



INNOVATORS IN ON-THE-MOVE FIREPOWER

Remote weapon stations and multi-mission
precision for the modern battlespace



US Army CROWS training class in Iraq

REMOTE WEAPON STATION PIONEERS

Electro Optic Systems (EOS) is a world leader in the fields of Space Domain Awareness, satellite communications and remote weapon stations. Headquartered in Canberra, the company has two manufacturing facilities in Australia and one in Huntsville, Alabama (US). EOS also has integration and sustainment centres in Singapore and Abu Dhabi.

Since 2003, a year after the company was listed on the Australian Stock Exchange, EOS Defence Systems has delivered 2,100 systems to nine customers around the world with many systems on order.

EOS' history dates back to 1983, when Dr Ben Greene, then an adviser to NASA, and a group of scientists formed the company as a



US Army "Hummers" with EOS CROWS I in Iraq

result of the privatisation of Australia's satellite tracking program, for which they had worked.

Dr Greene's vision saw global opportunities for laser rangefinders, imaging security and ground space stations. Eager to bring the company's technical know-how and innovations to a wider marketplace, EOS began to develop systems intended for space-related activities, particularly in the field of laser tracking and rangefinders. EOS' technology base expanded rapidly to cover a range of associated technology areas, such as optics design, gimbals, laser ranging telescopes, beam directors, optical coatings, precision mechanisms and ruggedised assemblies, along with the necessary associated electronics and software.

Having designed and engineered optical payloads ruggedised for the challenging conditions involved in launch into space, along



EOS CROWS I on a US Army "Hummers"

with the control and precision required for tracking, EOS saw an opportunity to apply this technology in the defence domain. EOS' Defence Systems division was formed in the late 1980s.

Drawing on its space payload experience, EOS designed the very first example of what is now known as the remote weapon station (RWS). The RWS – which allows weapons to be fired accurately on the move while the crew remains under armour – is now a widely deployed technology by armed forces around the world; in the late 1980s, however, the technology was seen as exotic and risky. The US Army was the first to recognise this as an important technological avenue to pursue.

In 1991, EOS secured an order from the US Army for MUGS (Multi-Purpose Universal Gunner Sight), a laser-based, battery-powered fire control

CUSTOMER AND SUPPLIER ENGAGEMENT

Aside from its pioneering technology, EOS has grown its business based on customer-focused fundamentals. This starts early with customer engagement that seeks to optimise both an understanding of the customer's requirements and how the technology can be enhanced to the customer's performance criteria. This detailed engagement approach continues right through to system delivery.

EOS' ability to achieve tight customer optimisation is facilitated by four critical advantages. First, EOS has designed and owns the IP for all its key technologies and components, allowing for detailed control over all layers of the system and over the quality of every component and process input. This control is what enables world-class precision engagement capability.

Second, design modularity is key, allowing EOS to optimise systems to meet each customer's specific requirements. Modularity through the employment of common line replacement units and operator interfaces also works to keep acquisition, training and life-cycle costs low by maximising simplicity and commonality across the entire EOS product family.

Third, all EOS RWS are C4I architecture-agnostic – that is, able to be integrated with Generic Vehicle Architecture or other customer-specified configurations – as well as platform-agnostic and not tied to any specific weapon, sub-system or interface systems.

Finally, EOS, as either prime contractor or supplier, has optimised its culture to emphasise collaboration with all potential partners. The company has forged strong commercial partnerships with many leading defence contractors as well and has developed a global network of suppliers, including a strong Australian supply chain, for the thousands of components and major assemblies that make up its product portfolio.

EOS is a completely vertically integrated Original Equipment Manufacturer for major system components, and thus maintains control over the obsolescence chain.



ADF Bushmaster in action



ADF Bushmaster in operation with EOS R400S

unit for fitment to a variety of direct and indirect fire weapon systems.

EOS developed the world's first RWS – which incorporated the company's sensors, lasers, operator interface, electronics and stabilisation technology – under the US Army's CROWS (Common Remotely Operated Weapon System) program from 1993, in partnership with the US company Recon Optical. Trial units were delivered to the army for testing in Iraq and Afghanistan from 2003, and in the following year EOS CROWS I went into full production, resulting in 500 units being delivered directly to US Army combat units.

Additional orders for the EOS CROWS I followed in 2005, and in late 2006 an AU\$14 million contract to supply 44 RWS to the Australian Defence Force (ADF)



EOS CROWS II with a 0.50 cal heavy machine gun

was awarded. The RWS were employed on vehicles operated by the ADF in Iraq and Afghanistan.

In 2007, the US Army was required to re-bid the CROWS contract, which was eventually awarded to another company. The loss of supplying RWS to the US Army was a bitter development for the company, but forced it EOS to rebuild and transform its defence business with more resilient products, processes and management.

The results were extremely positive, with the company positioning itself for stronger growth throughout the 2010s, opening up new major markets and launching new products to better suit the requirements of a wider range of potential customers.

REMOTE WEAPON STATIONS



R400S Mk1 with 12.7 mm heavy machine gun on a Dutch Bushmaster vehicle

Only a company with decades of experience in producing ruggedised and precise systems for demanding space and defence customers has the ability to deliver precision engagement to the maximum specification of any mix of weapons. EOS has the knowledge to understand the harsh demands of firing from a moving vehicle, against moving targets, in harsh environments, day or night – while accounting for demanding platform vibration and motion variables.

At the core of the EOS portfolio is a range of RWS that have been developed to answer a wide spectrum of requirements, from providing self-defence for light tactical vehicles through to medium-calibre turret systems for armoured vehicles. Having

pioneered the RWS market, EOS continues to develop innovative RWS products, and today it is the only company in the world to offer a lightweight RWS that can mount all weapons up to both 30 × 113 mm and 30 × 173 mm cannon and shoot them precisely on the move and over long range.

EOS' systems are used on land, on a variety of vessels at sea and also for airborne applications; for example, a side-firing 30 mm cannon being mounted in an Airbus AC-235 aircraft employed as an airborne gunship delivering precision air/ground engagement.

From its original EOS CROWS I system, the company has advanced the ability of its state-of-the-art technology to provide highly precise

on-the-move firing. The RWS concept not only increases combat lethality and situational awareness through ISR rated sensors but also significantly enhances crew survivability – three factors that are key to mission success. Use of the RWS also improves the versatility of all military vehicles, including ultra-light land platforms.

Successful RWS must be intuitive to use for the operator and robust, reliable and easy to maintain in the field. EOS products are built on modular components and common interfaces – vital attributes in keeping training, logistics and life-cycle costs down. Products share many common and modular elements to achieve this, and all have proven, excellent reliability on operational service.

EOS REMOTE WEAPON STATIONS AND TURRET



LIGHT GIMBAL: R150S with 12.7 mm heavy machine gun



MEDIUM GIMBAL: R400S Mk2 with M230LF 30 mm cannon



MEDIUM GIMBAL: R400S Mk2-HD Dual with M230LF 30 mm cannon, 7.62 mm and Javelin missile



R400S Mk2-HD Dual with M230LF 30 mm cannon, 7.62 mm and Javelin missile on the Polaris Dagor vehicle



The R150S with 12.7 mm heavy machine gun on a Hawkei vehicle



The T2000 with MK44S 30 mm cannon and the R400S Mk2 D-HD with 12.7 mm heavy machine gun on the Hanwha Defense Australia AS21 Redback vehicle

EOS has delivered more than 2,100 RWS to a range of customers, mounted on over 20 different platforms. The common control interface can be integrated with various architecture standards and customer-specified display units. Integration with vehicle battle management systems adds capabilities such as Slew-to-Cue and Far Target Location, and offers easy integration to other vehicle systems such as local situational awareness sensors, HUMS and active protection systems.

LIGHT GIMBAL RWS

The R150S is the world's lightest gimbal capable of operating the 12.7 mm heavy machine gun to the full extent of its capability. The RWS was developed to address a requirement for a lower-weight unit that can be mounted on vehicles with payload and roof loading limitations. One aim was to create an RWS that weighed around 50 per cent of the R400S but could mount 12.7 mm heavy machine guns, in addition to smaller-calibre 5.56 mm and 7.62 mm weapons.

In a typical installation of the R150S for self-protection – with a 7.62 mm machine gun and ammunition – the system weighs 100 kg (compared to 230 kg for the R400S in the same role). It has been integrated to a number of land

platforms, including the Thales Hawkei and Bushmaster vehicles.

The RWS has two sensor unit options. The lightweight uncooled sensor unit is intended mainly for self-protection duties and for support vehicles. Alternatively, a longer-range cooled sensor unit can be fitted that is capable of ISR for reconnaissance surveillance missions.

MEDIUM GIMBAL RWS

The mid-range EOS RWS is the R400S, which has its origins in the original EOS CROWS I design. Now much improved, the latest R400S Mk2 is a dual weapon/cannon system that can be configured for both anti-tank guided missile (ATGM) and surface-to-air missile launch. With a 12.7 mm weapon and 500 rounds, it has an on-the-roof weight of 295 kg.

Used with the cooled sensor unit, the RWS provides advanced surveillance and integrated battlefield sector scanning capabilities. It can be programmed with up to 200 target reference points for rapid engagement directly from surveillance mode. Firing inhibit zones can be programmed into the system, which also has a video tracker with recording options. First round hit probability is enhanced by a



R400S Mk2 Dual with M230LF 30 mm cannon and 7.62 mm on the JLTV vehicle

sophisticated ballistic solution system that takes into account various parameters such as weapon and ammunition type, range, atmospheric conditions, target motion and vehicle attitude.

The R400S is considered a "plug-and-play" system that can be quickly integrated into battle management systems, while its design allows it to be packaged into small modules that can be dispersed around the interior of the vehicle to take up small spaces and minimise intrusion into the cabin.



HEAVY GIMBAL: *The R800S with MK44S 30 x 173 mm and Javelin missile*



TURRET: *The T2000 with MK44S 30 x 173 mm cannon and R400S Mk2 D-HD with 12.7 mm heavy machine gun*



Independent gun sight unit



GUA Control Group



Although RWS are mainly applied to land platforms – including main battle tanks such as this M1A2 (top right), EOS' technology can also be employed at sea and in the air – as represented here by a riverine craft (left) and the 30 mm cannon installation in an AC-235 (above)



EOS has developed the R400S to mount a range of 30 × 113 mm cannons. With this system configuration, even small, lightweight military vehicles such as the Polaris Dagor or Land Cruiser utility vehicle can gain the range and accuracy required to outshoot significantly more capable enemy platforms. Previously, such vehicles did not have the structural strength to carry the 30 × 113 mm cannon and consequently were vulnerable to hostile fire. With the R400S lightweight cannon configuration, light vehicles can now out-range commonly encountered threat weapons such as 14.5 mm heavy machine guns and the 2A42 30 mm cannon.

HEAVY GIMBAL RWS

The R800S is a heavy-duty RWS that mounts the Bushmaster Mk44/XM813 30 × 173 mm cannon plus hard points for ATGM, rockets and other hardware. Employing the same interface as other EOS systems, the R800S is intended for customers requiring a lethality upgrade on lighter vehicles without compromising payload or making the extensive modifications required of a full turret system. The R800S offers protection levels from STANAG Levels 2 through 4 and delivers turret-level direct firepower for 30% of the weight.

TURRET

EOS has developed the T2000 turret to provide a modern medium-calibre turret that integrates situational awareness, protection and firepower using the proven Elbit MT30 turret as its basis. The T2000, fitted with EOS' fire control system, electro-optics, and control systems and drives, features a 30 mm cannon and coaxial machine gun and can be fitted with ATGM, active protection systems and situational systems. The crew compartment of the turret has been designed for crew protection, functionality and comfort. Operators use simple and robust controls arrayed around three multi-function screens. Fitted with manual gun controls and an emergency sight, the T2000 allows the crew to keep fighting even when critical systems are unavailable.

The fitted R400S RWS provides the commander with an independent sight for surveillance and target acquisition, and the capability to engage independent targets using the RWS' weapons. The RWS can also be fitted with a CUAS capability for drone defeat.

The main weapon fitted to the turret is the Northrop Grumman Mk44S 30 × 173 mm cannon. This cannon is widely used by the US, UK, NATO and other allies of Australia with

thousands of weapons in service. The Mk44S can be upgraded to the 40 × 180 mm Supershot through the exchange of just three parts, and larger cannons can also be incorporated within the design. The turret also includes a coaxially mounted machine gun and twin ATGM launcher.

The T2000 has integrated key technologies including:

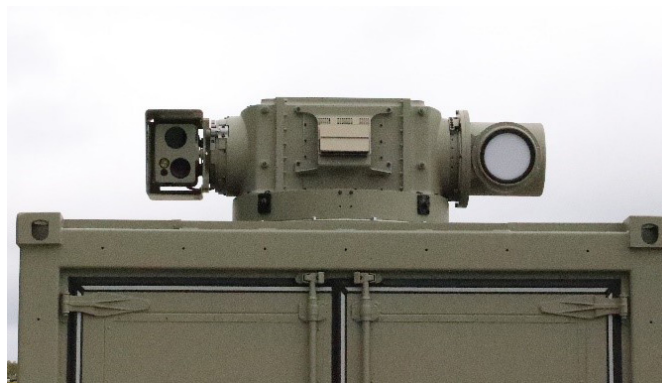
- Iron Fist active protection system
- Iron Vision helmet mounted situational awareness system
- laser warning systems
- ARTIST on-board training system.

SENSOR UNITS

EOS offers three sensor unit configurations, which can be enhanced with additional capabilities if required. The lightweight sensor unit has an uncooled thermal imaging unit. The medium-weight sensor unit has a 640× medium-wave infrared thermal imager and 34× zoom daylight camera, and has growth potential for 1024p and high-definition sensors. The system employs a continuous zoom camera that allows the user to switch between day and night cameras seamlessly. The panoramic gun sight unit is highly stabilised and can deliver main armament and independent commander sight performance in a compact, integrated unit.



Suicide drone swarms present an asymmetric threat



Titanis 35 kW Directed Energy beam director on containerised system

TITANIS DRONE DEFEAT

Countering the threat caused by drones is now a global issue and an increasing concern for military, government and homeland security forces across every continent. It is expected that unmanned aerial systems (UAS) will be increasingly used for malicious purposes, given their ability to carry cameras, weapons, toxic chemicals and explosives, and they are already being used for acts of terrorism, espionage and smuggling.

EOS has developed the Titanis Counter UAS (CUAS) system to address the growing threat from malicious and threatening UAS.

Based on the EOS R-Series RWS, Titanis is a fully integrated, scalable CUAS suite that combines the specific detection, command and control (C2), and layered hard and soft kill defeat capabilities necessary to acquire, track and defeat swarming UAS threats.

The Titanis system allows operators to match kill solutions to large numbers and varying combinations of small and large drones to ensure that the threat can be mitigated regardless of their direction, numbers and capabilities while managing environmental, geographic, airspace and personnel safety considerations.

A typical all-up Titanis configuration incorporates direct-fire engagement systems, passive and active soft kill electronic warfare (EW) systems, an integrated sensor suite – including Pulse-Doppler, software-defined radar, day/thermal camera, laser rangefinder and radio frequency (RF) detection systems – and an optional Directed Energy (DE) kill system. These systems sit together with, and are integrated through, a proprietary, EOS-developed C2 and fire control system.

High-volume fire point defence solutions range from the 7.62 mm Dillon Aero M134-series minigun to larger-calibre 30 mm guns (e.g. the Northrop Grumman M230LF 30 mm cannon with EOS R400S Mk2 RWS, or the Mk44 II Bushmaster chain gun with the heavier-weight EOS R800 RWS) firing airburst munitions (including 30 mm x 113 mm proximity fused airbursts and 30 mm x 173 mm airburst rounds) to deliver CUAS effects out to 3000 m.

One of the key differences between CUAS and other missions is the high angular speed that UAS can achieve at relatively short range. EOS RWS have been modified with a fourth-axis, independently slewing sensor unit that can move independently in azimuth to track fast-moving targets. A 1 Hz laser provides laser ranging and tracking throughout the engagement.

Passive and active soft kill EW systems designed to operate across all-threat frequency bands are, as with the radar solutions, integrated according to customer preference. Typical solutions include offerings from Blighter in the UK, Echodyne in the US and RADA in Israel.

Titanis' DE system has been deployed with a 35 kW high energy laser (HEL), although the HEL in its current format is capable of scaling to around 55 kW. The HEL system has been demonstrated as a small containerised system; however, while the DE beam director is slightly different to a weapons station, it has 60% commonality with the R400S RWS and is therefore effective from deployable platforms.

Developed and manufactured in-house by EOS, the DE system – which includes the beam director and the co-mounted optical



Kinetic CUAS using airburst munition



RWS fitted with Dillon Aero M134-Series minigun

target identification and tracking system – is designed to address Group I, II and III UAS swarm threats, with high rates of target engagement, out to ranges of 4000 m.

The ability to maintain and manage the quality of the beam, the software that ensures precision engagement and drives the process, and all the mechanical designs and architectures are all EOS designs and intellectual property.

Arguably, the largest current growth rate in lightweight lethality systems is in the unmanned systems space, both for integration on unmanned platforms with remote operation and for the engagement and defeat of unmanned systems. For CUAS applications, Titanis – with its direct engagement/point defence, and passive and active EW and DE capabilities – constitutes a significant force multiplier.



R400S on the Milrem THeMIS unmanned ground vehicle



R400S on the Pratt & Miller Engineering expeditionary modular autonomous vehicle



R400S with M230LF 30 mm cannon on the IAI LR2 unmanned ground vehicle

DEFINING THE FUTURE OF THE RWS

Demand for RWS continues to grow worldwide, as customers seek further network integration of their sensor-to-shooter assets and continuous improvements to the survivability of their soldiers. Today, the original underlying premises for an RWS remain the same: keep the operator safe by having them seated and strapped into a protected or mine-resistant environment while delivering situational awareness, accurate fire support and area suppression. However, customers are now seeking greater range, lethality and accuracy from these integral ISR and firepower assets as well as greater digital integration of the sensor/shooter

capability. The RWS is now viewed as a key lethality subsystem available to a force rather than simply as another platform accessory. EOS' family of products is leading the way in defining these new market expectations.

EOS' focus has always been on ensuring the RWS is optimised and integrated with other onboard subsystems, as well as being compliant with the customer's architecture. Modular and advanced human-machine interfaces and control groups coupled with proprietary software solutions facilitate low-latency enhanced data and sensor information, sharing not only with other on-board systems but to other platforms, sensors and C4I nodes within a networked battlespace.

EOS products and architecture are flexible and adaptable to enable rapid software updates/ amendments to achieve optimal integration matching specific customer requirements.

This highlights EOS' advantage has in owning the entire system and error budget; the company does not experience issues when integrating different manufacturers' assemblies or services to their systems.

This flexibility in software and control solutions is becoming even more important due to the growth in customer interest in unmanned and robotic systems. The RWS goes hand-in-hand with this revolution, as unmanned combat platforms will also require precise, low-latency sensor and lethality solutions. The only way to meet the specialised platform requirements of autonomous vehicles (such as the need for lighter-weight systems and to meet bandwidth challenges) will be to further develop the specialised capabilities found and championed in RWS and unmanned turret technologies.

EOS believes the RWS will continue to be remote rather than autonomous.



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