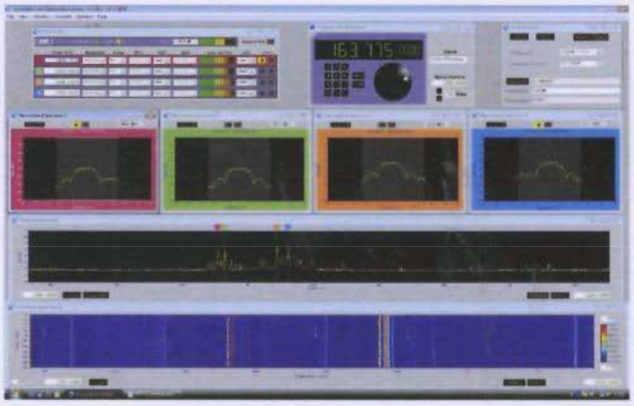
Block Diagram



DSG 2005

AGS Graphical User Interface examples

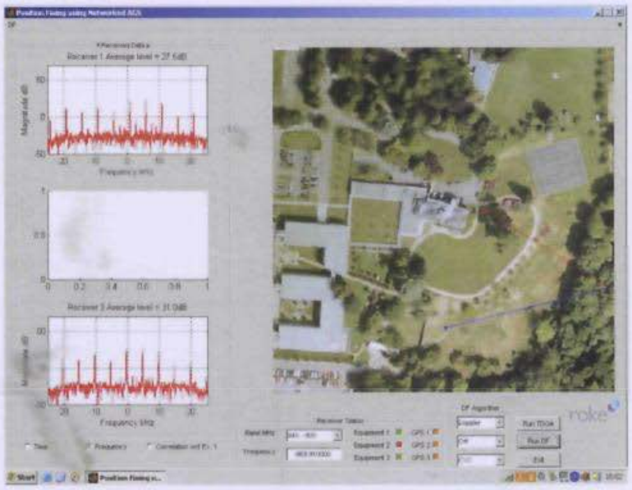
- 4x Digital Drop Receiver (DDR) controls including live audio and recording handoff
- Frequency/Band entry & Virtual Tuning Wheel - USB controlled ergonomic tuning wheel available
- Intuitive .WAV recorder with 'auto-record'
- Wideband spectral & waterfall displays c/w 4x Narrowband DDR channel FFT displays



Example - Wideband V/UHF spectral survey with DDR

Example - Monitoring and handoff of UHF FM channels
(note 'zoomed' spectral display)

GSM survey (further details on application)



Networked AGS Nodes performing Geolocation

For further information please contact:

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
es@roke.co.uk
www.roke.co.uk

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DWR16

Digital Wideband HF Receiver

Features and benefits

- Simultaneous monitoring and display of four HF channels and full HF spectrum
- Four independent receiver channels tune over entire HF band
- IF filters – wide range from 56Hz to 32kHz
- Compact package – ideal for portable applications
- Very low power consumption - 3.5W
- Low cost per channel
- 256K sample buffer capturing snapshots of the wideband spectrum
- Concurrent audio recording of all channels
- USB2.0 control
- Windows®-based GUI and API

Description

The DWR16 employs state-of-the-art A/D conversion to directly digitise the entire HF spectrum. The digitised spectrum is then fed to a digital down-converter that simultaneously provides in-phase and quadrature (I/Q) base-band representations of four independently tuned narrowband channels. These channels are routed to a PC or laptop via an industry standard USB2.0 interface for further IF filtering, signal demodulation, spectrum display and audio routing. Together with the four narrowband channels, rapidly updating snap-shots of the digitised HF spectrum are routed to the PC for wideband spectrum monitoring functions.

Advantages over conventional narrowband HF receivers

- Very low oscillator phase noise
- High linearity with low power consumption.
- No images or interference from local analogue oscillators/mixers
- Excellent gain and phase matching when used in multi-receiver systems such as beam forming and direction finding (see the Roke MCDWR16 datasheet for more details)

Receiver Functions

The DWR16 is supplied with a Windows® – based application providing a user-interface for receiver control and signal processing of the received signals. The interface displays and controls the following functions:

Wideband channel

- Attenuator: automatic or manual mode (0dB to −31dB in 1dB steps)
- Signal level.

Narrowband channels

- Centre frequency: 0 to 40MHz with 1Hz resolution)
- Bandwidth: (32kHz to 56Hz incremental)
- Demodulation (I/Q, AM,USB,LSB,ISB,CW,FM)
- Gain control: automatic (fast medium slow) and manual (6dB steps)
- Signal level
- Audio output level control: automatic or fixed (2 settings)
- Audio output
- Recording: I/Q or demodulated signal in .wav format.

The spectra of the wideband and four narrowband channels are displayed with pan, zoom and cursor-driven signal level measurement functions. A wideband waterfall display allows users to see the longer term trend.

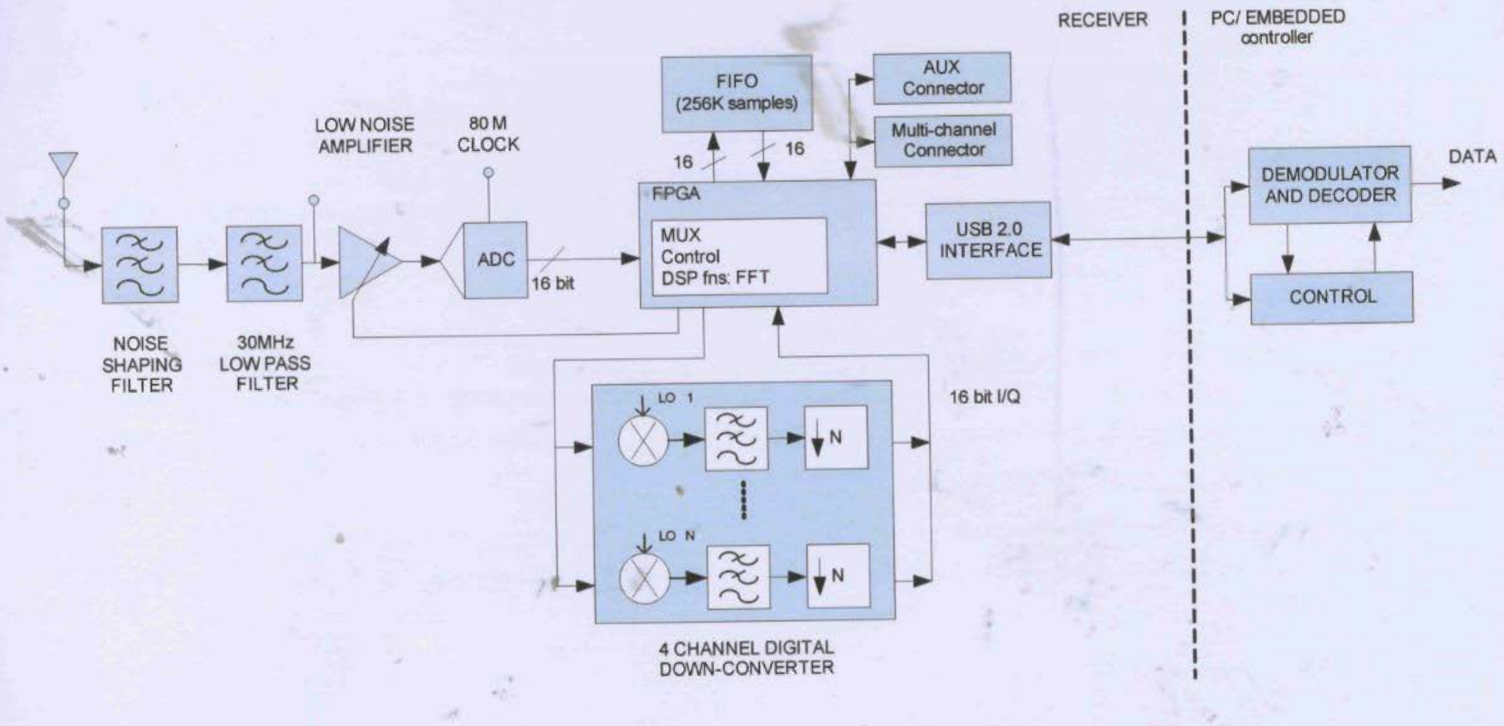
The application permits tuning of the narrowband channels by numerical entry, using the virtual-wheel, keyboard up/down, mouse-wheel or by clicking on a signal of interest in the wideband display and handing-off to the selected narrowband channel.

Customisation

An Application-Programming-Interface (API) is available for users wishing to develop their own custom control and signal processing software. The receiver hardware and API provide flexible support for narrowband channels with broader bandwidths than the 32kHz available in the application. The number of narrowband channels and channel bandwidths can be varied subject to the total available bit rate of the USB2.0 connection. For example, the receiver can be configured to provide a single 1MHz channel or four 250 kHz channels.

Similarly the receiver can be configured to provide a lower number of narrowband channels and a higher wideband update rate up to 18.4Hz (4.9kHz resolution).

Block Diagram



DWR-16 GUI example (User-defined layout):

- Multiple display layouts – User-definable to suit Operator's bespoke needs
- Wideband spectral display
  - In this User-defined example, showing 9-11MHz WB tuned strobe
  - showing frequency markers for User-allocated Narrowband Digital Drop Receivers (DDR)
  - Manual handoff capability to HFDF system
- Wideband waterfall display
  - in this User-defined example, showing full 3-30MHz HF spectrum (full span 100kHz – 30MHz)
- 4x Narrowband Digital Drop Receiver (DDR) channel FFT displays for NB stare on 4 discrete freqs.
  - Manual handoff capability to HFDF system
  - Channel power measurement
- DDR control interface
  - Frequency, Bandwidth, Mode, BFO, AGC, Audio, Record options for each DDR
  - live audio and recording handoff
- Frequency entry & Virtual Tuning Wheel
  - USB controlled ergonomic tuning wheel available
- Intuitive .WAV recorder with User-defined 'auto-record' capability

DSG 2009

Specifications

Frequency range	9kHz to 35MHz (reduced performance for <500kHz and >30MHz)
Frequency resolution	1Hz
Frequency accuracy	+/- 1ppm typ, +/- 4.6 ppm over temperature and 20 year aging.
External reference (option)	80MHz
Phase noise	-135dBc/Hz at 1kHz offset
Antenna input	SMA, 50 Ω
VSWR	< 2.0:1, <1.5:1 typ.
Input level	≤ -13dBm at max sensitivity ≤ +17dBm at min sensitivity
Max input level (non destructive)	+30dBm
Preselection	30MHz low-pass filter
Input attenuation	Automatic or manual, 31dB range, 1dB step
ADC resolution	16 bits
Number of narrowband receiver channels	4
DDC aliasing suppression	>90dB, 110dB typ.
Spurious signals	< -92dBm typ. (input: -14dBm tone, max sensitivity)
2nd order intercept point (at max sensitivity)	> +60dBm, f ≥1MHz > +50dBm, 500kHz≤f< 1MHz
3rd order intercept point (at max sensitivity)	> +23dBm, 1MHz ≤f≤ 30MHz > +15dBm, 500kHz ≤f< 1MHz

Noise figure	< 16dB at max sensitivity
Demodulation modes	AM, FM, CW (IF bandwidth ≤16kHz), USB, LSB, ISB, I/Q
IF bandwidths	74 filters : 56Hz to 32kHz
Shape factor (3dB/60dB)	< 1:1.2
Gain control	Automatic (fast, medium, slow) manual (-18dB to +72dB in 6dB steps)
Wideband spectrum update rate	1.15Hz (302Hz resolution)
Analogue audio audio	O/P from PC/laptop
Control and data interface	USB2.0 (High Speed)
Operating temperature range	0°C to 50°C
Storage temperature range	-40°C to +70°C
Humidity	< 95% non-condensing
Power supply	+5.0V DC (+/- 5%)
Power consumption	3.5 W
Size	98 x 218 x 38mm (W x D x H)
Weight	750g
PC/laptop requirements	1.6GHz Intel® P4 or better, Windows® 2000 / XP, USB2.0 (High Speed)
Software	Control and demodulation application, API available on request
Accessories	AC Universal input power supply, USB2.0 cable

For further information please contact:

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
es@roke.co.uk
www.roke.co.uk

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Superresolution Direction Finding (SRDF) & Adaptive Digital Beamforming (ADBF)

Features and benefits

- DF multiple signals within receiver bandwidth
- Real-time Azimuth and Elevation results
- Network enabled Client/Server operation
- Accurate Position Fixing of HF transmissions
- Single Site Location (SSL) Position Fixing techniques
- Supports numerous receiver hardware configurations via dedicated data servers
- Advanced published DF and signal separation algorithms
- Extensive display options - field proven accuracy
- Strategic and Tactical operations
- Discrimination between groundwave and skywave

Introduction

Over the last decade Roke has established itself as a world leader in advanced Superresolution DF (SRDF) systems and associated Adaptive Digital Beamforming (ADBF) techniques for enhanced signal reception (E-Copy). Recent developments in Higher Order Statistics algorithms offer new further approaches to both DF and ADBF.

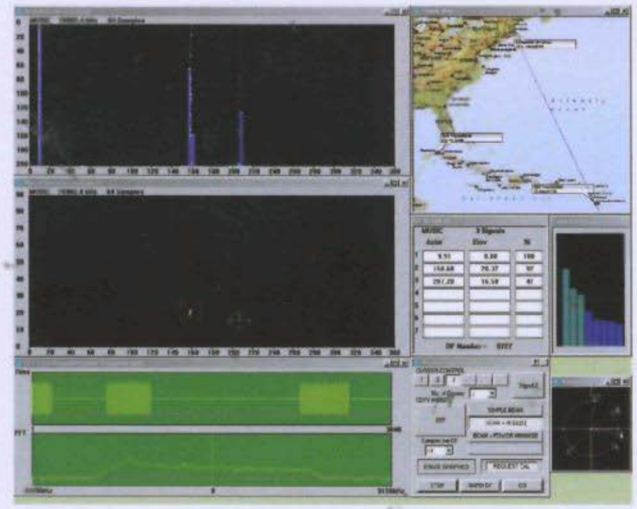

Figure 1: Roke SRDF Graphical User Interface

Roke SRDF systems are in operational use at a number of locations around the world. These have been primarily new installations but some have been to provide mid-life upgrades. For example, to the AX- 19 'Pusher' HFDF Circularly Disposed Antenna Array (CDAA) system.

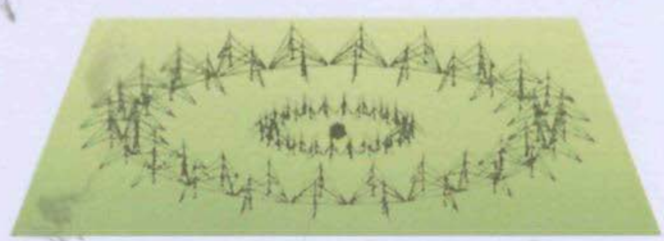

Figure 2: AX-19 'Pusher' HFDF CDAA

This Roke technology demonstrates excellent performance and is regarded by International End-Users as providing the highest standard of Direction Finding, Digital Beamforming and Geolocation capability.

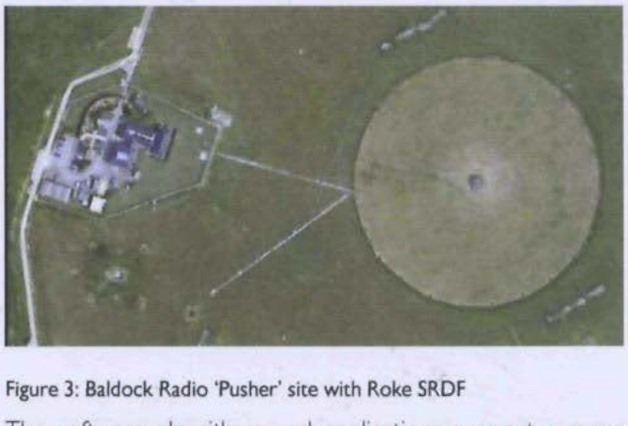

Figure 3: Baldock Radio 'Pusher' site with Roke SRDF

The software algorithms and applications support a range of COTS 'N' Channel, Phase-Coherent HF Receiver systems, including the Roke MCDWR16 for HF and higher bands using downconverters.

Figure 4: Baldock Radio Operations Centre with Roke SRDF (image courtesy of Baldock Radio Station)

Why Superresolution?

The term Superresolution implies the ability to resolve two or more signals whose angular separation is less than the natural beamwidth of the array. Superresolution algorithms also offer other advantages:

- ability to handle multiple signals
- operation with very few samples
- not fixed to particular array geometries

Figure 5: High-Band Section of 'Pusher' HFDF CDAA

Initial processing typically correlates the I/Q data from each element with that in every other element, to form the data covariance matrix. This contains a complete description of the incident signal environment. The algorithms then determine the numbers of signals present, and using a knowledge of the array geometry, estimate the azimuth and elevation bearings of each signal, see Figure 5.

Software Architecture

To accommodate different multichannel receiver types, the SRDF / E-Copy software is split into a Data Server and a DF Processor. Different Data Servers are produced for each receiver, whilst the DF processor is receiver independent, see Figure 6. DF and E-Copy results from the DF Processor are displayed on its own GUI, but are also made available over a network connection to a third party application. The format of all the commands and results returned is recorded in an Interface Control Document (ICD), to help with development of control clients. These interfaces have been successfully used by a number of companies.

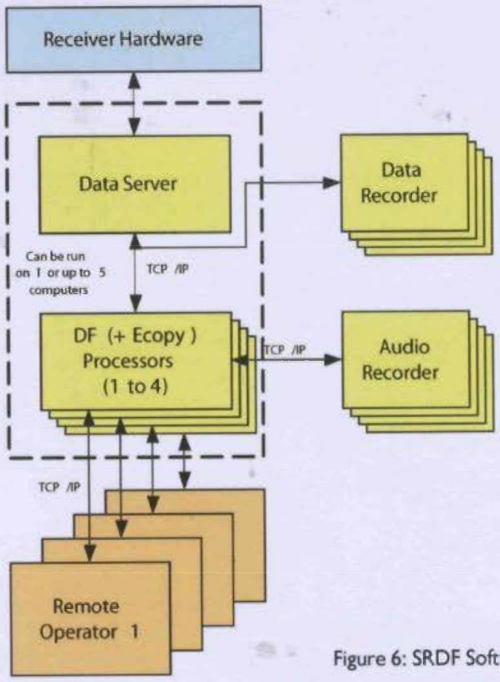

Figure 6: SRDF Software Architecture

DF Algorithms

The MUSIC (MUltiple SIgnal Cancellation) algorithm is a widely recognised Superresolution algorithm capable of finding the directions of multiple signals (although not fully coherent signals). The technique is resilient to jamming and de-correlated multipath since they just look like additional, independent signals. The performance tends to degrade in the presence of strong, correlated multipath. DF results and subsequent beam steering are in terms of both azimuth and elevation.

ADBF Options

The software has several Adaptive Digital Beamforming options to enhance the output audio of the chosen signal (E-Copy).

Figure 7: Ix element of Roke 8-Element HFDF Array incorporating Roke Compact Crossed-Loop (Central Europe)

(1) Simple beam – a conventional unweighted beam is formed in the direction of the wanted signal. For an N element array this will provide a signal to noise improvement of up to 10log(N). The beamwidth for typical HF arrays is some 10° to 40° and so beams are easily directed accurately enough to achieve full gain. However, the sidelobes of these beams are relatively poor and thus offer little protection to interference signals.

(2) Beam plus nulls – a beam is formed in the wanted signal direction, whilst introducing nulls in the pattern in the direction of interference signals. Again the accuracy of the direction estimate for the wanted signal direction is not that critical, however, the accuracy needed to provide deep nulls requires great precision. To provide 40dB nulls requires the phase and amplitude weights to be correct to around 1 degree of phase and 0.2 dB of amplitude. Even on a good antenna site it is not possible to characterise the array manifold to these accuracies and thus only modest nulling of say 15 to 20 dB is possible in practice. This level of interference rejection can still be very valuable when the interference is of a similar level to the wanted signal.

(3) Beam plus power minimise – this method works well when the interference is considerably stronger than the wanted signal. A gain constraint is imposed upon the ADBF algorithm to maintain gain in the wanted signal direction, whilst minimising power in all other signals. If the constraint direction is accurate then the wanted signal will be maintained whilst very deep adaptive nulls are directed towards the interference. With this algorithm it is possible to recover wanted signals buried some 40dB in interference. If there are errors in the wanted signal constraint, the wanted signal may also be minimised, and thus for this case the previous 'beam plus nulls' algorithm is more appropriate.

(4) HOS based ADBF Algorithm – this is a method of signal separation based upon the statistics of the signal rather than being driven from the DF results. The Roke implementation is based on the Public Domain algorithm JADE. The general principal of the algorithm is to analyse the 2nd order and 4th order statistics of the multi-channel data, to provide sufficient unique measures to extract the individual source signals. DF results are extracted from the steer vectors used by the HOS algorithm. The main restriction of this algorithm is that it only works well with non-Gaussian signals.

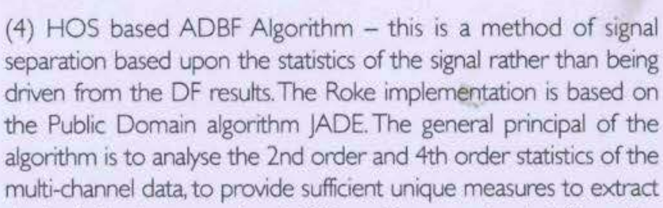

Figure 8: SRDF flow diagram showing receiver input through to bearing and audio outputs

DF Processor GUI

The DF Processor Graphical User Interface (GUI) has a main control panel, diagnostic plots and number of display views including a map. The basic controls allow the user to connect to and control the receiver and select the signal counting technique and E-Copy modes. The software can automatically estimate the number of signals present, or the user can apply thresholds or adopt a fixed count.

DF azimuth and elevation direction results can be viewed in 2D as a scatter plot with tracking cursors, or as an azimuth scan waterfall showing result history.

The 3D surfaces produced by the MUSIC algorithm may also be viewed in order to assess the quality of the results.

Detailed receiver data FFT displays and oscilloscope-like plots of the extracted audio help identify signals. Plots include a scrolling spectrum (waterfall)

The resulting lines of bearing can be overlaid on a map to help identify the location of signals. By coordinating DFs at multiple sites, emitters may be localised. Roke has enabled OFCOM (formerly the UK Radiocommunications Agency) to link its HF Direction Finding site at Baldock (central UK) into the European CEPT network for this purpose.

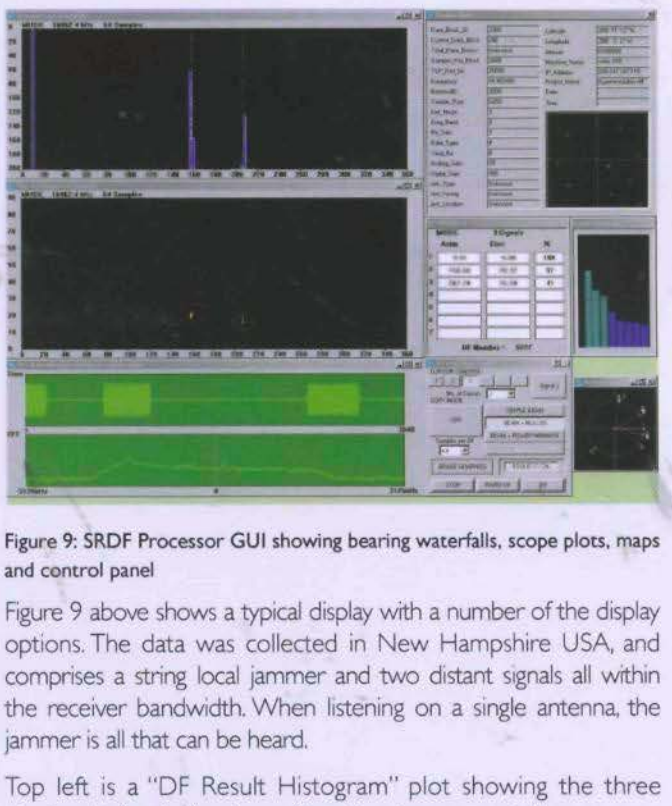

Figure 9: SRDF Processor GUI showing bearing waterfalls, scope plots, maps and control panel

Figure 9 above shows a typical display with a number of the display options. The data was collected in New Hampshire USA, and comprises a string local jammer and two distant signals all within the receiver bandwidth. When listening on a single antenna, the jammer is all that can be heard.

Top left is a "DF Result Histogram" plot showing the three dominant signal directions (the blue bars grow taller as more results fall consistently in that direction).

The display centre left is an "Azimuth Elevation Graph" showing a scatter plot of results. The local jammer is at 0° elevation around 10°, an FSK signal just above 20° elevation at 160° azimuth, and a Morse code signal just below 20° at 205° azimuth.

The display at the bottom on the left shows a "Scope Plot" of the Morse code signal. The signal is very clean and was interpreted by machine and human readers. The same signal could not be heard when switching back to a single antenna.

As there are currently 3 "cursors" (using a threshold counting method) active, the 3 signals are correctly being tracked and the three signals were cleanly heard using the "beam plus nulls" or "beams plus power minimise" E-Copy algorithm.

The map shows the Lines of Bearing plotted. Each respective LoB successfully intersects the known locations of each transmitter prosecuted in this scenario.

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Operational example:

Discrimination between groundwave and skywave transmissions

Specific User communities may, as an example, wish to rapidly discriminate between local, low power groundwave transmissions and higher power, long-haul skywave transmissions on the same frequency. In this example, the groundwave of a nearby low power tactical HF transmission, on a Line of Bearing of 180 degrees from the HFDF array, is being received on a frequency of 17807 kHz, but the skywave components of other transmissions on the same frequency are interfering with the User's monitoring of the groundwave tactical HF transmission.

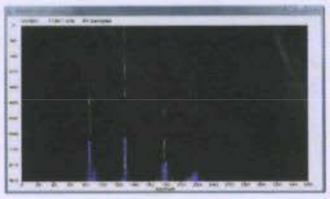

Figure 10: SRDF algorithms applied to 17807kHz showing 4 diverse signals on same frequency (azimuth vs time plot)

Without Super-Resolution Direction Finding (SRDF) and Adaptive Digital Beam-Forming (ADBF), it is difficult for the User to monitor and DF the Signal of Interest. However, once SRDF and ADBF algorithms are applied, the User can then rapidly determine that, in this example, his local Signal of Interest (i.e. groundwave) is on a Line of Bearing of 180 degrees, whilst the interfering skywave transmissions are on other Lines of Bearing from the HFDF array. Application of Roke ADBF algorithms to Signal 4 (see figure 11 below) then allows the groundwave Signal of Interest to be isolated for further processing. Note that Signal 4, on a low elevation, is visually discriminated as groundwave.

Conversely, similar techniques and procedures can be employed to instead reject local HF groundwave transmissions, whilst simultaneously enhancing distant skywave transmissions as required.

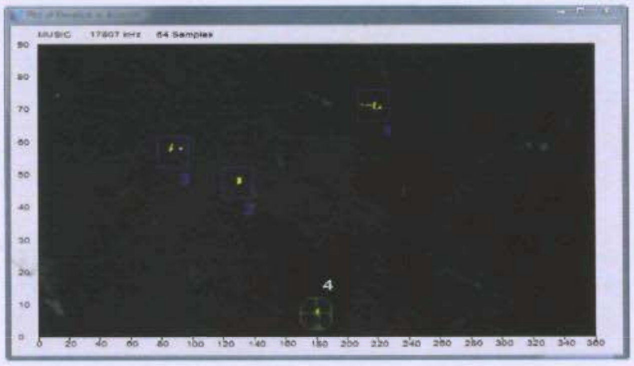

Figure 11: ADBF algorithms applied to 17807kHz – Enhanced Copy applied to Signal 4 (azimuth vs elevation plot)

Specifications

Parameter	Specification
Frequency Range	5kHz to 30MHz
Maximum Bandwidth	50kHz
Demodulation Modes	CW, FM, USB, LSB, ISB, AM
Number of Receivers supported (N)	3 to 16
DF Algorithm	MUSIC
DF Rate	100 DFs/s
DF Accuracy (Hardware dependant)	<1°
Number of Simultaneous signals in band	N-1, maximum 7
Azimuth Coverage	Full 360°
Elevation Coverage	0° to 90°
Samples per DF	64
ADBF Algorithms	4
Number of Beams/Nulls	6
Simple Beam Interference suppression	<9dB SINR
Simple Beam plus Nulls Interference suppression	<20dB SINR
Beam plus power minimise Interference suppression	40dB SINR
HOS Algorithm Interference suppression	40dB SINR
FFT Size (Spectrum)	1024 point
FFT Rate (Spectrum)	10 per second
PC Platforms Supported	Intel Pentium 4 or better
Operating Systems Supported	Microsoft Windows®

Ordering Information

Part: SRDF Number: X72/TB/2502/50
Part: SRDF E-Copy Number: X72/TB/2502/60
Part: SRDF HOS E-Copy Number: X72/TB/2502/70
Part: MCDWR_Server Number: X72/TB/2502/40

For further information please contact:

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
es@roke.co.uk
www.roke.co.uk

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Acoustic Sensing – An Essential Battlefield Capability

A White Paper

by

Dean Thomas, Steve Massie
Roke Manor Research Ltd

dean.thomas@roke.co.uk
steve.massie@roke.co.uk

PO 1-20

Abstract

Acoustic sensing in defence applications is often mistakenly viewed as either 'low tech' and hence 'easy', or as not sufficiently reliable to be of practical use. In reality the utility of system such as HALO® in real areas of conflict has demonstrated that acoustic sensing is more than reliable enough to bring significant military benefits.

This paper seeks to discuss the ways in which acoustic sensing can be used in the modern battlespace in the multiple roles of force protection, target acquisition and situational awareness. The strengths and weaknesses of acoustic sensing in each role against a range of threats and in a range of environments are considered.

Overview

In the modern theatre of conflict, the threats presented to the soldier are agile, easily hidden and difficult to detect. A mortar attack from beyond a hillside, sniper fire from a concealed location, rocket attacks where the assailants deploy, launch and move on rapidly, and machine guns used to ambush helicopters. All these threats present challenges even to a sophisticated and well-equipped armed unit.

The challenge is compounded further when the soldier's senses and the sensor systems given to the soldier are impeded by the environment. A foot patrol under sniper fire when a dust storm or fog makes spotting muzzle flash impossible has no way to know in which direction to return fire. A helicopter pilot, in the noisy environment of the cockpit, may not even know he is under fire.

The more sophisticated threats at which detection technologies such as radar are primarily targeted can still be concealed under many circumstances. A helicopter can hover low enough to be concealed behind trees and only 'pop-up' to engage its target.

Humans in common with most other species of higher animal utilise multiple senses to give them the situational awareness they need to protect themselves and to hunt. Any system or system of systems designed to enhance situational awareness and to aid the modern soldier should use such a multi-modal sensing approach.

Second only to sight in the human sensory armoury is our sense of hearing. Acoustic detection is so markedly different from other forms of detection - which predominantly rely on sensing some range of the electromagnetic spectrum - that it can perform a unique role in complementing these other forms of detection. In fact there are some circumstances where acoustic sensing may be the only way to detect a threat.

Just as electronic sensors have extended the limited bandwidth of man's sight beyond the visible range, acoustic sensors can listen well outside the human range of hearing. The use of microphone arrays can greatly improve the signal to noise ratio that might be presented to a human listener. The use of arrays of microphones and appropriate processing can locate the source of a sound to a greater degree of precision than can be achieved by any animal.

This paper seeks to discuss the ways in which acoustic sensing can be used in the modern battlespace in the multiple roles of force protection, target acquisition and situational awareness. The strengths and weaknesses of acoustic sensing in each role against a range of threats and in a range of environments is considered.

Although acoustic sensing can be very effective in isolation for some roles, in other cases it may be most effective when combined with other sensory systems. In particular the combination of acoustic and optical sensing has the potential to yield a capability that is significantly more than the sum of its parts. Roke is ideally placed to explore this combined capability given its strengths in both acoustic detection and location and vision processing, as well as data fusion.

The Acoustic Battlespace

The battlespace from an acoustic sensing perspective can be characterised by a range of threats and a number of environments. The threats are predominantly either weapon types or vehicles. The environments experienced by a sensing technology are dictated by meteorological conditions, terrain, ground cover, noise etc. One factor that greatly influences the environment experienced by a sensor is the platform on which it might be deployed. The noise environment of an Unattended Ground Sensor (UGS) is notably different from that of sensors mounted on an aircraft, for example.

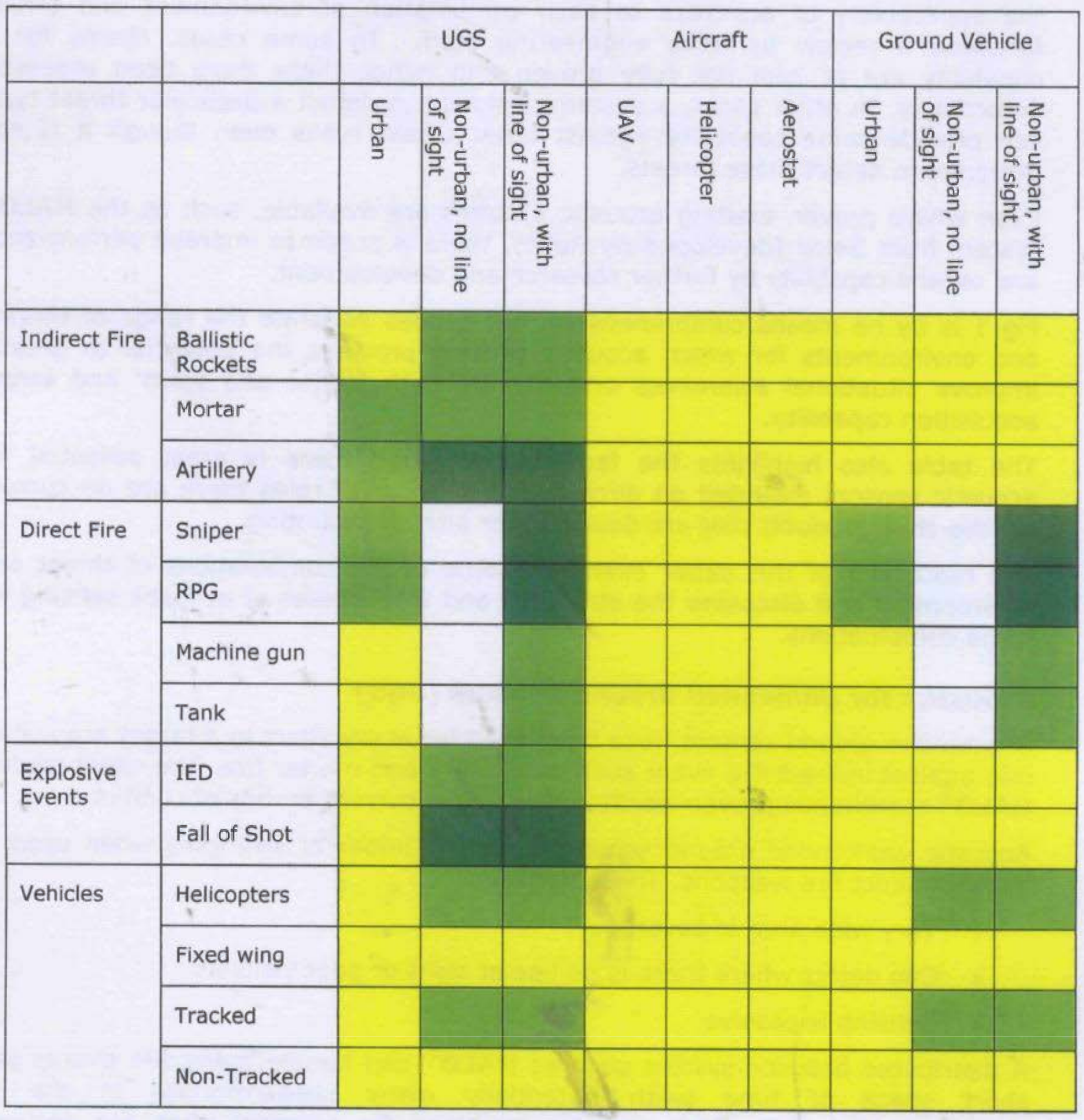

Fig 1 Applicability of acoustic sensing to threats and environments

	Not applicable
	Potential capability but no identified product
	Existing products provide limited capability but enhanced capability feasible
	Existing products provide useful capability

Fig 1 lists a number of threats (rows) and environments (columns) and indicates the applicability of acoustics to each combination of environment and threat following a review by Roke engineering staff. In some cases, claims for a capability are at best not fully proven and hence these have been assessed accordingly. In other cases, a system designed to detect a particular threat type can provide some capability against other threat types even though it is not designed to detect those threats.

Even where proven existing acoustic systems are available, such as the **HALO®** system from Selex (developed by Roke), there is scope to improve performance and extend capability by further research and development.

Fig 1 is by no means comprehensive, but it does illustrate the range of threats and environments for which acoustic sensing provides the potential to greatly improve situational awareness and provide both 'sense and warn' and target acquisition capability.

The table also highlights the fact that although there is great potential for acoustic sensors mounted on aircraft in a number of roles there are no current off-the-shelf products that are designed for aircraft mounting.

The remainder of this paper examines some of the combinations of threat and environment and discusses the strengths and weaknesses of acoustic sensing for those combinations.

Acoustics for Unmanned Ground Sensors (UGS)

Unattended ground sensors have been used for many years in a target acquisition role against indirect fire event such as artillery and mortar fire. The world leading **HALO®** system has proven worth in this role in current arenas of conflict.

Acoustic unattended ground sensors have a number of strengths when used to locate indirect fire weapons. These include:

- Very wide area of coverage
- Can detect where there is no line of sight or poor visibility
- Sensing is passive

A distributed acoustic system such as **HALO®** can handle many fire events in a short space of time (with potentially many shells/mortars in the air simultaneously) and often provides locations for weapons that are accurate enough for targeting purposes. Such systems can also pinpoint the locations of fall of shot which is very useful for the purposes of identifying the location of unexploded ordinance.

Figure 2 HALO® sensor post processor

Unlike mortar or artillery, most ballistic rockets do not create a shock wave from the launch event. Hence the use of an acoustic system for accurate location of a ballistic rocket launch site must rely on the ballistic shock generated by the supersonic projectile. With a distributed acoustic UGS system, it is possible to locate rocket launch sites with a useful degree of accuracy, though the problem is complex and merits further research and development.

Acoustic UGS based systems have weaknesses which mostly relate to the variability of the atmosphere through which the sound must inevitably travel. In particular the effect of wind on sound propagation can be significant. If the component of wind along the vector from sensor to source is in the direction of the source then sound will be refracted upwards. The upwardly refracted path traversed by a horizontal ray leaving the source marks the upper boundary of what is referred to as the sound shadow zone. Sound from a weapon can only propagate into this zone by means of scattering and diffraction (not directly) and is greatly attenuated.

This effect makes it essential that acoustic UGS systems are carefully deployed with account taken of the prevailing wind direction and likely locations of weapons. The use of a widely distributed array can also alleviate the impact of these effects.

In many areas of conflict it is not possible to deploy a widely distributed array of sensor nodes. The area under the control of your forces may be very small in a particular region. Acoustic sensors can still have a role in these cases, but such scenarios justify further research into novel deployments and improved performance of acoustic systems for short baselines.

Airborne Acoustic Sensors

Mounting acoustic sensors on aircraft to some degree overcomes many of the problems presented by the variable atmosphere. Upward refraction is rarely a problem as the aircraft can generally be flown at such an altitude as to be outside the acoustic shadow region. Furthermore, aircraft are highly mobile platforms so repositioning of an acoustic sensor node on an aircraft is readily achieved.

Acoustic sensor mounted on aircraft can fulfil multiple roles:

- Hostile fire indication for small arms fire (i.e. platform self protection)
- Provision of a mobile node for an indirect fire location system such as **HALO®**
- General acoustic intelligence gathering making use of the capability to detect small arms, indirect fire, explosive events, ground vehicles and aircraft.

With small arms detection, even when the gun is too far away for the muzzle blast to be detected, if the line of fire passes close enough to be detected (as it will if the aircraft is the target), the approximate position of the shooter can be deduced under many realistic circumstances.

There are, of course a great variety of aircraft on which acoustic sensors could be mounted. Acoustic sensors are only going to be useful on relatively slow moving aircraft, such as helicopters, propeller driven fixed wing aircraft and many UAVs. Faster aircraft generate more in the way of turbulent boundary noise which greatly reduces the signal to noise ratio.

High altitude aircraft are likely to be less suitable for acoustic sensing, although some sources such as artillery will be audible at useful ranges even at altitudes of several thousand feet.

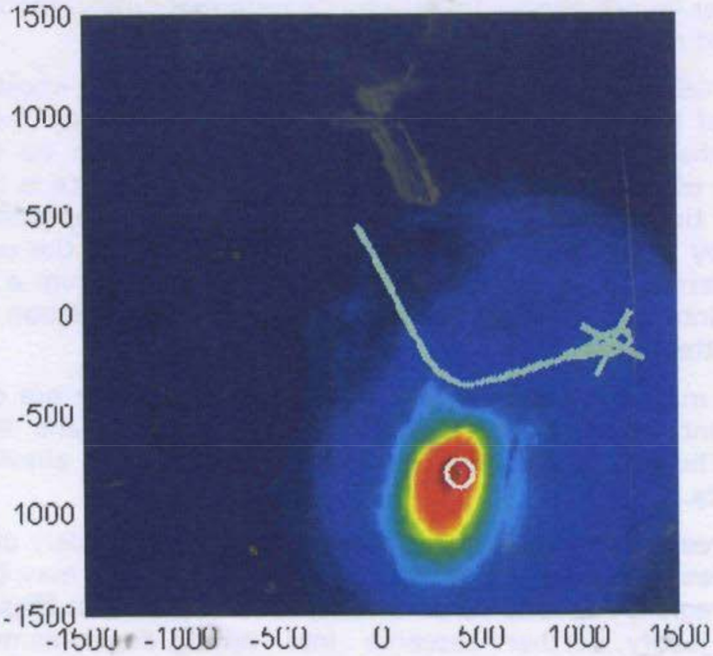

Figure 3 Output from Roke's acoustic HFI system

One of the principle challenges when mounting sensors on an aircraft is minimising the effect of platform noise. For most aircraft this noise is harmonic in nature, related to the motion of propellers and rotors, and the noise cancellation techniques developed at Roke as part of its acoustic HFI system can be utilised. However, once the propulsion related noise is cancelled there is still a significant contribution from noise created by air flow. This is best dealt with physical windshielding of the acoustic sensor. Roke has invested considerable effort in the development of windshielding methods that allow straightforward integration of acoustic sensors into airframes.

Mounting microphones on moving aircraft has the advantage that it can utilise existing air platforms. However, the advantages of acoustic sensing at an elevated location merit using a platform specifically deployed for this purpose. An ideal platform would be an aerostat. In this case there would be no platform propulsion noise, although the higher wind speeds at altitude would still require careful windshielding. An acoustic array mounted on an aerostat would be able to avoid the sound shadow even in unfavourable wind conditions, and has the potential to increase the available baseline from a compact protected location.

Ground Vehicle Mounted Sensors

Acoustic sensors mounted on ground vehicles can also be used in multiple roles, and although they don't have the advantage of altitude, they are mobile and better protected than unattended ground sensors.

Vehicle mounted acoustic sensors are already used for self protection against small arms fire, and in particular sniper attack. However, careful consideration of the different requirements for detection and location of other threats and the potential uses for that information could greatly increase the utility of vehicle mounted acoustic sensors.

A multiple-role acoustic sensor will need to have adequate bandwidth to deal with small arms detection, but also have good low-frequency performance (in terms of noise and phase stability) to be useful for long range artillery detection. The ideal array aperture and layout are different for the different threat types, so a suitable compromise has to be found.

Perhaps one of the most attractive prospects given a fleet of vehicles equipped with acoustic sensors is the detection and location capability afforded by the formation of a network of mobile acoustic sensing nodes. If a vehicle mounted system is to be used for intelligence gathering or as part of a wider network of sensor nodes, it will need to carry out accurate self survey of the array orientation and position. There will also be a need to carry out accurate time synchronisation between vehicles. Both of these objectives can be met using differential GPS, although the accuracy requirements for array self survey are such that providing this information for a moving platform will be challenging.

A moving ground vehicle is a very severe noise environment for acoustic sensors. For engine noise the noise cancellation strategy taken by Roke for helicopter platform noise minimises the impact of noise cancellation on the wideband signals generated by most threats of interest. Some tuning of the characteristics of the noise cancellation filters will be required for ground vehicles to account for the greater rate of variation of engine speeds and engine loading compared with helicopters – together, these factors will require an increase in the adaptation rate of the noise cancellation filters.

For other sources of platform noise such as road noise, and noise from vehicle tracks, a better approach is to use matched filtering to improve the signal to noise ratio for signatures with known characteristics. For an environment in which the noise characteristics are constantly changing, this approach requires the formation of an adaptive estimate of the noise spectrum.

Even when the vehicle is stationary, use of a large aperture array on the vehicle (as would be required for long range indirect fire location) requires consideration of the vehicles dynamics. The very low frequency nature of the gun signatures will interact with the vehicle mounted on its suspension. Furthermore the wind will excite the platform creating another source of noise or uncertainty in the sensor positions. All of these problems need to be accounted for in a vehicle mounted system.

Combined Acoustics and Vision Processing

In the natural world senses are rarely used in isolation. In particular, hearing and sight are often tightly coupled interdependent senses, with hearing often acting as a cue to sight. For example our sense of hearing is often what makes us aware that someone is behind us or that someone has entered a room, prompting us to turn our eyes toward that person (such cues are often not consciously registered as acoustic in origin).

Similarly, our eyes can tell us precisely where a person is and, given our auditory system's ability perform spatial filtering, this aids intelligibility when engaged in conversation in a noisy environment (the "cocktail party effect").

In the same way, a tightly coupled electronic acoustic and vision sensor system is likely to result a far greater capability than separate systems, or even a system in which outputs of independent sensors are simply fused.

An acoustic system can be used to direct a camera system with a limited field of view toward potential threats or targets. Similarly, a vision system utilising processing such as Roke's Video Motion Anomaly Detection (**VMAD**) software can be used to direct a highly directional electronically steerable microphone array such as Roke's **Universal Microphone**.

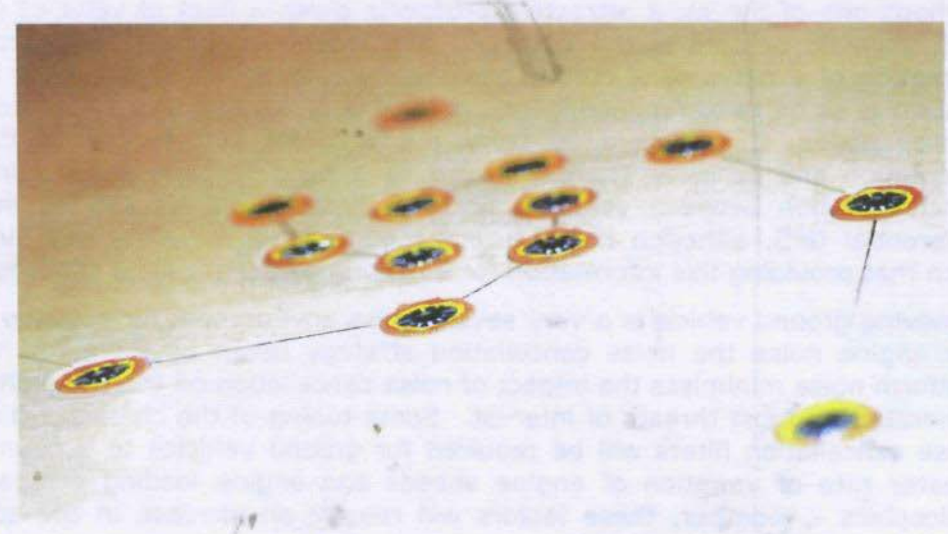

Figure 4 Universal Microphone

The fusion of acoustic and optical data also has enormous potential in both reducing false alarm rates in threat/target detection. Alternatively detection rates can be improved by using the greater confidence that comes from combining independent sensing modes to identify threats/targets that would be marginal detections at best in either sensing system alone.

Conclusions

Acoustic sensing in defence applications is often mistakenly viewed as either 'low tech' and hence 'easy', or as not sufficiently reliable to be of use. In reality the utility of system such as **HALO®** in real areas of conflict has demonstrated that acoustics is more than reliable enough to bring huge benefits (often unforeseen by the designers). Furthermore, continued research and development will bring improved performance and allow acoustics to be used against a wider range of threats and in a wider range of roles and environments.

Perhaps the greatest improvements (beyond the current state of the art) in the utility of acoustic sensing in military applications will come from combining acoustic sensing with other modes of sensing and in particular vision systems.

With the aid of acoustic sensor systems the modern soldier can sense beyond the hillside, be aware of hidden threats, even in poor visibility or total darkness, and be more certain that the information given to him by other sensors is reliable. Just as a soldier without hearing is vulnerable to stealthy attack from behind, a military wholly reliant on optical or electromagnetic sensing will always have gaps in its ability to detect threats.

roke

Roke Manor Research Ltd
a Siemens company

Intelligent Power & Resource Management

Roke's cross-domain Intelligent Power Management capability is applicable to a wide range of civilian and military autonomous vehicles.

Intelligent Power & Resource Management:

- Is **an enabler** for sophisticated mission autonomy
- Can reduce power generation and storage demands ...
- ... allowing platforms to be smaller and lighter
- Is applicable to manned and unmanned systems

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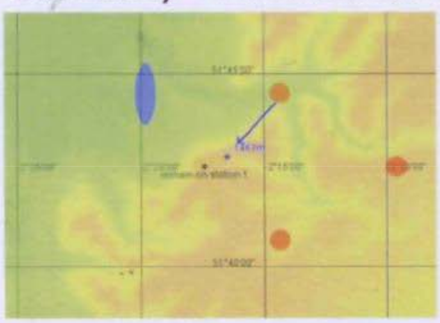
Case Study – Autonomous Soaring



Autonomous Soaring ground station user interface showing areas of rising air (red), falling air (blue) and the current planned route segment (arrow)

The Autonomous Soaring concept involves energy-efficient route planning for autonomous airborne vehicles, helping the vehicle's power management sytem extend mission range and endurance. An AI planning engine onboard a glider produces waypoint plans to be followed, which are designed to facilitate opportunistic energy harvesting from the surrounding atmosphere, without compromising overall mission objectives. Autonomous Soaring has been successfully shown in field trials and software demonstration. The Autonomous Soaring concept is equally applicable to ground-domain route planning in which the vehicle must avoid some regions (marshes and lakes etc) and prefer to travel through other regions, for example, those offering better traction.

The Autonomous Soaring prototype development was supported by the Ministry of Defence within the Propulsion, Power generation and Energy Management (PPEM) theme of the Systems Engineering for Autonomous Systems Defence Technology Centre (SEAS DTC).

Trials of Autonomous Soaring software used a cloud tracking camera for localisation of thermals and a two man glider was used as a surrogate UAV

Power & Energy Management

Power and energy management is a significant engineering challenge for the present and the future. Key concerns addressed by power management include cost of fuel usage and operations logistics for both manned and unmanned systems: future systems should be more efficient, require reduced direct control and be capable of increased self management without human intervention. Intelligent power management is an enabler for sophisticated mission autonomy.

What is Intelligent Power Management?

Conventional system architectures treat subsystem power requirements as independent and therefore often design for the worst-case use of "everything on simultaneously". By judicious scheduling of power consuming equipment, an overall mission can be carried out using significantly less power storage or generation equipment than would be conventionally required. This allows platforms to be smaller and lighter, reducing traction power requirements too. Furthermore, desirable mid-life enhancements can sometimes require more power than the platform can deliver whilst still keeping all the other subsystems running. Plan monitoring and efficient automated plan repair helps to ensure that the mission objectives can still be met despite a changing environment.

Power-Aware Mission Planning

A key challenge for an intelligent power management system is the need to plan in dynamic and unstructured domains. We have developed architectures and algorithms for modelling the world and for dynamic reasoning at multiple levels to generate and maintain robust mission plans. Our AI algorithms for power management are naturally domain independent, and may be tailored for domain-specific applications such as unmanned autonomous vehicle systems. Since traction is often a major power consumer, our approach to Intelligent Power Management incorporates intelligent route planning.

For further information please contact:

Mike Hook
T +44 (0)1794 833303
F +44 (0)1794 833616
mike.hook@roke.co.uk

Marketing department
T +44 (0)1794 833455
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

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Autoland Capability for Fixed Wing UAVs

Vision based autonomous landing for Fixed Wing UAVs

Intelligent Integration

The recovery phase is the most challenging and hazardous part of a UAV flight. By combining our knowledge of UAV retrieval with over 20 years of 3D vision processing experience, Roke has developed an autonomous landing capability for fixed wing UAVs.

Key Features and Benefits

- Requires no ground infrastructure – self contained landing capability
- Lands on a moving platform
- Works in a GPS denied environment
- Compiles database of potential emergency landing sites along flight path
- Exploits low cost sensors
- Compact system
- Passive system – covert operation
- Interfaces with flight control system or autopilot
- Detects obstacles on landing area

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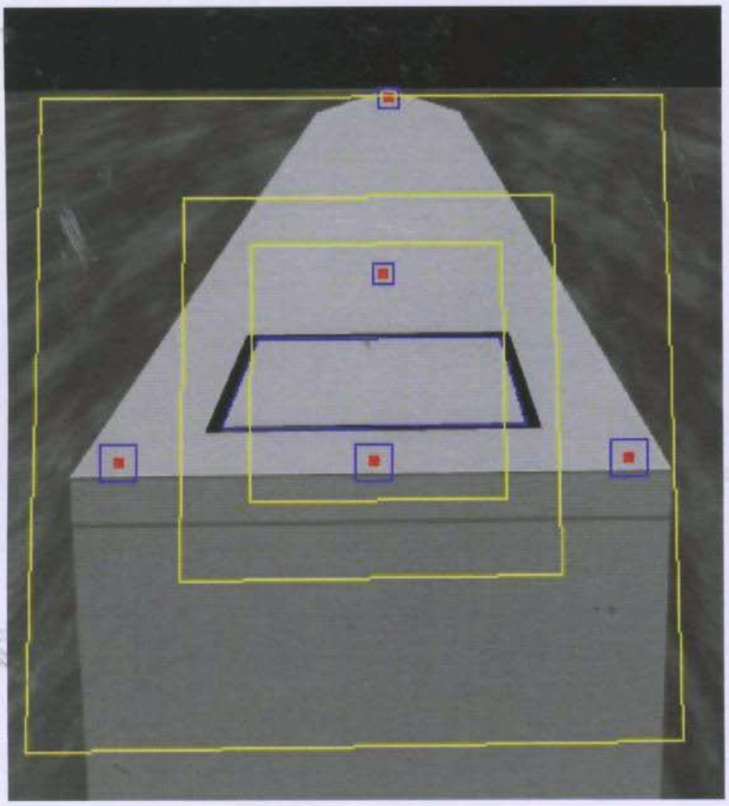
Our system uses video from a UAV mounted camera to identify the landing area, then calculates the relative position of the UAV.

The flight path from the current position to the landing point is then calculated. This information is passed to the autopilot or flight control system. The UAV is then flown along the calculated trajectory allowing the UAV to land autonomously.

Provides capability for fixed wing UAVs landing onto:

- Runways
- Temporary landing areas
- Aircraft Carriers
- Land Vehicles

The system uses RAPiD, Roke's model-based visual tracking software. RAPiD tracks pre-specified structures including 3D objects – such as buildings, ships – and 2D objects including painted markings. The autoland system calculates the position and orientation of the UAV relative to the landing area.



To discuss how this capability can be integrated into your platform contact us by using the details below

Other Datasheets of Interest:
Miniature Radar Altimeter
Autoland Capability for Rotary Wing UAVs

For further information please contact:

Robert Whitehouse
T +44 (0)1794 833372
F +44 (0)1794 833433
autoland@roke.co.uk

Marketing department
T +44 (0)1794 833455
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

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Autoland Capability for Rotary Wing UAVs

Vision based autonomous landing for Rotary Wing UAVs

Intelligent Integration

The recovery phase is the most challenging and hazardous part of a UAV flight. By combining our knowledge of UAV retrieval with over 20 years of 3D vision processing experience, Roke has developed auto-landing capability for V-TOL UAVs.

Key Features and Benefits

- Requires no ground infrastructure – self contained landing capability
- Lands on a moving platform
- Works in a GPS denied environment
- Compiles database of potential emergency landing sites along flight path
- Exploits low cost sensors
- Compact system
- Passive system – covert operation
- Interfaces with flight control system or autopilot
- Detects obstacles on landing area

DSG 2009

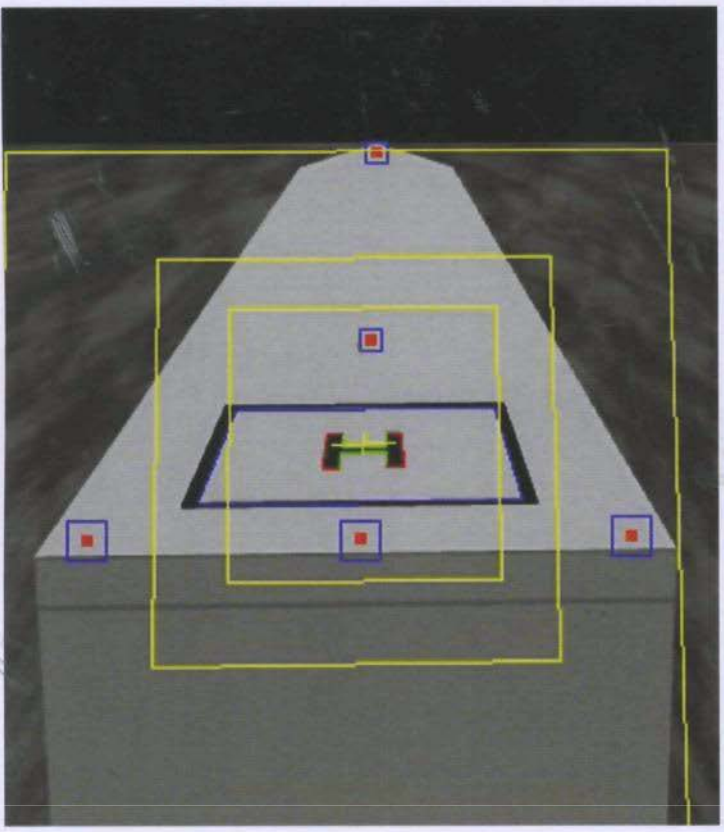
Our system visually identifies the landing area, then calculates the position of the UAV relative to the landing area.

The flight path from the current position to the landing point is then calculated. This information is passed to the autopilot or flight control system. The UAV is then flown along the calculated trajectory allowing the UAV to perform a successful landing.

Provides capability for rotary wing UAVs landing onto:

- Helipads
- Temporary landing areas
- Maritime Platforms
- Land Vehicles

The system uses RAPiD, Roke's model-based visual tracking software. RAPiD tracks pre-specified structures including 3D objects – such as buildings, ships – and 2D objects including painted markings. The auto land system calculates the position and orientation of the UAV relative to the landing area.



To discuss how this capability can be integrated into your platform contact us by using the details below

Other Datasheets of Interest:
Miniature Radar Altimeter
Autoland Capability for Fixed Wing UAVs

For further information please contact:

Robert Whitehouse
T +44 (0)1794 833372
F +44 (0)1794 833433
autoland@roke.co.uk

Marketing department
T +44 (0)1794 833455
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

roke

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Miniature Radar Altimeter
MRA Type 2 – 0.2-100m range

The highly precise Miniature Radar Altimeter (MRA) Type 2 is the world's smallest, low cost, lightweight, short-range radar altimeter. The MRA Type 2, which builds on the success of the MRA Type 1, is a unique product primarily aimed at the Unmanned Air Vehicle (UAV) and Aerial Target markets. The Type 2 operates at a lower altitude with a higher precision and incorporates an integrated antenna making the entire unit even more uniquely compact. It is ideal for use as an aid to Vertical Take Off and Landing (VTOL) of UAVs.

Key Features

- World leading resolution
- Compact unit with integrated antenna
- Low cost
- Lightweight and low power consumption
- Superior reliability
- RoHS compliant
- Ease of installation
- Designed to meet RTCA/DO-160

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MRA Type 2 – system specification

Altitude	
Nominal Range	0.2 to 100m
Resolution	
Default	0.02m

Physical	
Length	140 mm
Width	75 mm
Height	46 mm
Weight	400g
Integrated antenna dimensions	
Length	12.6 mm
Width	8.6 mm

Environmental	
Temperature	-40°C to +55°C operational -40°C to +85°C storage
Qualification	MIL-STD-810F

System power requirements	
Input Power	9 VDC to 32 VDC Normal consumption 3W Peak consumption 7W
Interfaces	
Signalling and control	RS232 (RS485 and RS422 options are available on request)
Altitude update	10 Hz (100 ms)
RF specification	
Frequency	76 to 77 GHz
RF output power	+11 dBm nominal
Antenna 3dB beamwidth	20° to 40° (regular pattern dependent on installation)
Antenna gain	10 dBi

Warranty and Safety	
Warranty	12 Months
Hazardous Substances	RoHS compliant

Applications

- Unmanned Air Vehicles (UAVs)
- Vertical Take Off and Landing (VTOL)
- Aerial targets
- Terrain Awareness and Warning System (TAWS)
- Wave height monitoring
- Surveying applications
- Airborne mapping

Figure: MRA Type 2 Integrated Antenna

The specification is typical of the performance that can be expected when the system is fitted in a UAV environment. Actual performance will be influenced by the specific operating environment.

For further information please contact:

Dr Donald Hardie
T +44 (0)1794 833125
F +44 (0)1794 833433
donald.hardie@roke.co.uk

Marketing department
T +44 (0)1794 833455
F +44 (0)1794 833433
mra@roke.co.uk
www.roke.co.uk

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

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Miniature Radar Altimeter

MRA Type 1 – 1.5-700m range

The Miniature Radar Altimeter (MRA) Type 1 is a market leading product primarily aimed at Unmanned Air Vehicles (UAVs) and airborne/aerial targets. Precise altitude Above Ground Level (AGL) measurements from the MRA Type 1 can provide information to automatic flight control, instrumentation systems, plus Terrain Awareness and Warning Systems (TAWS).

Key Features

- Compact
- Low cost
- Lightweight and low power
- Superior reliability
- Single compact antenna
- RoHS compliant
- Ease of installation
- Designed to meet RTCA/DO-160

PSG 2007

MRA Type 1 – system specification

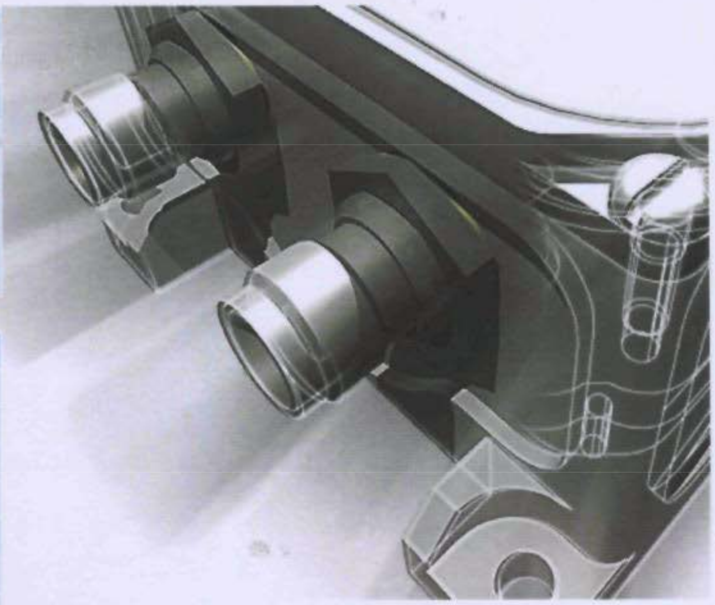
Altitude	
Nominal Range	1.5 to 700m
Resolution	
Normal	0.5m (1.5 to 700m)
High	0.125m (1.5 to 100m)
Low	5m (1.5 to 700m)
Automatic Resolution Selection	Automatically selects the resolution for optimum performance

Physical	
Length	140 mm
Width	75 mm
Height	46 mm
Weight	400g
External antenna dimensions	
Length	140mm
Width	75mm
Height	10mm

Environmental	
Temperature	-40°C to +55°C operational -40°C to +85°C storage
Qualification	MIL-STD-810F

System power requirements	
Input Power	9 VDC to 32 VDC Normal consumption 3W Peak consumption 7W
Interfaces	
Signalling and control	RS232 (RS485 and RS422 options are available on request)
Altitude update	10 Hz (100 ms)
RF connector types	TNC 50ohm
RF specification	
Frequency	4.2 to 4.4 GHz
RF output power	+17 dBm nominal
Antenna 3dB beamwidth	70° typical nominal (regular pattern)
Antenna gain	6 dBi

Warranty and Safety	
Warranty	12 Months
Hazardous Substances	RoHS compliant



Applications

- Unmanned Air Vehicles (UAVs)
- Aerial targets
- Vertical take off and landing (VTOL)
- Terrain Awareness and Warning System (TAWS)
- Wave height monitoring
- Surveying applications

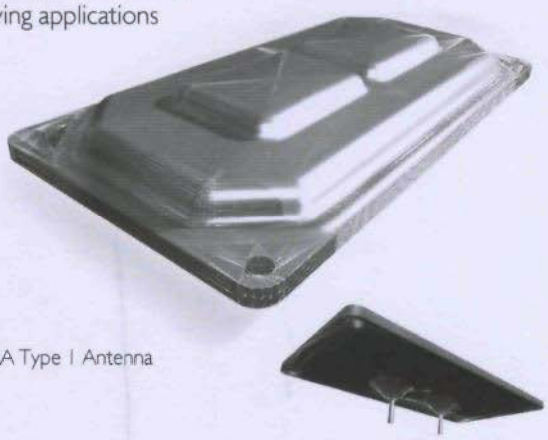


Figure: MRA Type 1 Antenna

The specification is typical of the performance that can be expected when the system is fitted in a UAV environment. Actual performance will be influenced by the specific operating environment.

For further information please contact:

Dr Donald Hardie
T +44 (0)1794 833125
F +44 (0)1794 833433
donald.hardie@roke.co.uk

Marketing department
T +44 (0)1794 833455
F +44 (0)1794 833433
mra@roke.co.uk
www.roke.co.uk

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

roke

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GPS protection

Roke Manor Research provides technology to protect military systems from jamming. A particular example of this is GPS where the latest techniques are used to give the maximum protection and provide jammer direction information.

Background

Roke Manor Research has a wealth of experience in the development of adaptive array technology. One specific application area of this is the protection of GPS. GPS is now extensively used in many systems for both timing and navigation. The low level satellite signals used in GPS make it especially vulnerable to low power jammers.

GPS receiver systems can be protected from interference using an adaptive array (controlled radiation pattern antenna – CRPA) to null jamming signals. The electronics employed to do this can be implemented using analogue or digital technology. Roke has recently exploited RF ASIC techniques to enable low cost, size, weight and power solutions to be achieved using analogue techniques. Exploiting fast real-time DSP (Digital Signal Processing) techniques offers increased performance due to:

- Much higher level of wideband cancellation by using Space Time Adaptive Processing (STAP)
- Improved satellite availability by beamsteering on the individual satellite signals
- Direction finding of the jamming signals

Photos of Eurofighter and Type 45 Destroyer courtesy of BAE Systems

DSG 2009

Benefits

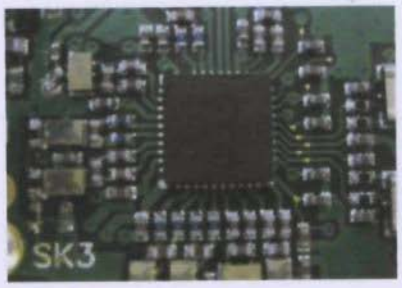
Integrating an analogue solution in an RF ASIC enables a compact solution to be achieved that avoids the size and power requirements of multiple analogue to digital conversions and high speed signal processing. However digital technology considerably improves the performance over an analogue system by maximising the signal to interference plus noise ratio. Analogue systems simply minimise the interference plus noise and the gain provided to the GPS satellites is relatively arbitrary. Forming beams in the direction of each GPS satellite maximises the signal to noise ratio in the absence of jamming. When jamming is present the beams are maintained but additional deep nulls are formed on the jammers. A digital processing approach enables each beamforming weight to be implemented as an adaptive transversal filter, allowing multipath and antenna frequency effects to be compensated and thus permitting much higher levels of wideband cancellation to be achieved. Also with the digital implementation the required beamforming weights are directly computed, avoiding the longer convergence times associated with analogue control loops.

As well as developing the DSP, Roke has experience in solving many of the associated issues in successfully adding GPS protection to a platform. These include:

- The design of small footprint antennas for confined locations
- The design of larger, higher performance antenna arrays for larger platforms
- The use of Epsilon for assessing the likely performance of different antenna sites on a platform
- The use of fibre optics for when the antenna array and the adaptive array electronics can be distantly sited
- The integration of the adaptive array electronics into RF and digital ASICs

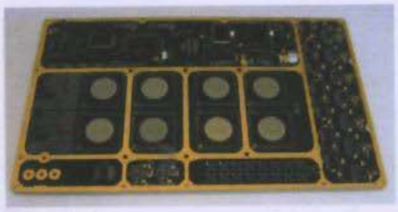
Our services

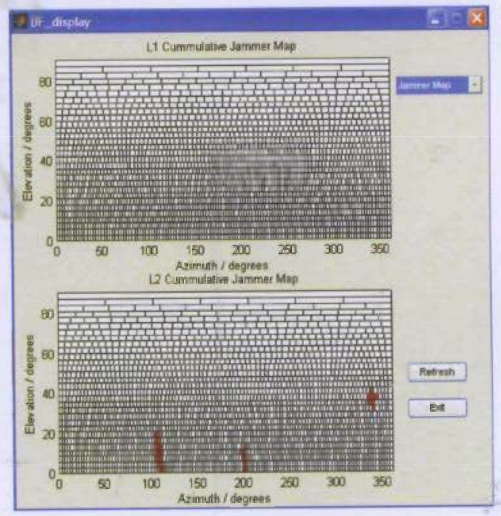
We can provide feasibility studies, modelling and simulations, technology demonstrators, prototypes, product development and small volume production to meet your requirements.



Analogue canceller implemented in an RF ASIC

Small footprint CRPA with analogue canceller integrated into its base


Single card implementing 8 STAP beamformers



Jamming signal direction finding

For further information please contact:

Mike Wells
T +44 (0)1794 833407
F +44 (0)1794 833433
mike.wells@roke.co.uk

Marketing department
T +44 (0)1794 833455
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

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Roke Manor Research Ltd
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Video Motion Anomaly Detection (VMAD)

As CCTV systems become commonplace in security, traffic monitoring and safety, improved methods are needed to monitor the video streams that these systems provide. Roke Manor Research's novel image-processing system, VMAD, provides a simple and flexible way of monitoring a range of CCTV applications, thereby improving the efficiency of staff and CCTV resources.

VMAD's features include:

Automatic learning, detection and analysis:

VMAD's intelligent learning capability eliminates the need to programme detection schemes for events which are difficult to define or foresee, resulting in:

- Reduced set-up overheads for individual cameras – simply plug in the video feed and the monitoring begins
- Adjustment to new behaviour as it becomes commonplace, screening out alarms which are no longer relevant.
- More effective policing – provides an early alert based on suspicious behaviour.
- Accommodation of drift in system parameters over time.

Analyses image features rather than changes:

- Changes in illumination levels have minimal impact on performance
- Suitable for indoor and outdoor use in varying image brightness
- No training required to recognise objects or events of interest

Analyses the characteristics of hundreds of features every frame:

- Detects abnormal motion even where motion is present
- Can be used in situations where different types of movement occur within the scene
- Features can be used to determine camera motion – meaning VMAD can be applied to moving camera solutions

Integrates with existing CCTV infrastructure:

- Digital or analogue feeds
- Configurable alarm triggers

DSEI 2009

What can VMAD detect?

VMAD detects anomalous behaviour, which varies from scene to scene. Typical examples of scenarios in which VMAD could be deployed include:

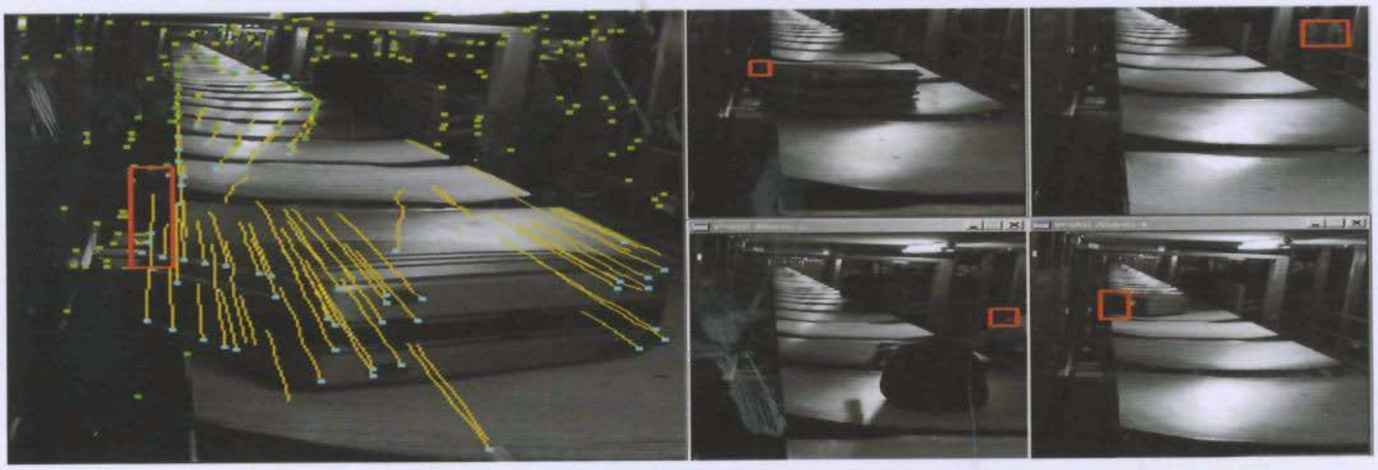
- Traffic travelling the wrong way on one-way roads, or traffic on the wrong side of a dual carriageway
- Pedestrians or animals in road tunnels or on roads
- Intruders climbing over a fence
- Somebody running in an area where people usually walk
- Swerving vehicles
- Pedestrians crossing railway lines
- Traffic coming to a halt in amongst normally flowing traffic
- Excessive speeding, for example near school gates.

Our research team has a unique breadth of skills in image processing, including feature extraction, pattern recognition and image enhancement. We developed the award-winning Hawk-Eye ball-tracking technology that revolutionised the TV coverage of Test cricket. We also have expertise in CCTV, security and transport applications and 3D computer vision for robotics and instrumentation. We understand the need for efficient, real time, processing algorithms and robust techniques able to handle data from real-life situations, and know that these must be implemented in end-to-end systems to meet customers' exact requirements.

Roke's portfolio of image processing techniques are used to extract meaningful information from video and 2D or 3D images.

These image processing techniques can be customised to your needs and include real time extraction so data can be obtained from live video feeds.

For further information on Roke's capabilities in image processing, please contact us.



How VMAD works

Unlike conventional video motion detectors which require manual programming to define areas of interest and motion parameters, VMAD learns the 'normal' movements in a scene and triggers an alert when unusual activity occurs.

This intelligent and flexible labour reduction tool can be used in a wide range of CCTV and security applications. Using a combination of real time alerts and active video recording staff can both react to events as they occur and easily locate past events when needed.

For further information please contact:

Emma Brassington
T +44 (0)1794 833288
F +44 (0)1794 833433
emma.brassington@roke.co.uk

Marketing department
T +44 (0)1794 833455
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk

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Roke Manor Research Ltd
a Siemens company

Visual Moving Target Indicator

There is an increasing use of unmanned aerial vehicles (UAVs) that use video cameras for viewing action and events occurring on the ground. Roke Manor Research has developed the Visual MTI video analysis system which automatically detects and quantifies the movement of vehicles and people from the continuously moving video taken from an air vehicle. Visual MTI can additionally provide image stabilisation; perform image mosaicing to provide a wider visual context; and align the mosaic to existing maps. Visual MTI can be used in a ground station to increase operator efficiency, or else be deployed onboard a UAV for increased autonomy.

Blue crosses – stationary features
Coloured trails – tracks of moving features

DSG, 2009

The challenge of dealing with video from UAVs

Unmanned Aerial Vehicles (UAVs) are increasingly used in military and civil applications. A video camera is often the primary sensor on a UAV, providing a torrent of imagery of the overflown ground. From this imagery, it is possible to detect the presence of moving objects on the ground, such as vehicles and people, which can be of strategic importance.

Currently, the assessment of UAV video is overwhelmingly performed by human operators. This requires that the video is first transmitted to a ground station over a high bandwidth link, and then carefully examined by the operator. The rapid and unceasing movement of the video footprint over the ground makes this is an exceedingly expert and demanding task. The operator's memory is relied upon to place in context events occurring on different images, which can be separated either in space as well as time – perhaps hours or days later. If a number of UAVs are operating over an area, then human operators may struggle to coordinate the information obtained from each separately.

How Visual MTI works

Visual MTI can operate on any video stream of the ground that has sufficient continuity, from either a visible band or infrared camera. From each image are extracted hundreds of so-called feature-points, which are persistently present in regions of distinctive visual texture. These features-points are tracked across images. A geometric analysis is performed on these tracks, which allows them to be categorized into those that are moving in ground coordinates, and those that are stationary on the ground (though moving on the images).

Blue crosses – stationary features
Coloured trails – tracks of moving features

Mosaic image constructed by stitching together individual video frames

What can Visual MTI do?

The stationary tracks can be used to automatically construct an image mosaic (see left), which provides a wider visual context. The mosaic is constructed from individual video images, each of them being perspectively warped so that they are in correct geometric alignment. The mosaicing can be extended to a larger area by detecting and acting on so-called loop-closure events, where regions of the ground are revisited in the camera view. The mosaic can be aligned to a pre-supplied ground map, and overlaid on it. This can be performed automatically if suitable MetaTag positional information is provided along with the imagery.

The stationary tracks can also be used to provide image stabilisation, by performing a perspective warping that keeps stationary tracks locally immobile on the image.

The mosaic image provides a wide-area, but static, depiction of the viewed ground from an overhead viewpoint. By itself this will show an up-to-date view of the material on the ground, irrespective of whether it is moving or stationary. A facility is provided for overlaying the moving tracks onto the mosaic, so that movement can be seen in context, and the source video shown alongside. The user can then view the video source and classify the tracked object as either threat, friendly or unknown.

Future

Research is ongoing to analyse the tracks of moving objects. By regularly monitoring a region from overflying UAVs, a statistical map of normal movement can be built. Movements will be associated with roads and paths, perhaps with the aid of an aligned symbolic map, and labelled according to attributes such as direction, speed and time. Automatic detection will occur on unusual movement events, or the occasion of trigger events pre-specified by the operator. This could result in the UAV automatically responding by changing course to follow the unusual moving object, and acquiring imagery of it at higher resolution.

For further information please contact:

Maria Bright
T +44 (0)1794 833483
maria.bright@roke.co.uk

Esin Turkbeyler
T +44 (0)1794 833197
esin.turkbeyler@roke.co.uk

Chris Harris
chris.harris@roke.co.uk
T +44 (0)1794 833337)

Roke Manor Research Limited
Roke Manor, Romsey, Hampshire SO51 0ZN UK
T +44 (0)1794 833000
F +44 (0)1794 833433
info@roke.co.uk
www.roke.co.uk