Pedestal Mounted Air Defense System – fully integrated system delivers technology refresh and increased reliability at lower cost

Business Need

- To source a fully integrated system for the Fire Control System of not only the largest military contract ever placed with a Turkish prime contractor, but also the first locally-managed commercial-off-the-shelf (COTS) program

Solution

- A fully integrated system comprising a fan-cooled chassis, advanced single board computers with mezzanine cards, and other I/O devices
- Innovative techniques delivering reduced cost, lead times and risk while increasing Radstone’s ability to respond to customer requirements
- Full thermal and environmental type approval to Radstone Level 4

Business Benefits

- Insertion of COTS-based technology providing an ongoing path to combat obsolescence
- Reduced cost of ownership
- New business opportunities derived from COTS-based solution

Able to fire up to eight Stinger missiles – each traveling at Mach 2.2 – the Turkish Armed Forces Pedestal Mounted Air Defense System (PMADS) delivers supersonic short-range air defense capabilities for troops in exposed positions.

Its tactical importance on the battlefield is, however, only matched by its strategic importance to Turkey’s national defense industry. After years of manufacturing defense systems under license, the PMADS program is the first to be placed with a Turkish company taking the lead as prime contractor.
As that prime contractor, Aselsan Electronic Industry Inc. has created an advanced vehicle mounted stinger platform that delivers significant advantages over the previous ManPortable Air Defense System (MANPADS) used by the Turkish Army. In doing so, the company turned to Radstone Technology to provide the Fire Control System that lies at the heart of the program.

Faced with the need to deliver uncompromising quality and reliability as cost-effectively as possible, Radstone has combined its advanced systems-level expertise with innovative techniques it has been developing to reduce costs, weight and production lead times by 30 percent.

“Radstone's people are very professional,” explains Mustafa Kaval, Aselsan’s Project Manager for the PMADS program. “They are technically excellent and have been very supportive, giving good answers to any questions. Not only was this our largest ever weapons systems integration program, it was our first using COTS. We needed technology and we needed support that we could rely on – and Radstone have delivered both.”

**Strategic Procurement Policy**

The responsibility for coordinating Turkey's large scale and foreign defense industry and procurement process lies with the country’s Under Secretariat for Defense Industries (SSM), an autonomous agency created in 1985 within the Defense Ministry.

In 1997, while announcing that Turkey’s annual defense spending was set to rise steadily to reach a total of $31 billion during the next ten years and as much as $150 billion through to 2025, SSM explained that the spending would be accompanied by an increasingly stringent policy of local production to meet the country's defense procurement needs.

“We have used the last ten to twelve years to establish our productive defense infrastructure in Turkey. We are now ready to tackle design and integration capabilities – goals which the Turkish armed forces fully support,” said Veyssel Yayan, Deputy Under Secretary at SSM at the time.

The first program to benefit from this strategy was PMADS. For some years Turkey had procured a MANPADS version of the Stinger missile as part of an international consortium with the Netherlands, Germany, and Greece. Within that program, Aselsan produced an electronic guidance section of the Stinger missile.

**Aselsan – A Leading Electronics Company**

Aselsan was founded in 1975 by the Turkish Armed Forces Foundation to produce tactical military radios and defense electronic systems for the Turkish Army. Today Aselsan is the country's leading multi-product electronics company, designing, developing and manufacturing modern electronic systems for military and professional customers.

Headquartered in Ankara, the company operates through three main divisions. They are:
• Communications, covering military and professional communications systems
• Guidance and Electro-Optics, which manufactures hybrid microelectronic circuits, night vision equipment, thermal cameras, laser ranger/designators and inertial navigation systems
• Microwave and System Technologies, which is primarily focused on radar, electronic warfare and command-control systems.

In 1992 SSM commissioned Aselsan to undertake a feasibility study on the design and production of a pedestal mounted platform for Stinger missiles which could be used on two different vehicle platforms. The ZIPKIN would be based on a four-wheel Land Rover Defender, while the ATILGAN would be based on an armored/tracked M113A2 personnel carrier.

Aselsan was already very familiar with the program having started conceptual studies in 1989 to help define requirements and how best to meet them. Kaval, who works in the Microwave and System Technologies Division, explains the drivers for the program. “The key objectives were to overcome the limitations of MANPADS, primarily the fact that the man-operated system can only fire one missile at a time and its accuracy is dependent on the skill of the operator. Our brief was to create an easy to deploy and fast moving platform that could fire multiple missiles and be integrated into a single command control system.”

Radstone Provides Development Platform

PMADS comprises a number of advanced subsystems, from thermal imaging to a laser rangefinder and the Fire Control System. “The Fire Control System is actually the heart of the entire platform,” explains Kaval. “At that time our systems design experience had been focused primarily on applications running on PCs. This was to be our first rugged project and we wanted a vendor that could not only provide a complete solution for the FCS, but one that could support us through the development.”

After an exhaustive study, Aselsan concluded that Radstone was the only company with the board level and system level expertise required to partner them through the development program. As the world’s leading independent supplier of rugged, high-performance COTS embedded computer products, subsystems and support software for defense and aerospace applications, Radstone’s portfolio extends from systems chassis to boards and completely integrated systems.

But it wasn’t just the technology that attracted Aselsan. “Radstone offered a very competitively priced solution, but for me what was even more important was the support that they showed. They were willing to work directly with us, without an agent, and even in those early stages they proved that they could work well with our engineers.”

The contract was placed with Radstone in 1996 to supply a fully integrated system for the FCS. It proved to be a sound decision, especially as Aselsan had only two and a half years in which to complete the entire design and development phase, culminating in a firing range field test.

“It was a very challenging timescale,” recalls Kaval, “because we not only had to design and integrate all the subsystems, we also needed to select the best vendors and complete negotiations with them for each of the subsystems as well as integrating them into the overall PMADS system.”

To ease development times, Radstone provided Aselsan with commercial versions of the boards that would comprise the final rugged system. Asked how important those boards were, Kaval is unhesitating. “They were very, very important. Without that commercial platform we would not have been able to start our software development. As soon as we received the platform we were able to start work on writing our software which enabled us to shorten the development process by about six months, so it was critical.”
The completion of the development phase was a series of demanding firing range tests with the system firing – while stationary and on the move – targets comprising metal plates set up on distant hillsides and in-flight drones. Aselsan and senior observers from the Turkish Army and SSM were delighted to witness 100 percent success in all nine test firings.

With this success came the formal completion of the development phase and negotiations began between Aselsan and SSM on the exact number of systems required and other details. “We signed the production contract in November 2001,” recalls Kaval, “and Radstone was the first supplier we started to talk to about the production system.”

**Significant Advances in Production System**

With over 40 years serving the military marketplace, Radstone understands better than most the challenges posed by the use of COTS components in military systems destined not only to operate in hostile environments, but in programs with lifespan stretching up to 25 years.

The company’s response has been to develop its concept of Whole Program Life COTS™ which aims to reduce overall cost of ownership and provide industry-leading safeguards against obsolescence. It does so by addressing the issue at all stages of the program lifecycle, from designed-in compatibility across generations of products through to a highly resourced team of design engineers and support staff dedicated solely to supporting programs throughout their extended lives.

Part of this approach is a strict policy of maintaining the ‘form, fit, and function’ of boards across generations of silicon to provide ‘plug and play’ processor upgrades. While the development system used its PowerPC2A Single Board Computer (SBC), for the production system Radstone was able to recommend an immediate upgrade to the latest generation PowerPC4A.

“I very much agree with Radstone’s policy of maintaining form, fit and function,” observes Kaval. “Radstone are leaders in guarding against obsolescence and while we did not need the performance gains the new processor offered, it is a very useful means of combating component obsolescence.”

Radstone’s innovation didn’t stop with a processor upgrade, however, as the company’s designers worked with their counterparts in Aselsan to introduce to the system a range of techniques that Radstone had been working on.

**New Chassis Construction**

Among the first improvements was the use of a new chassis construction method. Previously, Radstone used a dip brazing process to solder the aluminum walls of a chassis together to create a very strong enclosure. However, this method requires the various parts to be assembled on a jig and moved to a brazing oven where the temperature needed approaches the melting point of aluminum. The unavoidable distortion that frequently results from this method therefore required a post-brazing machining operation.

Transferring lessons learned from another program it had worked on, Radstone has developed a new way of bonding the chassis using high performance bonding agents first developed and used in the aviation industry. The new technique delivers a chassis with the same mechanical, environmental and EMC performance as the dip-brazing method, but in a far more controlled production process without the need for post-brazing machining.

**Customized Power – off-the-shelf**

The power supply for any integrated system typically represents some 30 percent of total system cost. Radstone offers a range of power supplies meeting MIL-STD-704E. However, the vehicle generator environment of the PMADS meant that Aselsan required a power supply that met MIL-STD-1275B, where the low voltage operating level is lower and the spikes and transients are much more severe – +/-250volt 100micro sec spikes and 100volt 50msec transients.

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Mustafa Kaval
- Project Manager for the PMADS program
  Aselsan
To meet this requirement Radstone took advantage of a new approach to power supplies it was developing. The objective was to break away from the traditional ‘fixed configuration’ model and derive a cost effective way of offering flexibility in terms of both Power Supply Unit (PSU) input specification and output voltage rail configuration.

To achieve this, Radstone has developed an innovative approach to power supplies by specifying and then sourcing a range of power modules which it can ‘mix and match’ to create a bespoke design that meets a customer’s precise needs. This means, for example, that if a customer does not need a particular voltage rail then they do not have to pay for it merely because it is part of the ‘standard item’. And in Aselsan’s case, this modular approach enabled Radstone to design and build a power supply that met the customer’s particular requirement for bespoke voltage rail power sequencing and also for the facility to upgrade in the future to 3.3 volts – something that would have been impossible in a pre-built configuration. And because each module is a proven item, each new power supply configuration carries inherently less risk than a new design.

**Custom 19-layer Backplane and Front Panel Flex-Circuits**

For the development of the prototype system, Radstone provided an ATR chassis with VMEbus tracking and wirewrap spills on user-defined pins. These pins can be wired to a series of connectors and then cabled to the chassis’ front panel connectors.

In designing the production system, however, Radstone implemented other innovative techniques, drawing on its experience and expertise in designing PCBs that use some of the world’s most advanced construction materials and practices, combined with an imaginative approach to wiring to the front panel.

Essentially the two developments are:

- the integration of all I/O wiring into the tracking of the backplane itself as opposed to wire-wrap
- ‘translating’ the complex cable harnesses from the backplane to the front panel into easy-to-assemble flexible interconnects known as flex-circuits.

To achieve tracking in the backplane itself, Radstone added seven additional electrical tracking layers to a standard PCB backplane which comprises 12 layers. Conventional approaches carrying these signals as a mesh of complex cables, each configured to reflect the nature of the signal – in terms of, for example, a twisted pair compared to a screen twisted pair – and which cater for specific interfaces which might have controlled impedances.

Typically, the time taken to manually wire a chassis took six weeks – Radstone’s new approach slashed that time down to two days.

Using advanced CAD tools, Radstone’s engineers recreated the wiring as circuits which were translated within the seven tracking layers of the backplane. The characteristics of the different cable types were reflected in the design. For example, twisted pair cable was simulated by parallel traces, and screening by guard traces, connected to digital ground above and below the signals.

For the connection from the backplane to the front panel Radstone again offered an innovative solution through the use of flexible circuits which could be easily attached to either end of the PCB.

“But while the use of flex-circuits has saved a lot of time,” observes Kaval, “the most important thing for me is that it reduces the risk of wrongly routed circuits or short circuits. Translating most of the wiring into the tracking dramatically reduces any scope for human error, as well as streamlining the assembly process.”

Future developments have again been designed-in, with the tracking for a 1553 interface already included which will enable PMADS to interface to digital launchers when required.

Completing this part of the system is the chassis’ front panel, for which a bespoke configuration of connectors was designed to meet Aselsan’s particular needs which included the use of gaskets in case the chassis is subject to ‘hose down’ in the field.

Radstone’s attention to detail went as far as ensuring that there was sufficient space around connectors to enable easy connections by gloved hands.

**Thermal Analysis and System Testing**

Radstone’s approach to thermal management starts with component selection and placing. Critically, the company designs its own boards which represent the leading edge of PCB technology with micro-vias, laser imaging and new laminate materials harnessed to improve thermal conductivity and provide enhanced stiffness to reduce the harmful effects of vibration. But while Aselsan’s system benefits from being air-cooled via an avionics-class fan drawing air over the surface of the boards and out of the chassis, leaving nothing to chance Radstone undertook a full thermal analysis using Flomerics’ FLOTHERM.

As board level configurations were defined, Radstone performed a full system level thermal analysis to validate that, in theory at least, using standard Level 4 boards (-40 deg C to +75 deg C) would meet the required operating temperature range for the equipment. This theoretical
analysis was later backed up by measurements made on individual production units, including putting the entire production system successfully through full type approval testing, including full Environmental Stress Screen (ESS) and temperature cycling and random vibration testing.

As with all Radstone systems, testing does not end with successful qualification. For each of its products the company writes a set of test paradigms that deliver built-in-test (BIT) firmware to assure confidence in the operation of equipment at power up, and also a BCS (Background Condition Screening) toolset that goes beyond the field capabilities of BIT to provide continuous test routines during actual deployment – with no loss of performance.

**The Importance of Teamwork**

Kaval’s experience of working with Radstone has been so positive that he has recommended the company to other parts of Aselsan, and importantly, the success of PMADS has seen a prototype of a naval variant – the BORA – enter field trials.

While Kaval is the first to acknowledge the technical innovation and leadership Radstone has demonstrated, asked for what he feels has been Radstone’s most significant contribution his response is ‘teamwork’. “Radstone’s technology is impressive, but so too are their people. Our engineers have built up very good working relationships with their engineers and there have been several visits by each group of engineers to the other. They are,” Kaval says simply, “compatible.”

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**PMADS – Advanced Air Defense**

The main mission of Low Level Air Defence System ZIPKIN, is the low level air defense of fixed locations of strategic importance, like radar, air bases and harbours. Based on a four-wheel drive Land Rover Defender 130, the ZIPKIN carries four Stinger missiles and is operated with a two-man crew: the gunner and the driver (gunner assistant). ZIPKIN can easily be loaded into and transported by C-130 and C-160 aircrafts.

The main mission of Low Level Air Defense System ATILGAN is the low level air defense of stationary and moving forward troops, convoys and tactical bases in the battlefield. The gunner is seated in the electrically powered turret with a highly accurate stabilization, which enables on-the-move surveillance, detection, tracking and firing capabilities. ATILGAN can carry four or eight Stinger missiles and can shoot on the move. It is based on an armored/tracked personnel carrier M113A2 operated with a three-man crew: the driver, the gunner and the commander.

Besides autonomous operation, the system architecture of both systems provides coordinated operation with C3 System and other air defense assets. In remote control mode, the Optical Target Designator is used for the System to be directed automatically towards the coordinates that the commander is tracking.