Battle Management Command, Control, Communications, Computers and Intelligence (BMC4I) for International Ground Based Air Defence (GBAD), Counter-Unmanned Aerial Systems (C-UAS) and Counter-Rocket, Artillery & Mortars (C-RAM)

Strategy White Paper

Version 3

Executive Summary

In order to deliver the enhanced Command and Control (C2) element of a fully integrated and interoperable BMC4I capability for GBAD, C-UAS, and C-RAM components of an Integrated Air and Missile Defence (IAMD) System, a systematic approach is required.

In the past, BMC4I systems have been procured for specific purposes in order to meet specific threats, leading to a cluttered Battlespace littered with equipment doing specific jobs for specific arms of the Military.

Often without the ability to share data or cross cue targets, future conflicts are going to be characterised by increasing tempo, the requirement to overcome mass, the need for greater reach, and a thirst for 'real-time' data. Therefore, sensors and effectors must be broken out of their current 'stovepipes' in order to improve efficiency, flexibility, interoperability and future-proofing.

Stove piped information represents a wasted opportunity to enhance the situational awareness for all users, improve operational performance and seek to gain an information and tactical advantage over the enemy. It is also a threat, in that it can easily be targeted by hostile actors, thus collapsing a pillar of data, without the ability to circumnavigate via another gateway. A fully networked and interoperable BMC4I capability helps to alleviate this shortfall. It enables information to be received, analysed, utilised and forwarded to those that require it. However, such improvements should not just be limited to those capabilities historically associated with GBAD, C-UAS and C-RAM, but include the full array of airborne and Littoral sensors, including: Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR), Unmanned Aerial Vehicle (UAV), or Close Air Support (CAS) platforms that could provide additional sensory information into IAMD networks at the tactical as well as strategic levels.

Operational Scenario:

- A friendly warship picks up a group of targets heading towards friendly forces on the adjacent shoreline.
- They are not a direct threat to the Task Force (TF), but clearly could be to an allied defended critical asset in their direct flight path.
- A fifth-generation aircraft is also flying directly overhead, but whilst its mission is not dedicated to Intelligence, Surveillance and Reconnaissance (ISR), its sensors detect separate threats, possibly UAVs, heading towards the same critical asset.

- The GBAD unit, assigned to protect that critical asset now picks up several different targets heading towards it from multiple directions.
- How does this critical time sensitive information get to where it is needed, both in terms of decision making and mission execution, and how can the operators make sense of it?

This paper will cover the growth and opportunity that a mature, scalable BMC4I system can offer, in terms of meeting the current and future requirements for GBAD, C-UAS, C-RAM, and potentially even Precision Deep Fires, by integrating a mixture of new and legacy sensor and effector capabilities, providing a spiral development pathway that helps smooth strained budgets, whilst also being able to react to new threats and the advantages that future advances in technology bring, without requiring wholesale system re-design or replacement.

Lockheed Martin's 'SkyKeeper' is that BMC4I capability; it is a United Kingdom (UK) 'sovereign' system, which possesses considerable latent stretch capability as a universal BMC4I system and is the BMC4I system of choice in the land environment for scalable, interoperable and future proofed GBAD, C-UAS and C-RAM requirements.

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1 Introduction

Scope

The purpose of this White Paper is to highlight the key features and benefits that a truly interoperable, flexible and future-proofed BMC4I capability can bring to the GBAD, C-UAS and C-RAM battlespace, whilst also signalling its wider utility across multiple domains.

Lockheed Martin Air & Missile Defence (AMD)

Lockheed Martin is a global leader in the design, development and production of missiles and IAMD solutions. It has over 110,000 employees worldwide and operates in 54 countries.

The Corporation's relevant capabilities include: Missile Defence, C2, Battle Management (BM), Sensor Systems, Weapon Systems, and Systems Integration.

As the world's leader in IAMD technologies, Lockheed Martin provides bespoke and tailored solutions to meet specific customer requirements. The strength, variety and versatility of Lockheed Martin's current AMD capabilities is illustrated in **Error! Reference source not found.** below:

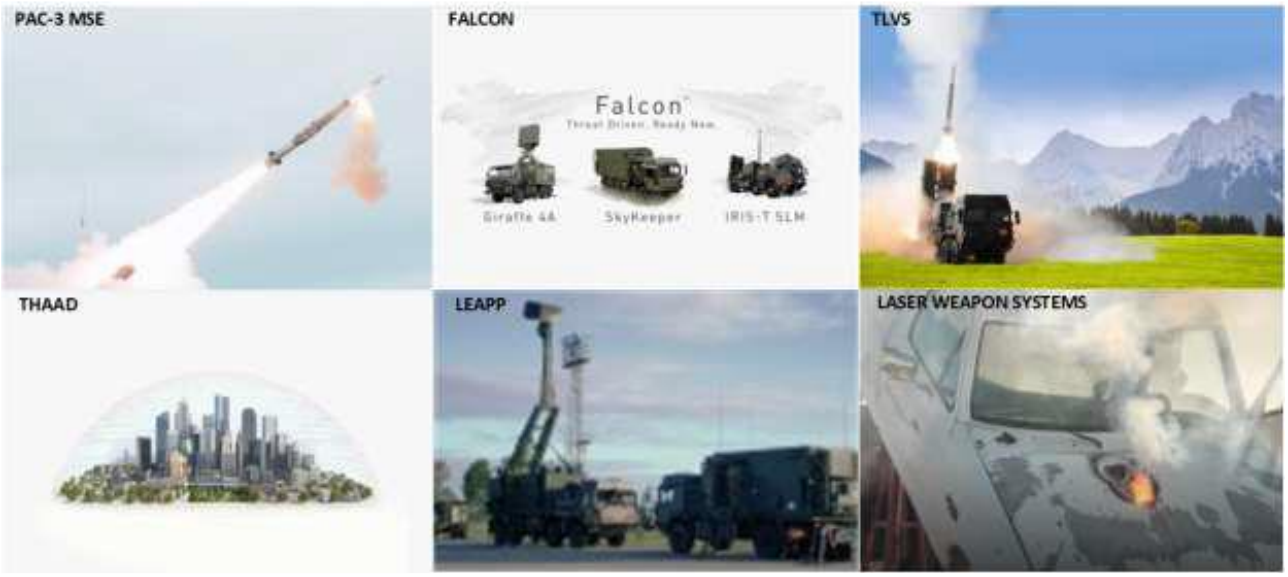

Figure 1- Lockheed Martin AMD Experience

GBAD Family of Systems

In order to meet the breadth of needs of customers worldwide, Lockheed Martin regularly forms a team of trusted partners to deliver bespoke solutions to meet specific customer requirements; no one company can maintain a portfolio that can cover all permutations. However, Lockheed Martin is well versed in acting as a Prime Systems Integrator and solutions are often based on

Commercial Off-the-Shelf (COTS) military products already in service across a multitude of countries.

Therefore, whilst a specific system may be unique, and therefore un-fielded in that format, the constituent components are invariably tried and test capabilities, providing credible assurance to the customer and rapid capability without the risk of development.

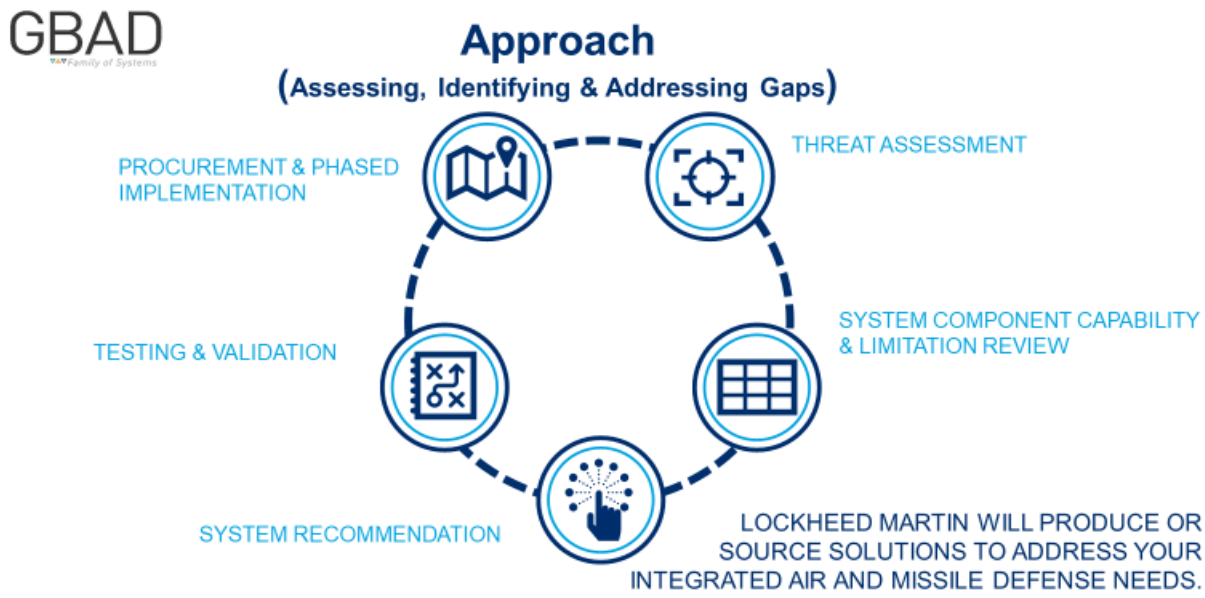

Figure 2- Lockheed Martin's GBAD Family of Systems Approach

Following an incremental pathway through the development and procurement process, as illustrated in Figure 2, the right solution, to meet the extant threat, utilising the appropriate equipment, will be sort. It may incorporate some existing, or legacy, equipment or may consist of entirely new components. However, at its heart will be a flexible BMC4I system that can adapt and evolve; this is SkyKeeper, which will be discussed in more detail in Part 2. However, everything comes back to the threat, which we all know is ever changing and ever evolving. Therefore, being able to adapt, change, and add to, in terms of sensor and effector mix, with minimum disruption, and therefore cost, to the backbone architecture, future proofs any GBAD, C-UAS, and/or C-RAM system that has SkyKeeper at its centre.

2 SkyKeeper

Overview

Lockheed Martin UK Ampthill (LMUKA) is the current provider of the operationally proven British Army's Land Environment Air Picture Provision (LEAPP) capability, which provides land formation headquarters with both a Local Air Picture (through organic Saab Giraffe-AMB radar), and a wider Recognised Air Picture (RAP) by fusing sensor feeds from across the joint force including Digital Data Links (DDLs) such as Link 16. It also features elements of the Automated Sense and Warn (AS&W) system which was successfully fielded to support British Troops in Afghanistan.

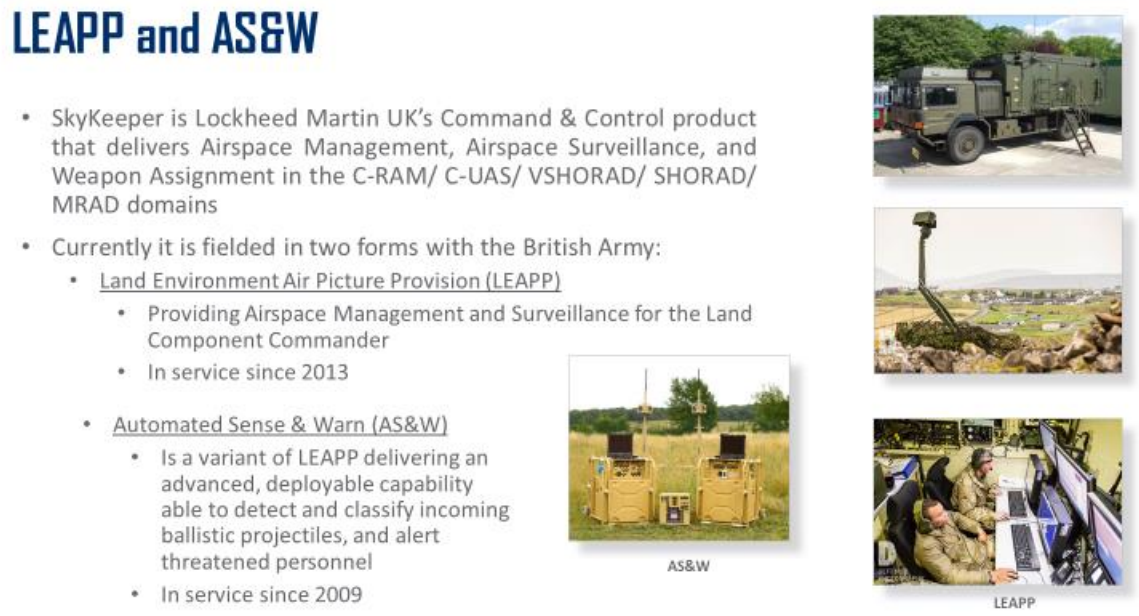

Figure 3- LEAPP and AS&W in operation

Since its introduction into service in 2014, the UK developed software that drives LEAPP has continued to evolve and mature beyond the scope of the original requirement and as such it is now a step change in capability. As a result of this, it needed a new branding to differentiate it from the capability in service with the UK. "SkyKeeper" is now a genuine BMC4I capability with utility across all domains, but specifically GBAD, C-UAS and C-RAM.

Sensor & Effector Integration

By virtue of its scalable open architecture, SkyKeeper is equipped to integrate multiple organic and non-organic sensors and effectors into a universal networked BMC4I system for GBAD, C-UAS and C-RAM, whilst also acting as a 'funnel' for DDL transmitted information, that may include both specific tactical air picture information and/or wider ISTAR information.

The SkyKeeper BMC4I system uses an open architecture based on the UK Ministry of Defence (MoD) Land Open System Architecture (LOSA), using the Data Distribution Service (DDS)

middleware and the GBAD Network Message Set (NMS) to achieve connectivity and interoperability between sub-systems, with gateways embedded as required to external services.

Within the UK as the LEAPP and AS&W capabilities, the system has already demonstrated full integration with Giraffe-AMB, Mobile Artillery Monitoring Battlefield Asset (MAMBA) and Lightweight Counter Mortar Radar (LCMR), as well as Infra-Red/Electro-Optic (IR/EO) sensors such as the current VSHORAD Air Defence Alerting Device (ADAD) or the Wide Area Sense and Detect (WASAD) sights of AJAX Fighting Vehicles. In addition, through Lockheed Martin's work in the international market, SkyKeeper has either integrated or de-risked integration with a range of sensors and effectors from many different allied countries, including sensors from Saab, Weibel and Hendsoldt, and effectors from Diehl Defence and MBDA. **Error! Reference source not found.** 4 provides a full overview including current integration status.

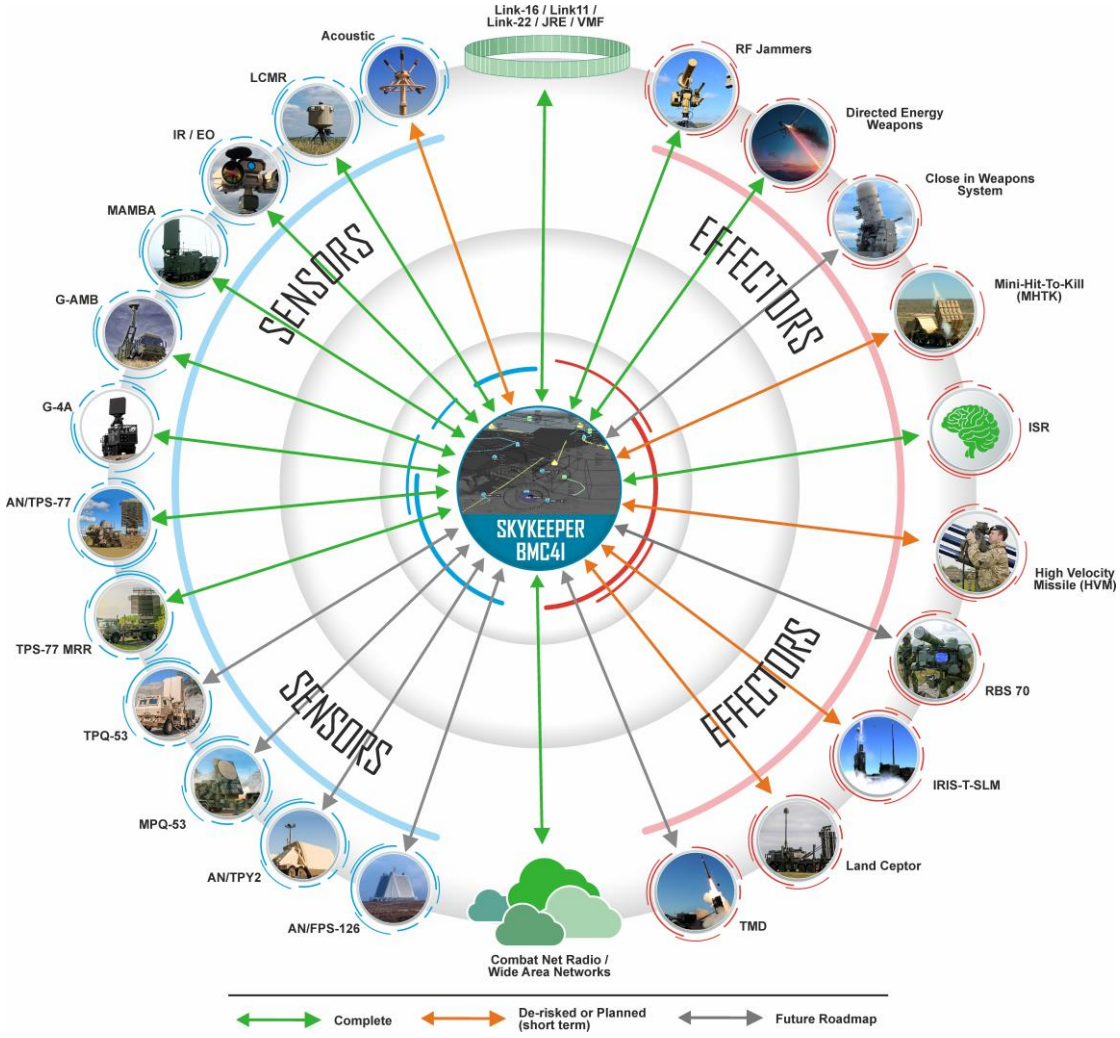

Figure 4 – SkyKeeper sensor and effector integration

SkyKeeper's Threat Evaluation Weapon Assignment (TEWA) functionality provides the bridge between Air Picture identification and hand-off of targets to the Fire Units and has sufficient accuracy

and low latency to enable in-flight correction, via datalink, to systems such as Diehl's IRIS-T SLM and MBDA's CAMM Landceptor, the latter using an active RF seeker in terminal tracking.

By virtue of its open architecture and integrated data links, SkyKeeper could easily be evolved to integrate wider sensors and effectors beyond the current suite of GBAD, C-UAS and C-RAM capabilities.

Likewise, SkyKeeper could also be used to cue non-GBAD kinetic and non-kinetic effectors. For example, Chess Dynamics Anti-UAS Defensive System (AUDS) was integrated fully into the SkyKeeper BMC4I in just 2-weeks, demonstrating not only the true 'plug and play' utility, but real futureproofing.

The system also provides operators with the toolset necessary to assign the most appropriate effectors to targets based on its current track and likely engagement windows as well as the ability to turn engagements semi or fully autonomous, depending on the rules of engagement and threats being faced. Fully autonomous engagement in the C-RAM role may be essential, as the warning and decision times may be too short for operator interaction.

Communication

In its current UK implementation as LEAPP, SkyKeeper uses a combination of Bowman Radio`s, Harris PRC 117G, and Falcon[1] trunk networks – however export solutions exploit the Harris RF-7800W-OU500 High Capacity Line Of Sight (HCLOS) Radio system, which is capable of delivering up to 400 Mbps of Ethernet throughput, and can operate at distances up to 25 km under clear line-of-sight conditions. Connectivity via pre-positioned fibre optic cables may be the preferred solution for enduring critical asset defence.

However, the most import point to note is that the communications mediums used are entirely flexible; some customers may already have backbone communications networks that a new GBAD capability 'plug' into, whilst others may require a completely new network designed specifically for their new requirement.

SkyKeeper is also capable of networking using NATO standard datalinks such as Link-11/16/22, as well as Joint Range Extension Applications Protocol version-C (JREAP-C) and Variable Message Format (VMF) - thereby providing options for data connectivity across the combined and joint environment. Datalinks, direct to the effectors, enable subsequent targeting by the relevant components of the NMS.

A diagram illustrating SkyKeeper's Infrastructure is provided at Figure 5. It illustrates the core and associated module design of the SkyKeeper system, that enables it to be adapted to meet critical

[1] Not to be confused with the LM FALCON GBAD System (see Annex A)

changes, without having to completely re-design the system, saving cost, improving operational efficiency, and providing all important future-proofing.

Figure 5 – SkyKeeper Infrastructure

Mission planning

During operational planning, SkyKeeper is able to assist commanders in the laydown of sensors and control nodes by providing 'heat maps' of sensor coverage (where terrain data is available) and analysing likely air and land avenues of approach. The same functionality can also be used to assist in the laydown of short- and long-range weapon systems (Friendly and Enemy) and assist with Information Preparation of the Battlefield (IPB). This functionality will significantly reduce the time required to undertake sensor/effector laydowns as well as allowing commanders to visually check these laydowns in real time. The ability to laydown weapon ranges offers the ability to wargame the enemy's options. Figure 6 is an illustration of this capability in 3D mode.

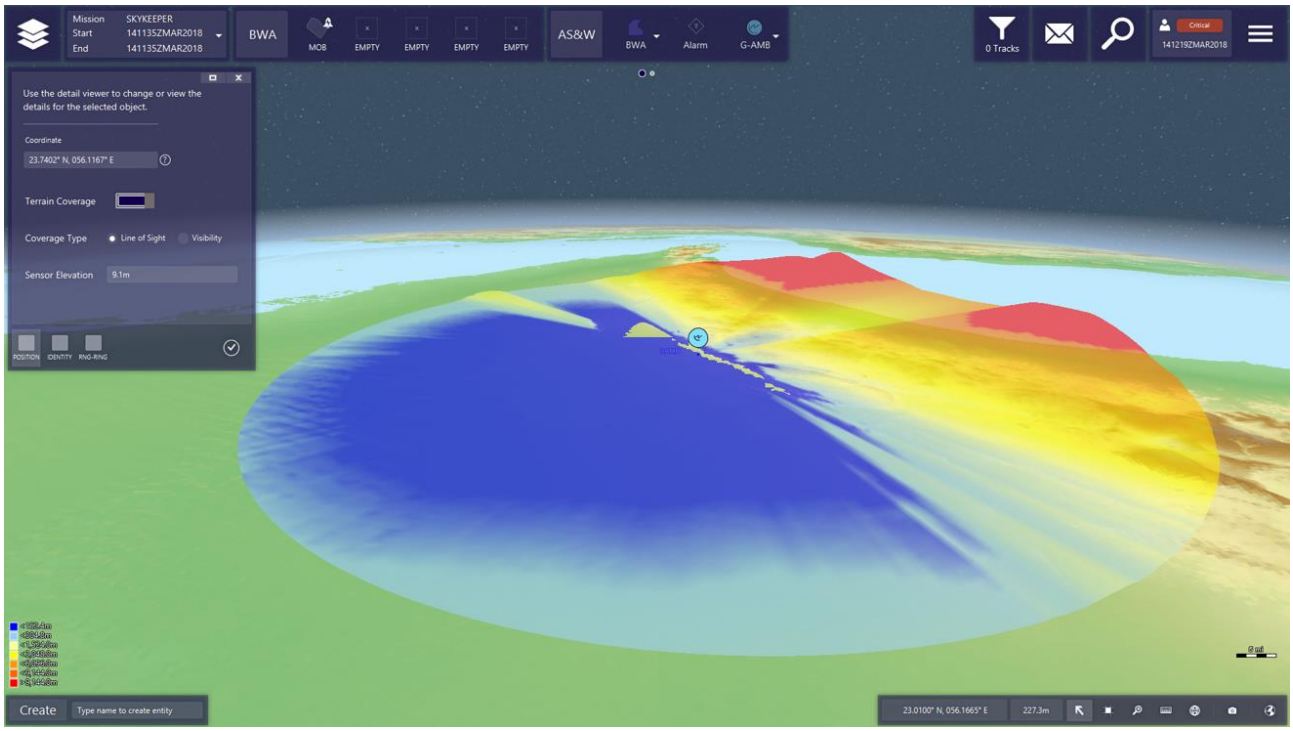

Figure 6 – Sensor coverage in 3D mode

Once the Common Operating Picture (COP) has been compiled, track history (can be days, weeks or months depending on archive policy) can be assigned to tracks of interest in order to assess patterns of behaviour, points of origin or historical movements. This will allow the user to view what the track has done over the archived period and assist with classification of the track or assist with Intelligence collection; the system supports this in both 2D and 3D modes. This functionality is particularly important when operating in the “Grey zone” as it will assist with the point of origin for UAV`s or C-RAM and significantly speed up the identification of whether the track is friendly or hostile.

Variable Form Factor

The current SkyKeeper system is optimised to run from a dedicated ‘ops room’ environment (typically containerised, or as a command mission module on an armoured vehicle), however, work has been conducted to allow the use of ‘scaled’ SkyKeeper applications within different environments.

Clearly the processing power and links to high-bandwidth bearers will be limited in such applications. That said, where the user is interested in only a local picture (VSHORAD or C-UAS capabilities that are unable to be linked directly into SkyKeeper, e.g. hand-held point defence systems) or potentially in a view only mode, then the bandwidth requirements are not excessive and such an application would be a powerful tool at the subunit level and significantly improve situational awareness and operational capability. When fitted to Armoured Fighting Vehicles (AFVs) – which are capable of firing 40mm airburst ammunition – then a scalable SkyKeeper interface would provide a highly

effective means of augmenting All-Arms Air Defence (AAAD). From 'TOC[2] to Tablet', the choice rests entirely with the customer. Figure 7 depicts a generic TOC configuration, utilizing either a vehicle mounted standard International Organisation for Standardisation (ISO) container or ruggedized stand-alone crates with associated display equipment.

Figure 7 – Tactical Operations Centre (TOC)

Scalable capability

As alluded to in the sections above, SkyKeeper is a scalable system. By utilising a "publish and subscribe" architecture, the ability to view information and perform operations can be limited based on user requirements. For example, a hierarchy for information dissemination and receipt can be established that will help to reduce the cognitive burden placed on those operating at the lower level, but significantly reduces the bandwidth required to pass this information around. "Access points" would also allow the vertical passage of information between subunits before being passed horizontally within the unit. This horizontal sharing of information creates resilience within the system and allows units to be self-sufficient. Figure 8 gives an overview of the types of mission, form factor and "Bolt-on's" that the system can support.

[2] Tactical Operations Centre

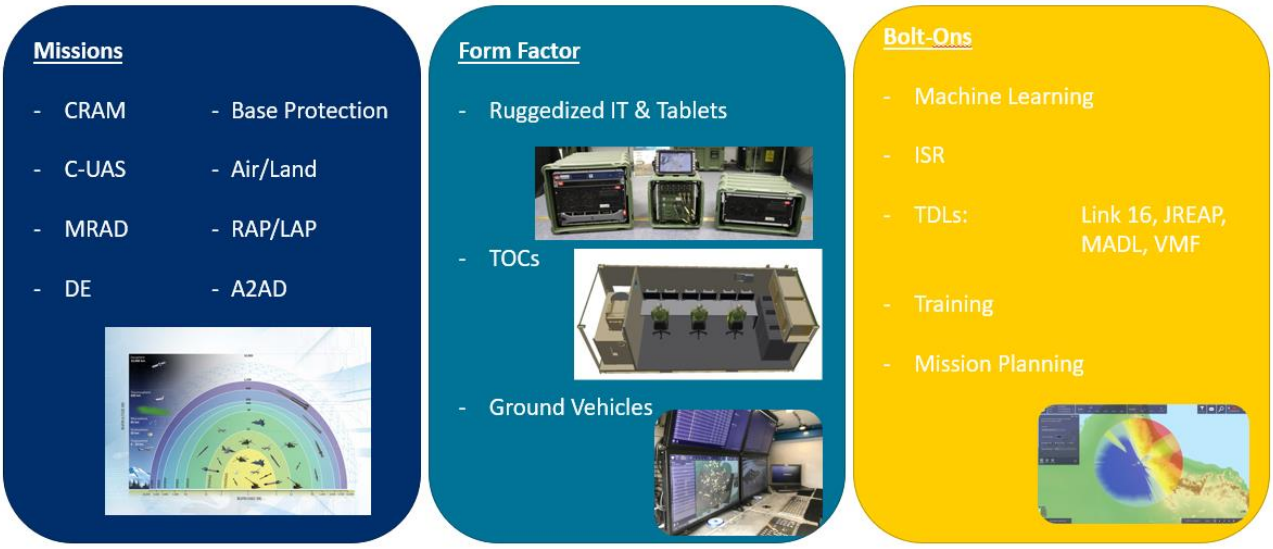

Figure 8 – SkyKeeper scalable mission, form factor and bolt-on's

3 Tailored Solutions

GBAD

For GBAD, Lockheed Martin will provide an integrated solution centred around the SkyKeeper Battle Manager, designed and manufactured by the LMUKA division. Lockheed Martin is also able to team with multiple effector and sensors providers, in order to ensure the solution proposed perfectly matches the customer's requirements. An example of this collaboration is the FALCON GBAD System tailored as a HAWK replacement programme for the Middle East. This capability features the SkyKeeper BMC4I system at its heart, with the German built Diehl Defence IRIS-T SLM missile as its principal effector, and the Swedish built Saab Giraffe 4A radar as its principal sensor. The FALCON example is illustrated below in Figure 9.

Figure 9 - Lockheed Martin Falcon System

The list of potential partners is limitless, as SkyKeeper truly is a 'plug and play' C2 capability. For example, in the MSHORAD environment, tailored vehicle mounted effectors and sensors will be required, with SkyKeeper providing the glue that ties the disparate elements together, making it a truly integrated capability designed to meet a specific requirement. As part of ongoing development work, integration of Weibel Doppler Radar emulators with SkyKeeper has taken place in early 2020 in order to enhance the portfolio of trusted partners and cutting-edge sensor technology and develop further integrated solutions in the VSHORAD and C-UAS battlespaces.

The SkyKeeper Battle Manager will provide the consistent user interface for all GBAD users throughout the echelons, provide a communications gateway for all radio interoperability needs

and integrate existing sensors and effectors to optimise interoperability. The Lockheed Martin approach is to provide the customer with a fully integrated system that leverages their legacy platform capabilities while delivering the architecture to layer and cluster their GBAD units. This moves away from the traditional fire unit approach and utilises the new information sharing technologies to enable greater system interoperability; this can be seen in Figure 10.

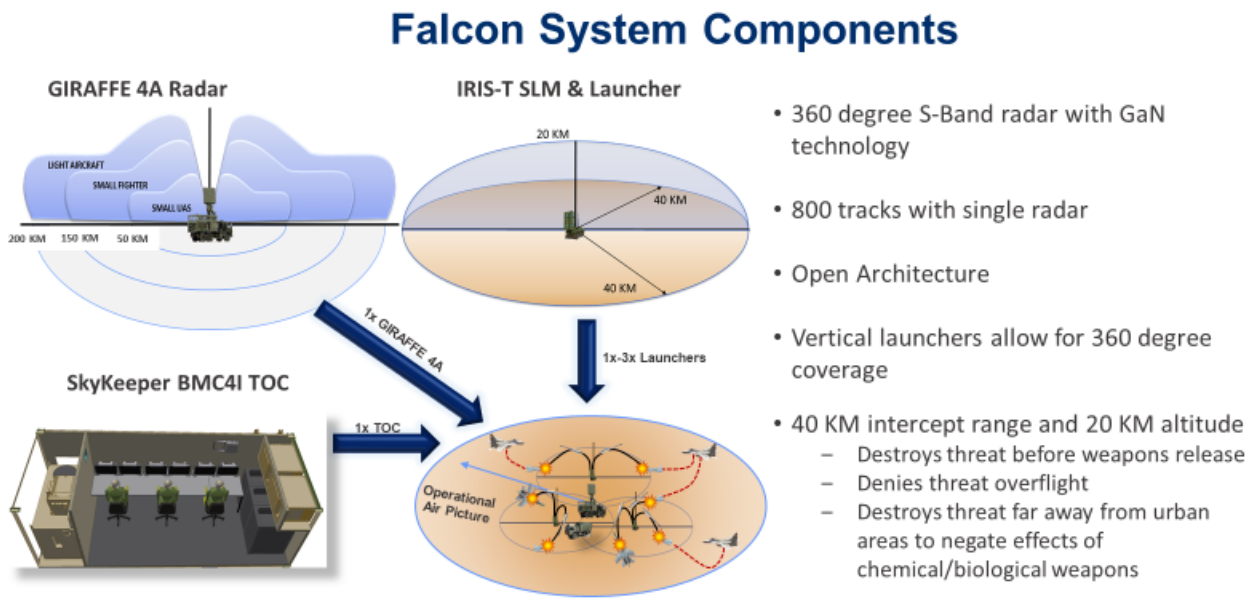

Figure 10 - Lockheed Martin Falcon System

By placing emphasis on the BMC4I solution, the user can optimise the timeliness of decision making, increasing the value of the customer's assets on the wider regional stage. This approach also offers the opportunity for the customer to work closely with Lockheed Martin to strengthen a regional solution with geographically close NATO and/or Allied partners and potentially cost share with partners who share a common goal and follow the same approach for BMC4I interoperability.

C-UAS and C-RAM

For C-UAS and C-RAM, Lockheed Martin will also provide an integrated solution centred around the SkyKeeper Battle Manager; this could be either as a separate system, or as part of a wider IAMD capability that sees the sensors and effectors required for these two missions added to the overarching GBAD BMC4I system.

Kinetic and non-kinetic solutions exist, and SkyKeeper can integrate with either type. An example of this was when Chess Dynamics AUDS was recently fully integrated with the SkyKeeper BMC4I in less than 2 weeks, again demonstrating the true 'plug and play', flexible, adaptable, and future-proof nature of the system's inherent design. Figure 11 illustrates the AUDS capability.

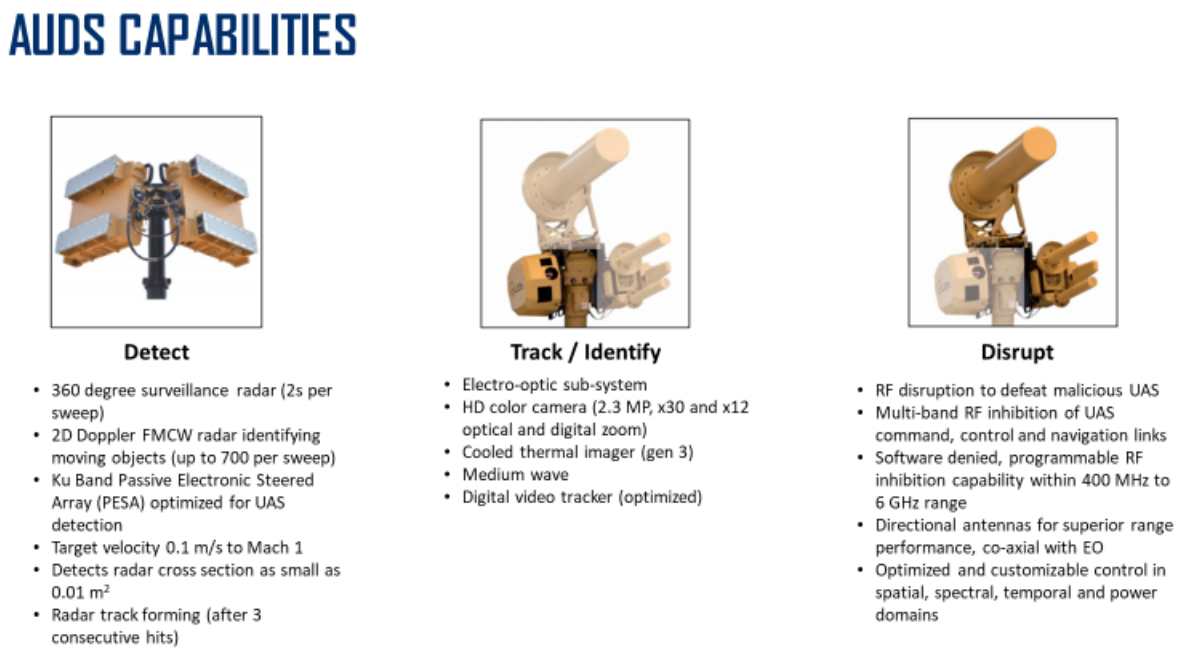

Figure 11 – AUDS

SkyKeeper's C-RAM credentials are battle proven. As previously mentioned, the AS&W capability that has been used successfully on operations by the British Army forms an inherent part of the SkyKeeper core software. This capability, if enabled with the appropriate sensors, will provide instant warning of attack to pre-defined defended areas. If integrated with appropriate effectors, then a proven and automated C-RAM capability could form either part of a wider IAMD system or be deployed as a stand-alone dedicated base or critical asset protective shield.

Interoperability

The open architecture within SkyKeeper enhances interoperability by allowing the integration of sensors and effectors of Allied nations into the Network. This could significantly enhance a user's capability in a coalition environment. With many nations now desperately trying to reverse years of investment neglect in the GBAD area, capability gaps will continue to be evident. Therefore, mutual support from friendly nations in times of need is very relevant. Incremental development of a new system, concentrating first on the BMC4I and communications architecture, may prove sensible. Existing surveillance sensors could be used to provide a threat surveillance picture, whilst interoperable allied effectors could fill the defensive and deterrent gap until indigenous effectors come online.

Such an approach would also provide a natural stepped training roadmap for those nations that are new to the GBAD world. Taking this thought further, nations may even consider a joint procurement, which could still utilise existing legacy equipment where applicable, but share the procurement burden and improve the overall capability to cost ratio.

Joint Effects

SkyKeeper's potential utility does not stop at just GBAD, C-UAS or C-RAM. It has the capability of performing the C2 task for a host of battlefield missions and requirements and could therefore grow into the BMC4I spine for land forces, playing an important role in the Joint Effects arena. Against a peer-level enemy, it is likely that the targeting cycle for Joint Effects will need to be extremely efficient, particularly in the 'Detect' and 'Deliver' phases, where opportunities will be limited, and assets will themselves be vulnerable if exposed unnecessarily.

Given that Air Supremacy/Air Superiority cannot be guaranteed against a peer-level enemy for extended periods, the GBAD component of Joint Effects is likely to be severely stressed – which may coincide with periods of threat Cyber and Electromagnetic Activity (CEMA) attack, requiring additional resilience in C2.

The ability to disseminate, fuse and cross-cue multiple sensor feeds – as well as other forms of intelligence – and link them to the most appropriate effectors, would therefore be a significant force-multiplier in this regard.

Air Land Integration

The F-35 has the potential to gather up a tremendous amount of sensor and intelligence data, but while some of it will be strategic, a large proportion will be tactical. How this information is disseminated to those that need it in a timely manner could be critical in defeating an enemy or prosecuting High Value Targets (HVTs).

As the manufacturer of the F-35, Lockheed Martin is uniquely placed to offer dissemination solutions for relevant information into the land domain. Furthermore, SkyKeeper has already been used to demonstrate this ability during US Deep Fires experimentation. In addition, Attack Helicopters (AH) with VMF and Link 16 could provide another valuable source of information exchange.

4 Development Pathway

Overview

The flexibility of any GBAD, C-UAS and/or C-RAM system centred around the SkyKeeper BMC4I allows for an incremental development pathway. Budget considerations, as well as end of service dates for legacy equipment can all disrupt and influence the pathway to the final required capability. Furthermore, the threat, and therefore the original requirement, is constantly evolving, therefore, a truly 'plug and play' BMC4I that can react to these changes and requirements is not only highly desirable, but wholly essential.

Artificial Intelligence (AI)/Machine Learning

The current SkyKeeper implementation already contains several decision aids and support tools, and this capability could be further enhanced by utilising emerging technologies that assist across the targeting cycle from optimisation of sensor/effector laydown, through target recognition and identification, and engagement planning.

This has the potential to significantly reduce the cognitive burden on the user, especially over protracted deployments. This AI could be used to enhance the user`s capability, with the option to increase and decrease the level of automation depending on the needs of the user. Figure 12 is an overview of an LM AI product currently in development which shows the transition from Human "in the Loop" to Human "on the Loop"

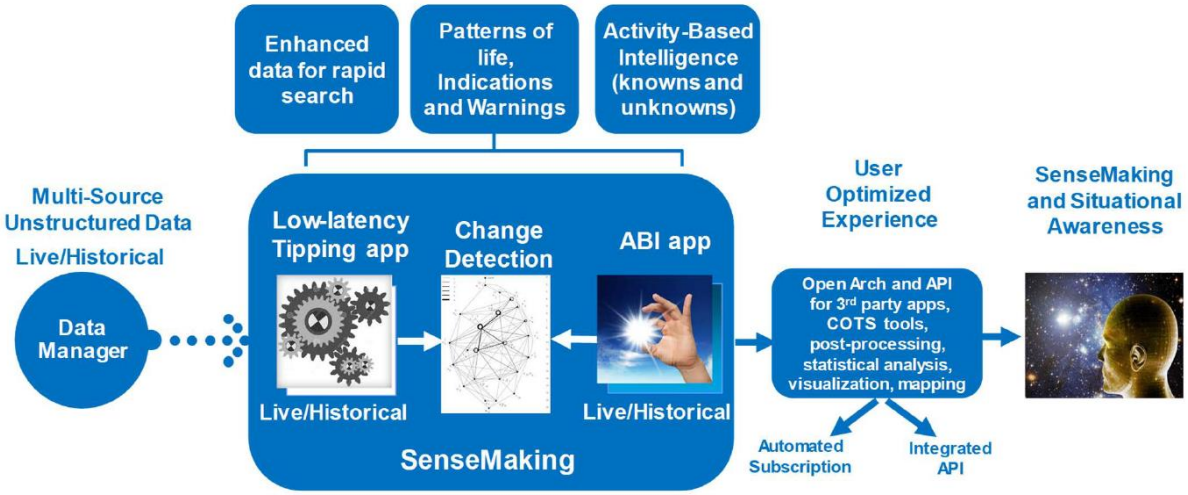

Figure 12 Cognition showing the transition from Human "in the loop" to Human "on the loop"

Directed Energy Weapons (DEW)

Finally, whilst both Laser and RF-DEW can be considered as just another form of effector, their very nature has significant implications for battlespace management – and particularly for manned and unmanned aircraft operating within the battlespace. By virtue of its direct linkage with the RAP and ability to predict electromagnetic propagation across terrain, SkyKeeper is well placed to not only cue DEW effectors, but also ensure appropriate control measures across a joint area of operations. In fact, SkyKeeper is already being utilised in this manner on some emergent US programmes.

5 Summary

Lockheed Martin is a key player in providing solutions to the myriad of GBAD, C-UAS and/or C-RAM requirements that currently exist amongst allied nations. Recognising that there is no one solution that fits all, Lockheed Martin's tailored approach, utilising existing and proven components, integrated by a corporation with vast experience in IAMD, can only benefit the customer. Risk is minimised, compromise is reduced, whilst a flexible development pathway ensures tangible future proofing.

At the centre of Lockheed Martin's offering, is the SkyKeeper BMC4I system; developed from the operationally proven LEAPP and AS&W systems, it provides a scalable, open architecture and tactical C2 spine for purposely designed GBAD, C-UAS and C-RAM capabilities. Through the integration of either legacy or new sensors and effectors, and by acting as a 'funnel' for DDL transmitted information, that may include both specific tactical air picture information and/or wider ISTAR information, SkyKeeper provides a single source of truth within a complex battlespace.

With flexible communication connectivity options, mission planning functionality, and variable form factor, SkyKeeper is a truly scalable system, utilising a "publish and subscribe" architecture that provides the ability to view information and perform operations that can be fully tailored to the user's requirements.

Examples of this flexible approach include the Falcon GBAD solution, that satisfies a HAWK replacement MRAD requirement, through to the SkyKeeper/AUDS solution for Group I and II C-UAS. However, SkyKeeper provides much more than this, as it can also fulfil the tactical BMC4I requirements for Joint Effects and Air Land Integration; the tactical glue that provides the operator with the necessary information that enables timely and effective mission decisions to be prosecuted.

The flexibility of any GBAD, C-UAS and/or C-RAM system centred around SkyKeeper allows for an incremental development pathway. Budget considerations, as well as end of service dates for legacy equipment can all disrupt and influence the pathway to the final required capability. In addition, the threat, and therefore the original requirement, is constantly evolving, therefore, a truly 'plug and play' BMC4I that can react to these changes and requirements is not only highly desirable, but wholly essential.

Annex A Definitions and Abbreviations

Abbreviation	Description
A2AD	Anti-Access/Area Denial
AAAD	All-Arms Air Defence
ABI	Activity-Based Intelligence
ADAD	Air Defence Alerting Device
AFV	Armoured Fighting Vehicle
AH	Attack Helicopters
AI	Artificial Intelligence
AMD	Air and Missile Defence
APIs	Application Programming Interfaces
AS&W	Automated Sense and Warn
AUDS	Anti-UAS Defensive System
BM	Battle Management
BMC4i	Battle Management Command, Control, Communications, Computers and Intelligence
CAMM	Common Air Missile Module
CAS	Close Air Support
CEMA	Cyber Electromagnetic Attack
C2	Command and Control
COP	Common Operational Picture
COTS	Commercial Off-the-Shelf
C-RAM	Counter-Rockets, Artillery and Mortar
C-UAS	Counter-Unmanned Aerial System
DDL	Digital Data Link
DDS	Data Distribution Service
DEW	Directed Energy Weapons
F-35	The Lockheed Martin F-35 Lightning II is a family of single-seat, single-engine, all-weather, stealth, fifth-generation, multirole combat aircraft, designed for ground-attack and air-superiority missions.
Falcon	The **Falcon Secure Trunk Communication System** provide a modem, secure communications infrastructure for deployed formations and operating bases
FALCON	LM GBAD system designed for the Middle East market comprising LM SkyKeeper BMC4I, Diehl Defence IRIS-T SLM, and Saab G4A radar
FMCW	Frequency Modulated Continuous Wave
GaN	Gallium Nitride
GBAD	Ground Based Air Defence
Giraffe-AMB	Saab Giraffe-Agile Multi Beam radar providing organic sensor data to LEAPP
HAWK	The MIM-23 Homing-All-the-Way-Killer (HAWK) missile system is a medium-range**,** surface-to-air guided missile system**.**
HCLOS	High Capacity Line of Sight
HVTs	High Value Targets

Abbreviation	Description
IAMD	Integrated Air and Missile Defence
IPB	Information Preparation of the Battlefield
IR/EO	Infra-Red/Electro-Optic
IRIS-T SLM	Infra-Red Imaging System Tail/Thrust Vector-Controlled Surface launched Missile
ISO	International Organisation for Standardisation
ISR	Intelligence, Surveillance and Reconnaissance
ISTAR	Intelligence, Surveillance, Target Acquisition and Reconnaissance
IT	Information Technology
JREAP-C	Joint Range Extension Applications Protocol – version C
LAP	Land Air Picture
LCMR	Lightweight Counter Mortar Radar
LEAPP	Land Environment Air Picture Provision
Link 11	NATO Standard Digital Data Link used for the transmission of track data and fixed format messages
Link 16	NATO Standard Digital Data Link used for the transmission of track data and fixed format messages
Link 22	NATO Standard Digital Data Link used for the transmission of track data and fixed format messages
LM	Lockheed Martin
LMUKA	Lockheed Martin United Kingdom Ampthill
LOSA	Land Open System Architecture
MADL	Multifunction Advanced Data Link
MAMBA	Mobile Artillery Monitoring Battlefield Asset
MBDA	Matra, BAe Dynamics and Alenia.
MoD	Ministry of Defence
MRAD	Medium Range Air Defence
MSHORAD	Manoeuvre Short-Range Air Defence
NATO	North Atlantic Treaty Organisation
NMS	Network Message Set
PAC-3 MSE	PATRIOT Advanced Capability-3 Missile Segment Enhancement
PATRIOT	Surface to air missile system
PESA	Passive Electronic Steered Array
RAP	Recognised Air Picture
RF	Radio Frequency
SHORAD	Short Range Air Defence
SkyKeeper	LM BMC4I system for GBAD, C-UAS and C-RAM
TEWA	Threat Evaluation Weapon Assignment
TF	Task Force
THAAD	Terminal High Altitude Area Defence
TLVS	‘Taktisches Luftverteidigungssystem’ – German IAMD System
TOC	Tactical Operations Centre

Abbreviation	Description
UAS	Unmanned Aerial Systems
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
VMF	Variable Message Format
VSHORAD	Very Short-Range Air Defence
WASAD	Wide Area Sense and Detect