DEFENSIVE AIDS SYSTEM CAPABILITY ASSURANCE - WHY & HOW?

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White Paper
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DEFENSIVE AIDS SUITE

ELECTRONIC WARFARE DEFENSIVE AIDS SUITE (DAS)

The correct, largely automated, operation and performance of aircraft DAS, when needed, is achieved through a combination of verified mission dependent data, sophisticated BITE and evidence-based DAS capability assurance testing. It is mission critical, and is imperative in ensuring that aircrew and Operational Commanders have the utmost confidence in the DAS equipment fitted. **DAS must work first time, every time.**

The modern radar and infra-red guided missile threats to military aircraft are evolving; more capable, more complex and increasingly lethal. To equip aircraft with a Defensive Aids Suite (DAS) that can offer a degree of protection is now a pre-requisite theatre entry standard for the operations of today and tomorrow. Equally, under the scrutiny of continuous media coverage, the loss of even a single platform has the potential for a strategic shock that could undermine the political will to continue. The challenge, therefore, is to achieve an acceptable balance between DAS capability and platform risk.

Whilst platform protection is much more than just an effective DAS; the 'don't be there, don't be acquired, don't be engaged' philosophy, along with high quality training and well-rehearsed tactics all remain invaluable parts of that equation, ultimately, it is the DAS that provides the final layer of protection to deliver effect[1] in a hostile environment and at an acceptable level of risk.

However, equipping our platforms with DAS is challenging and, as the threat evolves, increasingly complex. Also, the short reaction times and sophistication of emerging threats means that DAS fits need to be highly automated, such that the pilot has to trust the DAS to detect and defeat the threat, often with little or no human intervention.

DAS fits are, therefore, becoming very expensive to install and maintain and must work first time, every time. So if we accept the need to acquire and install DAS at considerable cost, intuitively it makes sense to ensure that before each mission is flown the DAS undergoes rigorous, evidence-based capability assurance to ensure it is functioning correctly and provides an understood level of protection.

Whilst the manufacturer's Built-In Test Equipment (BITE) continuously monitors the DAS to ensure most performance related problems are found prior to flying a mission, in some cases, especially involving hardware changes and alignment or where there are multiple points of failure, evidence- based DAS capability assurance can provide the added confidence that the DAS will function as intended.

Failure to do so undermines the significant financial investment and leaves Commanders to make risk decisions based on assumed levels of protection that, without such evidence, are demonstrably not As Low As Reasonably Possible (ALARP). Ultimately, it risks the loss of life and aircraft that could affect political will. Therefore, rigorous, evidence-based DAS Capability Assurance is not simply a desirable add-on, rather it is an essential part of the Operational Commander's risk calculus and an invaluable part of air platform survivability.

[1] Effects-based warfare doctrine.

EVIDENCE-BASED CAPABILITY ASSURANCE SCENARIO

The following scenario describes an example of evidence-based capability assurance:
A DAS equipped platform is flown against threats in a range environment. The sensitivity of the DAS system BITE indicates a fully functional system and, in addition, a test is also carried out using Leonardo Tier 1 and 2 stimulations. The results of these stimulations are shown below.

Figure 1 represents the sensitivity of a DAS system being measured from four receive antenna quadrants mounted on the platform. With each of the coloured loops being of equal size indicates that each quadrant has a similar receiver sensitivity.

What Use Is This Diagram to a Commander?
Using this known sensitivity of the DAS, it can be determined whether the platform is inside or outside a missile engagement zone. Put simply, it confirms whether the DAS is capable of detecting the threat and keeping the platform safe.

Missile Engagement Zone
A missile engagement zone is the kinematic range of the missile system being fired at a platform. The closer to the missile launch point, the higher the probability of a missile kill (PK).

To increase the chances of survival from a missile engagement, the DAS has to be able to detect and counter the missile threat as far from the launch point as possible. If the DAS sensitivity is degraded, then PK increases and aircraft survivability decreases.

Figure 3 depicts a DAS system that has poor sensitivity in the forward quadrants. This could be due to damaged antennas, be caused by incorrect maintenance or degraded cable runs ; BITE would not detect this degradation in the DAS. In an operational scenario, the DAS would not detect the missile threat until the aircraft was well inside the missile engagement zone, where the missile PK would be considerably higher.

Question...
Many platforms now have very sophisticated DAS systems, with extensive BITE capability and complex MDD or PFM software.

However, if these platforms are operationally deployed, how does the Commander know that each individual aircraft DAS is capable of detecting a missile threat outside of a missile engagement zone and, thus, have an assured, evidence-based capability of keeping the platform and crew safe from harm?

Without the combination of BITE and rigorous and documented tiered testing, fundamentally, he doesn't know and is, therefore, demonstrably not ALARP when taking risk decisions.

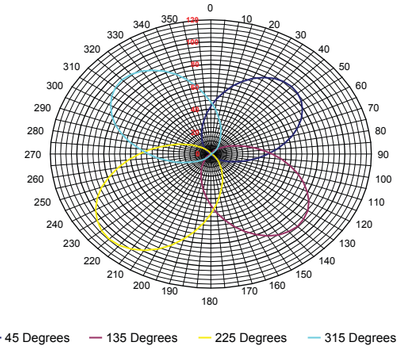

Fig 1. DAS System Sensitivity

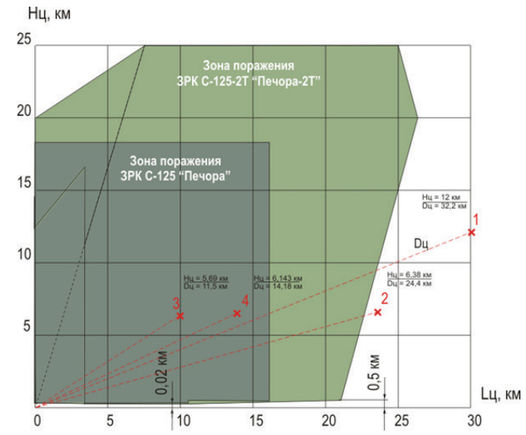

Fig 2. Missile Engagement Zone

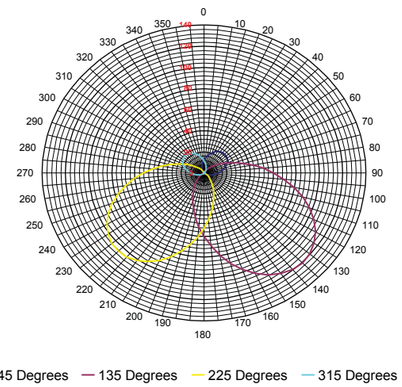

Fig 3. Damaged DAS Forward Antenna Quadrants

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OPERATOR AWARENESS AND MISSION REHEARSAL

The same test equipment could be utilised for training technicians in DAS system operation whilst the aircraft are on the ground, and aircrew could conduct 'on aircraft' EW training from basics up to, and including, full mission rehearsal when at a deployed location – a concept termed 'Operational Awareness' that would minimise EW skill fade.

This would use real operational intelligence of the threats likely to be encountered, including their parameters, whilst factoring in terrain screening using ground mapping models, flight plans and route timings. Special Forces missions and pre-planned deliberate operations, in particular, could make very good use of this capability.

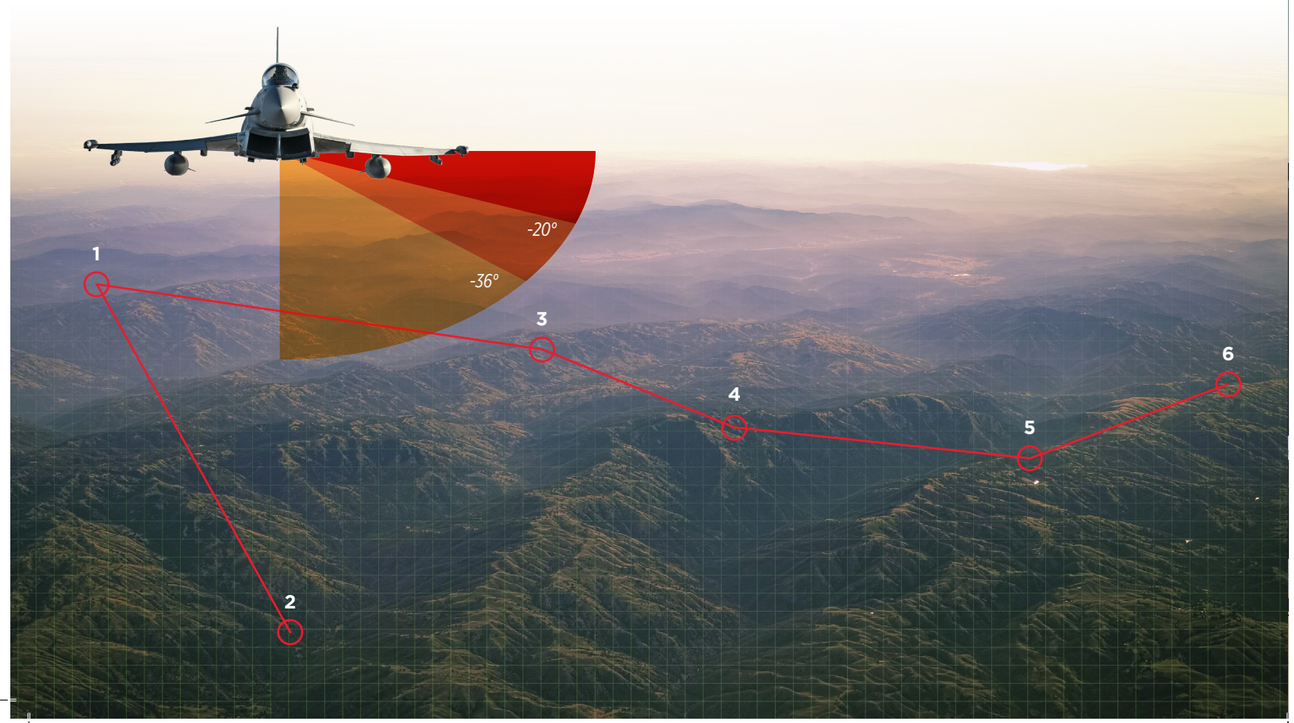
The aircrew training could be conducted in the classroom, using a computer display connected to the test set, and then, finally, on the actual aircraft to be flown using the hoods and test equipment, before the mission is executed, thus further improving aircrew confidence in their automated equipment.

Such training would be particularly effective when conducted on deployed operations, away from home-based simulators, to reinforce complex EW 'combat-ready' training.

SUMMARY

The complexity and significant financial investment to install DAS fits onto aircraft, makes assuring DAS performance of critical importance to aircraft survivability and operational risk. The correct and largely automated operation, when needed, combined with BITE and evidence-based assured DAS performance, is imperative in ensuring that aircrew and Operational Commanders have the utmost confidence in the DAS equipment fitted – the DAS needs to work correctly first time, every time.

This DAS capability assurance can be provided through a combination of extensive BITE, supported by mandating rigorous, tiered pre and post flight testing regimes, which generates auditable evidence of installed DAS performance on every platform. Such test equipment can also provide wider consequential benefits to support 'on aircraft' MDD V&V, technician and aircrew training, particularly when on deployed operations, and may offer tangible supply chain savings through a better understanding of system operation and LRI reliability.



CAPABILITY ASSURANCE

So what should evidence-based DAS capability assurance consist of? Ideally, it needs to be reasonably simple to deliver pre-sortie, but given the complexity of modern DAS will, by necessity, be more detailed when establishing capability baselines, for example following Depth and Minor level aircraft maintenance.

This suggests a tiered approach methodology. Whilst this process is already adopted on many platforms, such as the RAF's Typhoon, this Paper contends that a more rigorous and documented regime using, by and large, already fielded test equipment could deliver a step change in understanding DAS capability on a mission-by-mission basis and thus inform risk-based decisions with evidence-based data.

Tier 3 Testing
In-depth analysis of full spectrum DAS capability conducted to accept delivery of a platform and then at intervals dictated by Major and Minor servicing schedules, or after significant rectification work.

The evidence gathered and supported documentation would show receiver sensitivity, balanced antenna receiver patterns, confirm Direction of Arrival (DoA) accuracy is within tolerance, cable and antenna integrity and performance with acceptable cable signal losses, correct DAS Line Replaceable Item (LRI) operation and correct Mission Dependant Data (MDD) interpretation of an incoming signals across the installed frequency coverage, with correct cockpit display.

[2] Typhoon currently uses a Leonardo Tactical Systems 'on wing' end to end test kit supporting signal injection and a spectrum analyser which can provide all of this information in the RF domain. A similar system is available for UV/IR DAS fits.

[3] Information documented in aircraft servicing log, such as the RAF Form 700.

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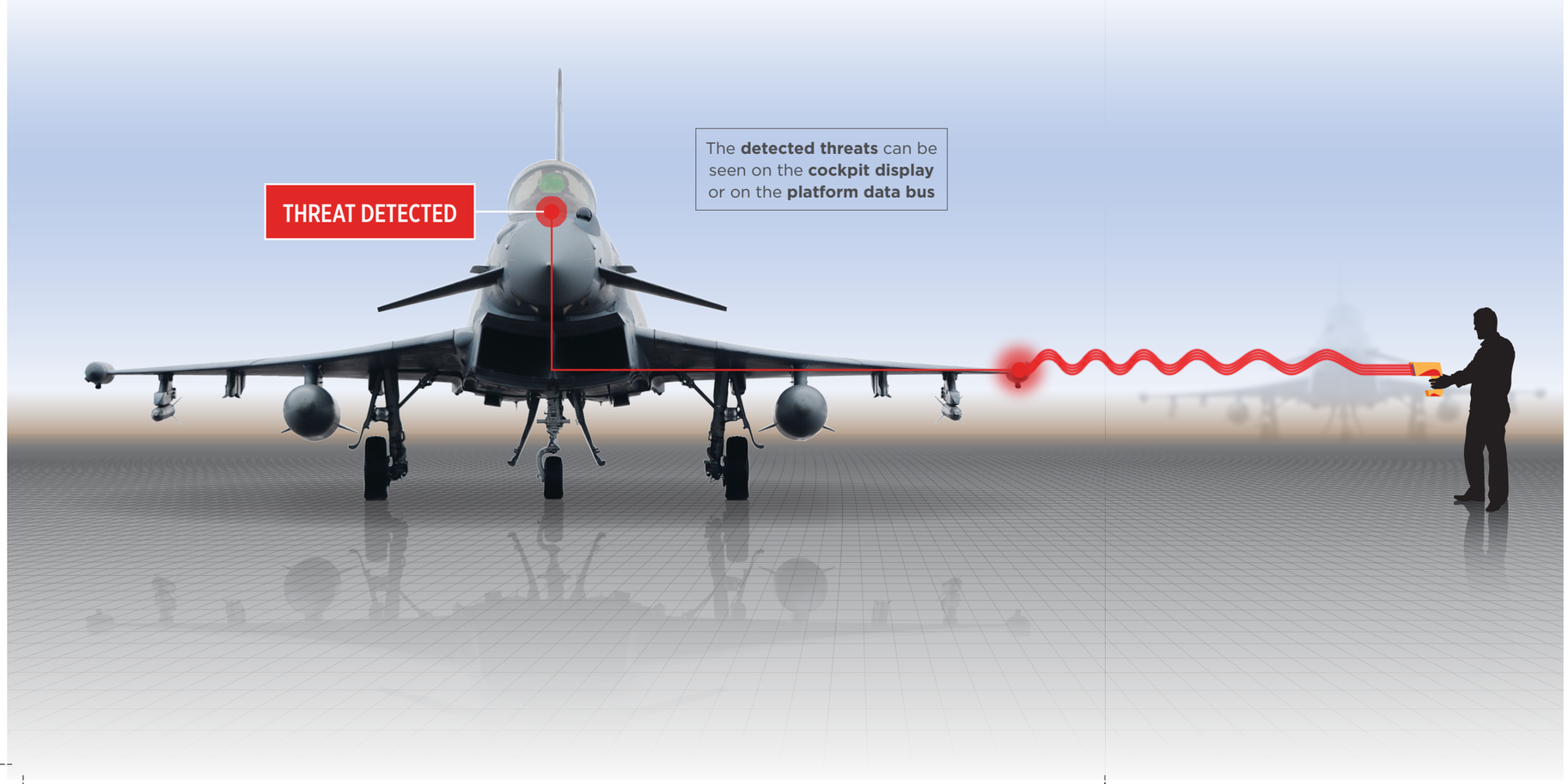
Tier 2 Testing (Hooded)
Conducted after operational missions, Test and Evaluation missions, or complex EW training missions, such as Exercise Red Flag, as a mandated part of the after-flight servicing schedule to allow repeatable test conditions with the minimum of known variables.

This can be quickly achieved using a sophisticated, but compact and portable, stimulator attached to on-antenna hoods to allow an operational MDD to be used securely with no 'free space' transmissions. The evidence gathered and documented, for inclusion in the aircraft log as a DAS health check, would cover similar parameters to Tier 3 listed above, but in less detail. This would, effectively, be the assurance that the DAS is fit for purpose for the missions planned, thus providing confidence in the DAS equipment whilst satisfying the Operational Commanders' ALARP risk responsibilities.

Tier 1 Testing (Free Space)
Conducted pre-flight after aircraft power interrupt using a hand held stimulator to confirm DAS system operation remains valid after the power interrupt. Essentially, a final combat confidence check of DAS system operation before take-off.



CONSEQUENTIAL CAPABILITY BENEFITS

Finally, providing the in-service test equipment is configured correctly there are some highly beneficial consequential capabilities of the test regime outlined:

The test regime would document aircraft tail-number DAS serviceability; such information could highlight common failures and mean time between failures of LRIs and associated equipment, such as antennas etc. This information would be invaluable for supply chain management that could both increase serviceability and save money with more intelligent LRI purchase/management. It would also baseline squadron aircraft DAS standards.

Electronic Warfare Operational Support (EWOS) Derived MDD Verification & Validation (V&V). The situational awareness and performance obtained from DAS can only be as accurate as the data and skill with which it has been programmed through its MDD, or Pre-Flight Message (PFM). EWOS provides that programming and, when considered in its entirety, may be thought of as the equivalent to Integrated Mission Support (IMS).

Stimulating the operational MDD loaded onto the aircraft would provide an absolute confidence check that the MDD is accurately coded and correctly identifies and displays threat emitters – essentially, additional confidence to 'stim- hall' test rig V&V using the real aircraft DAS.