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Gaining and maintaining advantage in space: Space Domain Awareness or Space Domain Understanding?

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Gaining and maintaining advantage in space: Space Domain Awareness or Space Domain Understanding?

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About the Author

Late in 2021, Tim Adcock joined Inzpire Ltd after 20 years of service with the Royal Air Force.

Through a varied RAF career, that included tours on the staff of the UK's Joint Force Air Component HQ, the British Army's 16 Air Assault Brigade HQ, and time delivering capability as part of 56 Test & Evaluation Squadron, Tim was fortunate enough to focus much of his service career on space operations. As well as commanding the operations squadron at RAF Fylingdales, Tim has found himself at the forefront of UK military space operations development, with key roles as the Space Tactics and Training Officer on the Air and Space Warfare Centre's 92 Squadron, the lead space instructor at the Air and Space Warfare School and ultimately the first UK national to serve on an operational US Director of Space Force's staff; directly supporting US Central Command as its Deputy Director of Space Forces in 2020/21. Tim is also proud to be one of a small number who have graduated from the RAF's Qualified Space Instructor programme, and indeed operated as that programme's lead instructor for several years.

Tim recently added a Master of Science in Aerosystems – Air Operations and Tactics (despite the topic of his dissertation being space operations!) to other academic qualifications, to include a doctorate, gained in and out of the Service. And, as well as remaining affiliated to the RAF as a Reservist operating out of the Royal Auxiliary Air Force's 616 Squadron, Tim is now relishing the challenge of working as the Deputy Head of Inzpire Ltd's recently established Space Division.

Abstract

In October 2019, Deputy Commander US Air Force Space Command (AFSPC), Major General John Shaw directed AFSPC to stop using the term Space Situational Awareness (SSA) and in its place use Space Domain Awareness (SDA). Since then, there has been debate as to how the two differ, and how each coexists alongside other activities such as Space Surveillance and Tracking (SST) and Space Traffic Management (STM). However, there are more fundamental questions that should also be asked:

> As a term describing arguably the most critical core competence of military space power, is SDA fit for purpose?
>
> Does military doctrine define the space domain in a way that fully characterises the range and reach of space operations and activities associated with their delivery?

This paper compares SST, SSA, SDA and STM, and how those activities are defined and or described in UK and US military doctrine. Then an assessment is made whether SDA, as a term describing a critical role or core competence of military space power, is fit for purpose. And associated with that, defining the space domain conceptually to better characterise the range and reach of military space power is discussed. Finally, recommendations are made as to how military space doctrine might be changed to better meet its aim, that is make clear the fundamental principles by which military [space] force is employed.

Introduction

In October 2019, citing Air and Maritime Domain Awareness as concepts to be emulated, Major General John Shaw, Deputy Commander US Air Force Space Command (AFSPC), directed AFSPC (the kernel from which the US Space Force was established in 2020) to stop using the term Space Situational Awareness (SSA) and in its place use Space Domain Awareness (SDA).[1] Since then, SDA has been widely adopted by the military space community, to include the UK[2] and other 'Five Eyes' countries,[3] and was listed as one of five core competencies within the US Space Force's inaugural capstone doctrine of 2020.[4]

Despite SDA being well-established within space doctrinal lexicon, there remains debate as to how SSA and SDA differ.[5] There is also discussion as to how other activities, such as Space Surveillance and Tracking (SST) and Space Traffic Management (STM), coexist and potentially interconnect with SSA and or SDA. 'Doctrine draws on the lessons of history, upon original thinking, and from experiences gained from training and operations. It sets out the fundamental principles by which military force is employed'[6] and to ensure military space doctrine meets this aim, any ambiguity between SSA and SDA should be removed. All efforts should be made to ensure the term used to describe arguably the most critical aspect of military space power is fit for purpose, ie it accurately reflects and describes those activities required in its delivery, to ensure effective application of military space power.

Awareness or understanding

Across operational domains, 'the nature of war remains constant, but the character of conflict changes. Therefore, while we hope to learn from experience, this must be tempered by anticipating change.'[7] In recognising and responding to challenges within the battlespace, a commander must be aware of events as they develop. But to gain and maintain advantage in that battlespace, awareness alone is not enough and it must be coupled with understanding: an understanding of an adversary's intent (insight) and wherever possible an appreciation of what is likely to occur next (foresight). This is as true for military forces operating in the space domain as it is for those operating in any other operational domain.

Understanding is defined as 'the perception and interpretation of a particular situation in order to provide the context, insight and foresight required for effective decision-making.'[8] Understanding helps a commander make decisions; it also helps them manage any associated risks and any second and subsequent order effects. In a military context, understanding underpins all operations as it 'informs choices when developing state policy and strategy; supports the application of national power to achieve influence; and is a pre-requisite for effective decision-making. Understanding helps identify the causes of conflict, the nature of emerging crises, and the context required for determining deterrence, coercion, or response postures.'[9]

Situational awareness is defined as 'how Defence perceives a particular area of interest, problem or situation bounded by time and space in the context of a mission or task.'[10] Situational awareness is critical to identifying what has happened and is happening, but not necessarily why it has happened: 'Commanders and staff require situational awareness in sufficient detail and currency to support effective and timely analysis which in turn enables effective and timely decisions.'[11]

It is clear from these doctrinal definitions that awareness is complementary to understanding but understanding is critical for any commander intent on gaining and maintaining advantage in the battlespace. Understanding is the ultimate goal.

Gaining awareness

In a military context, surveillance is defined as the 'systematic observation of aerospace, surface or subsurface areas, places, persons or things, by visual, aural, electronic, photographic or other means,'[12] and, 'It is conducted against adversaries [and potential adversaries] and can be achieved via passive or active, covert, or overt means' and 'be broad to provide early warning of activity over a wide area or focused to cover a particular location or system. Surveillance, over extended periods, enables patterns and habits to be identified which leads to deeper understanding of other potentially threatening activities or behaviour.'[13] However, accepting space as a unique operating environment, surveillance of space must extend beyond those spacecraft operated by adversaries (or potential adversaries). During times of conflict, within the maritime, land or air domains, it is reasonable to assume that third-party users will avoid active operating areas, or at the very least, they will reduce significantly in number and operate under very tight control. The same will not be true in space. During times of conflict, spacecraft (and orbital debris) will remain in the battlespace and look to operate unchecked. To account for this added complexity, surveillance of space must extend to accommodate those objects and activities associated with their operations.

Space Surveillance and Tracking (SST)

SST is a term often used within the civilian/commercial space community. It describes activities undertaken to survey space and track non-natural objects resident within it, ie spacecraft and orbital debris. By detecting and tracking those objects, orbital information is generated, and services such as collision avoidance, re-entry analysis and fragmentation analysis provided.[14] As part of SST, the sensors used to detect and track spacecraft/orbital debris are the same types of sensors used by military space forces when conducting their own surveillance of space. In fact, it is common to find military forces making use of data collected by the same sensors used by the civilian/commercial sectors, and vice versa.

Activities identified as being associated with SST are a subset of those activities undertaken by military space forces when developing and delivering SSA or SDA. And those services and products that a civil or commercial operator would associate with SST are services and products a military operator would be familiar with, but more readily associate with SSA or SDA. But as a subset, SST is distinct from SSA or SDA. SST does not account for monitoring of the space environment; there is no provision made for assessing spacecraft operator intent; and aspects of spacecraft operations undertaken outside of the space environment are beyond its scope.

Space Environmental Monitoring (SEM)

Space Environmental Monitoring (SEM) involves the systematic observation of the space environment. Different to SST, SEM focuses on the space environment to include detecting and tracking naturally occurring objects within it, for example meteoroids and micro-meteoroids. SEM provides military commanders with an awareness of the natural environment in which spacecraft operate, and how that environment is changing due to natural phenomena such as the solar wind, solar flares, coronal mass ejections and galactic cosmic rays etc. It is then through further analysis and assessment that a commander gains insight as to the effect the space environment is having on spacecraft performance and/or service provision or be able to apply foresight to characterise their future performance.

SST and SEM are complementary activities. Combined, they provide a commander with an awareness of the space operating environment, and events ongoing therein – this will be used later as the basis of a re-worked definition of SSA. However, in combination SST and SEM do not deliver SSA or SDA (as currently defined). Nor do they provide a commander with the insight and foresight required to gain and maintain advantage in the space domain: additional activity is required.

Surveillance outside of the space environment

Military space doctrine commonly characterises a space system that exploits orbital flight as including an orbital segment, a link segment, and a terrestrial segment (to include control and user elements), operating across physical, network and cognitive dimensions.[15] A ground-based space system is characterised in a similar way, save the orbital segment. To fully appreciate an adversary's plan, and gain and maintain advantage in the battlespace, surveillance across all segments and dimensions associated with a space system or space force is required. Limiting surveillance (and, as required, reconnaissance) to the space environment and activities ongoing therein will not provide a commander the insight and foresight they require.

For this work, the author sees little value in providing further information as to the detailed surveillance/reconnaissance activities that might be employed outside of the space environment, other than it should be systematic and delivered via passive, active, covert, or overt means. And like surveillance of space, those activities undertaken outside of the space environment should not necessarily be limited to known or potential adversaries. As a pre-cursor to understanding, awareness should be maintained across all activity that could influence or impact friendly/adversary space operations, regardless of their underlying intent.

Space reconnaissance

Reconnaissance is defined as: 'a mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an opponent or potential opponent, or to secure data concerning the meteorological, hydrographical, or geographic characteristics of a particular area. It is a focused method of collecting information about specific locations, facilities, or people. Reconnaissance is a mission specific task usually of relatively short duration.'[16]

To augment information collected through surveillance, reconnaissance against any or all segments/dimensions of a space system and/or space force may be necessary. As with surveillance, it may be delivered via passive, active, covert, or overt means. But it will be a focused event and as such tailored to provide agencies and organisations with sufficient information to enable rigorous analysis and assessment of adversarial action – again, a precursor to understanding.

Gaining understanding

A commander intent on gaining and maintaining advantage in the space domain must certainly be aware of events that have the potential to influence and impact friendly/adversary space operations. As described above, that awareness is achieved via effective surveillance and reconnaissance, both in and outside of the space environment. However, to be best placed for success, a commander's ultimate goal is to understand: a holistic understanding of all activities pertinent to current and future space operations.

> As currently defined within military doctrine, is SSA or SDA the vehicle by which a commander gains and maintains that holistic understanding?

Space Situational Awareness (SSA)

UK and US military space power doctrine describe and/or define SSA differently:

> UK doctrine describes SSA as 'underpinning all other space roles, as it provides an understanding of the space environment. It enables the timely assessment of and response to space threats, risks, and events, both natural and man-made. It is broken down into four core functions: detect, track and identify; threat warning and attack assessment; characterisation; and data integration and exploitation.'[17]

> US doctrine defines SSA as 'the requisite foundational, current, and predictive knowledge and characterization of space objects and the operating environment upon which space operations depend – including physical, virtual, information, and human dimensions – as well as all factors, activities, and events of all entities conducting, or preparing to conduct, space operations.'[18]

And to add context, the civil/commercial space community also reference SSA, one example being:

> 'Space Situational Awareness refers to the capability of detecting and tracking man-made and natural threats, predicting and assessing the risks involved, and providing services enabling the implementation of appropriate mitigation measures aiming at protecting space and ground assets.'[19]

While President Trump, in his third Space Policy Directive (National Space Traffic Management), defined SSA as:

> 'The knowledge and characterization of space objects and their operational environment to support safe, stable, and sustainable space activities.'[20]

Assessing the UK's description of SSA, two things are immediately clear. First, understanding is clearly identified as the ultimate goal and by stating that SSA 'provides an understanding' it immediately identifies the use of 'Awareness' within the overarching term as being misplaced. This is further supported by amplifying text contained within the doctrine publication that identifies 'attack assessment' as a core function of SSA, ie attempting to understand intent. Second, understanding is limited to the space environment – suggesting any activity outside of the space environment is beyond the scope of SSA. That is not to say those activities are not important, and not potentially addressed by other means, but they are not within the remit of SSA. As currently defined for the UK, SSA provides a commander with a holistic understanding [rather than awareness] of the space environment, to include naturally occurring phenomena.

Assessing the US's definition of SSA, its scope and focus appear distinctly different from that outlined within UK doctrine. While it lists 'characterization' [sic] as a core function, amplifying text limits this to basic or foundational characterisation and as such would provide a commander with awareness rather than understanding. Assuming this is true, in contrast to UK doctrine, the use of 'Awareness' in the overarching term appears appropriate.

However, the US definition of SSA goes on to describe activity focused on 'physical, virtual, information, and human dimensions – as well as all factors, activities, and events of all entities conducting, or preparing to conduct, space operations.'[21] It seems clear that the awareness provided to a commander would encompass all elements of a space system/space force likely to influence their space operations. This is in stark contrast to the UK's definition, which limits itself to those activities in the space environment only.

So, while both nations' description of what is required in the development and delivery of SSA clearly reach beyond those activities associated with SST and/or SEM, each describe different things. UK doctrine describes a mechanism by which a holistic understanding of the space environment is derived, while US doctrine describes a mechanism by which a holistic awareness of the space domain is derived. Neither provide a commander with a holistic understanding of activities pertinent to their current and future space operations that would in turn best support their endeavours to gain and maintain advantage in the battlespace.

Space Domain Awareness (SDA)

As with SSA, UK and US military doctrine describe or define SDA differently:

> UK single service doctrine describes SDA as 'underpinning all other space roles, and provides details of the hazards, risks and threats to the domain. The term moves away from having an awareness of a benign environment towards having a more comprehensive understanding of the entire war fighting domain. This understanding must extend to the ground and link segments of the space system not just tracking a space object itself.[22]

> US Space Force capstone doctrine defines SDA as 'the effective identification, characterization, and understanding of any factor associated with the space domain that could affect space operations and thereby impacting the security, safety, economy, or environment of our Nation.'[23]

And again, to add context, the civil/commercial space community also reference SDA, one example being:

> 'Space Domain Awareness – the ability to monitor, understand and predict natural and man-made objects in orbit around the Earth.'[24]

While the specific text used by the UK and the US military to define SDA is different, the intent appears to be the same: to provide a commander with a holistic understanding of the space domain, to include threats and hazards due to various actors that operate in, to, from, and through the space environment, and those environments across which a space system or space force is required to operate.

The one anomaly that exists with both nations' version of SDA is that its function is to provide understanding, yet the overarching term used to describe it promotes awareness. And while this might seem trivial, it has the potential to leave the reader underestimating or even unaware of the pivotal role analysis, assessment and judgment has when developing and delivering operationally effective SDA.

So, in adopting SDA, and more specifically the description associated with the term SDA, each nation has clearly identified the need for a holistic understanding of the space domain. And through that holistic understanding, rather than awareness, a commander who is tasked with gaining and maintaining advantage in the space domain battlespace will be best placed to succeed.

It is the author's opinion that this is exactly what Major General Shaw was indicating when directing the use of SDA as a replacement for SSA. Drawing from other operational domains, Shaw recognised that commanders conducting space operations need understanding not just awareness, and that such understanding must reach across a broad range of activities and not be limited to the space environment only. What Shaw didn't recognise was that the term he directed AFSPC to use fails to emphasise the critical role robust analysis, assessment, and judgement has in developing insight and foresight. And it is this insight and foresight (understanding) that General James Dickinson, commander of US Space Command, talked to when stating that 'the challenge in the space domain is determining intent' and 'if a competitor satellite is near an allied satellite or an asset, it is extremely important that we understand not just the distance and orbital characteristics, but why it is there? What exactly is its objectives?'[25]

Aiding understanding through Space Traffic Management (STM)

Regardless of the doctrine used, SST, SEM, SSA and SDA have been shown to be distinct and different. And activities associated with SST and SEM have been identified as being a subset of, and complementary to, those associated with SSA or SDA. So, how does STM support these activities?

At this time, while there are several international treaties, principles and resolutions associated with the use of space, there is not a comprehensive set of rules and regulations that dictate the way spacecraft operate. There is not even an agreed set of norms of responsible behaviour. In the air domain, such rules, regulations, processes, procedures etc do exist, and are captured as a collective under the term Air Traffic Management: 'the aggregation of the airborne and ground-based functions (air traffic services, airspace management and air traffic flow management) required to ensure the safe and efficient movement of aircraft during all phases of operations.'[26] A similar concept has been suggested for space and is referred to as STM: 'encompassing the means and the rules to access, conduct activities in, and return from outer space safely, sustainably and securely.'[27]

The scale of challenge associated with agreeing and implementing STM should not be underestimated: 'Designing, developing, and implementing a Space Traffic Management system entails significant policy, legal and technical issues at both national and international level.'[28] Without attempting to provide detail as to how STM might be employed, if a system analogous to that employed in the air domain were to be employed in space, what effect might that have with respect to SST, SSA or SDA?

Put simply, while those who 'operate in space would certainly benefit from a more safe, predictable, and efficient operating environment',[29] STM has no impact on the fundamental requirements underpinning the military need for SST, SSA or SDA. Whether regulated or not, a military commander operating in the space domain would still require awareness and ultimately understanding of activity ongoing across the domain. Where the implementation of STM would have an impact is a likely uplift in capability able to support the development and delivery of SST, ie enhanced sensor coverage with greater fidelity; a regulated, enhanced and presumably assured conduit for data sharing; and an aid to SSA/SDA brought about by having universally recognised guidelines against which spacecraft behaviour could be judged.

To the same point, adopting norms of responsible space behaviour would also enable spacecraft behaviour to be judged and anomalous activity more easily identified, reported, attributed and potentially policed/punished.[30] By having accepted, agreed, or regulated norms of behaviour in place, violation of those norms offers an opportunity to develop criteria by which hostile intent or hostile act in space can be judged.[31] And if these thresholds can be identified, actions taken in self-defence, including actions taken to nullify an attacking force, are likely to be recognised as just and reasonable.

The application of STM through times of conflict is also worthy of consideration. As previously described, commanders operating in the maritime, land and air domains might assume their areas of operation would be devoid of third-party users during periods of conflict. Or, if such users remain, their numbers would be dramatically reduced, and strictly controlled to ensure safe deconfliction. The same luxury will not be afforded a commander operating in the space domain. Spacecraft and orbital debris will continue to exist in the battlespace, and if a STM system were in place, spacecraft being operated by those nations and organisations outside of conflict would likely continue to adhere to it, whereas those nations who are in conflict would presumably abandon STM rules and regulations, favouring unrestricted freedom of manoeuvre and action. In such a circumstance, those nations who abandon the use of STM in favour of freedom of manoeuvre and action would likely be expected to take greater responsibility for deconfliction. Similar behaviour is already commonplace in other areas of 'shared space', 'for example Article 3 of the Convention on International Civil Aviation provides that the Convention does not apply to "state" aircraft, although such aircraft are required to exercise due regard for the safety of navigation of civil aviation.'[32] And military commanders already estimate, account for and even limit operations based on likely levels of collateral damage due to activities such as kinetic targeting.

Fit for purpose doctrinal terms

In their current form, SST, SSA, SDA and STM have been shown to be distinct and different, with SST and STM being identified as complementary to SSA and/or SDA. Also, Major General Shaw's direction to use SDA as a replacement for SSA has been assessed as being linked to a recognition that there is a fundamental need for a holistic understanding of the space domain; something SSA does not provide for (regardless of the doctrinal definition used).

What is yet to be discussed is whether these doctrinal terms, and the activities associated with them, are fit for purpose as they are currently defined – doctrine is 'meant to make clear the fundamental principles by which military force is employed.'[33]

SDA, as initially defined by Major General Shaw, and later adopted by the US Space Force (albeit with a very minor amendment), reaches far beyond awareness – it demands 'understanding of any factor associated with the space domain that could affect space operations.'[34] Whatever the context, understanding refers to the acquisition and development of knowledge to enable insight (knowing why something has happened or is happening) and foresight (being able to identify and anticipate what may happen).[35] Developing understanding initially relies on sufficient awareness so as to allow for further analysis. Through that analysis, insight can then be realised, and by applying judgement to that insight, foresight developed. Military space power doctrine should describe this process in its totality as it underpins the successful delivery of all other facets of military space power: it is arguably the most critical aspect of military space power. The author recommends that the doctrinal terms in current use, and their definitions, be replaced or re-defined, to make clear the commander's overriding need for insight and foresight, ie understanding across the whole of the space domain.

Recommendation: Space Domain Understanding (SDU) should replace SDA as a critical core competence[36] or role[37] within military space power doctrine. And the concept of SDU should capture the need to develop Space Domain Insight (SDI) and Space Domain Foresight (SDF) – knowing why something has happened or is happening (insight) is critical to fighting the current battle but being able to identify and anticipate what may happen in the future (foresight) offers an opportunity to dominate the battlespace and through that assure friendly forces freedom of action while denying the same to the enemy.

Delivering SDU would draw on SDA and SSA (both needing to be re-defined), that are themselves reliant on SST and SEM. Adopting SDU in place of SDA, and describing the process associated with its development in its totality, would make it clear that understanding, not awareness, is the ultimate goal, and in doing so place appropriate emphasis on the role intelligence and military judgement plays in analysing and assessing information to gain and maintain advantage in the battlespace.

As an initial proposal, and to make clear the staged development of SDU, definitions for SST, SEM, SSA, SDA, SDI, SDF and SDU are provided below, along with a graphical representation as to how SDU would be incrementally developed, see Figure 1.

Space Surveillance and Tracking (SST)
Systematic observation of the space environment by active, passive, covert, or overt means, to detect and track non-natural objects resident in, or transiting to, through or from that environment. And allied to that activity, generating foundational knowledge of, and characterisation of, those non-natural objects.

Space Environmental Monitoring (SEM)
Systematic observation of the space environment by active, passive, covert, or overt means, to include detecting and tracking naturally occurring objects resident in or transiting from that environment. And allied to that activity, generating foundational knowledge of, and characterisation of, the space environment and those naturally occurring objects.

Space Situational Awareness (SSA)
Foundational knowledge of, and characterisation of, the space environment and those objects resident in, or transiting to, through or from that environment.

Space Domain Awareness (SDA)
Foundational knowledge of, and characterisation of, the space environment and those objects resident in, or transiting to, through or from that environment. And allied to that, foundational knowledge of, and characterisation of, space system/space force elements operating outside of the space environment and across physical, network and cognitive dimensions.

Space Domain Insight (SDI)
Sufficient knowledge of, and characterisation of, space systems/space forces operating across physical, network and cognitive dimensions to provide a commander with insight of adversary/third-party actions and/or intent.

Space Domain Foresight (SDF)
Sufficient knowledge of, and characterisation of, space systems/space forces operating across physical, network and cognitive dimensions to provide a commander with foresight of adversary/third-party actions and/or intent.

Space Domain Understanding (SDU)
Sufficient knowledge of, and characterisation of, space systems/space forces operating across physical, network and cognitive dimensions to provide a commander with insight and foresight of adversary/third-party actions and/or intent.

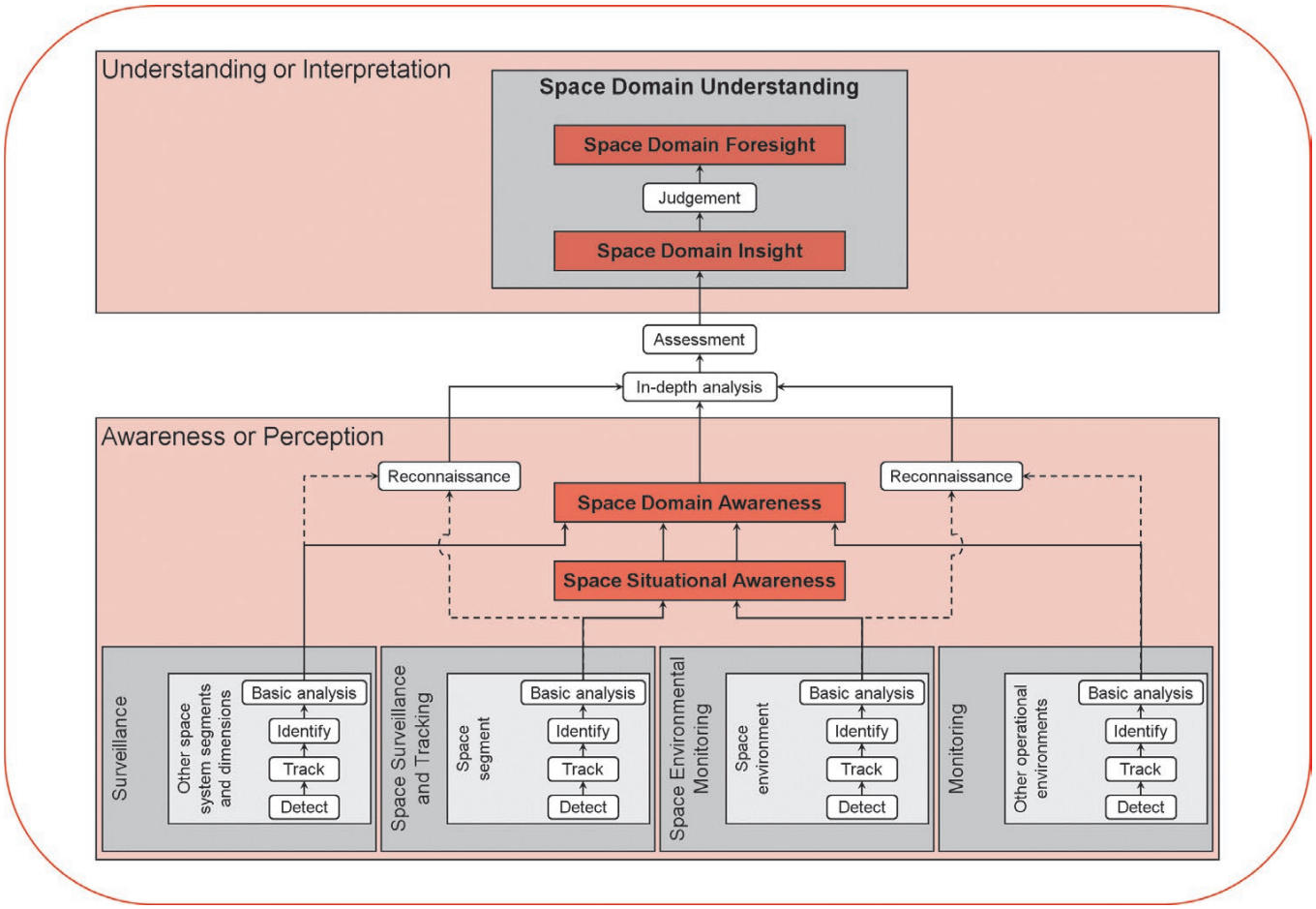

Figure 1 – Space Domain Understanding development

Domains defined by concept rather than geography

As well as replacing SDA with SDU as a core competence or role of military space power, there is also value in altering the way the space domain is defined within military doctrine. Doing so would help reinforce the need to develop understanding across all segments and dimensions used by a space system and/or space force.

US military space power doctrine currently defines the space domain as 'the area above the altitude where atmospheric effects on airborne objects become negligible.'[38] UK space doctrine does not specifically define the space domain, but alludes to it being where spacecraft operate, ie the space environment. However, UK's Joint Doctrine Publication 0-01.1 defines an operational domain as a discrete sphere of military activity within which operations are undertaken to achieve objectives in support of the mission.[39]

Defining the space domain geographically does not help a reader appreciate the range and reach of a space system or the totality of how a space force operates, and with it the diverse set of activities needed to protect, defend and as necessary attack such systems and forces. Dolman also argues that defining a warfighting domain simply 'by medium (land/solid, sea/liquid, air/gas, and space/vacuum) exacerbates overlap and interoperability tensions.'[40]

As listed in US Space Force capstone doctrine, a space system is likely to be made up of several segments (orbital, link and terrestrial), operating across several dimensions (physical, network and cognitive).[41] Military commanders responsible for space operations need to have insight and foresight of: all activities occurring or likely to occur across all segments of a space system and/or space force; how those segments are connected; any critical capabilities, requirements, and vulnerabilities; and the environments in which they operate.

Recommendation: It would be useful to define the space domain conceptually, and in doing so ensure all segments of a space system or force, operating across physical, network and cognitive dimensions, as well as rules and regulations that apply to them, are accounted for. As an initial proposal, Figure 2 illustrates some aspects of what a conceptual space domain might include. The author accepts that this might not be an exhaustive list, but it provides the reader of military doctrine a better appreciation of the full range of activities and considerations that influence and/or impact the day-to-day delivery of military space power and as such should be recognised as activities germane to the space domain. And, in fact, is not far removed from the UK's approach to defining an operational domain, albeit it would better accommodate the complexity of space and the likelihood of third-party users operating unchecked throughout periods of conflict.

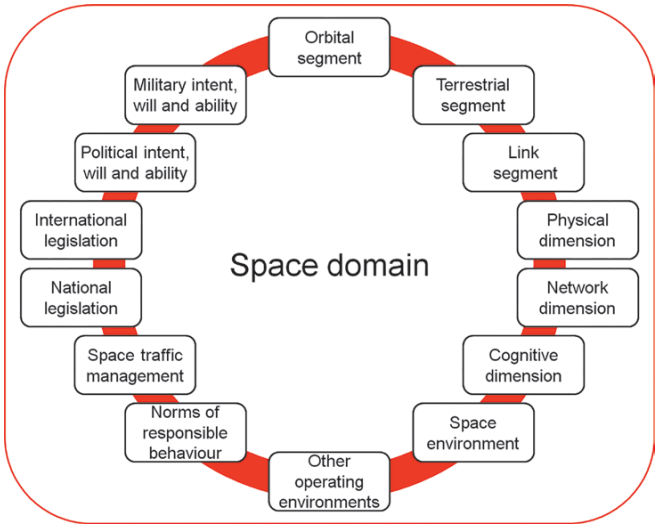

Figure 2 – Conceptual space domain

Jah suggested a similar concept, defining the space domain as:

> 'All conditions, areas, activities and things terrestrially relating to space, adjacent to, within, or bordering outer space, including all space-related activities, infrastructure, people, cargo, and space capable craft that can operate to, in, through and from space.'[42]

Of note, US joint doctrine acknowledges that the concept of domains is a 'useful construct to aid in visualizing and characterizing the operating environment in which operations are conducted'.[43] The recommendation made here is an attempt to codify what the author already believes is implicitly understood, in that an operating domain is different to an operating environment. As an example, if an aviator was to be asked whether an airfield was an intrinsic part of the air domain, it is highly likely they would suggest it is, however, in accordance with US joint air operations doctrine an airfield is excluded from the air domain as the 'air domain is the atmosphere, beginning at the Earth's surface, extending to the altitude where its effects upon operations become negligible.'[44]

Listing SDU as a critical core competence of military space power, coupled with an all-inclusive conceptual space domain, would best make clear the extent to which a commander's understanding must stretch, and thus fully inform readers of doctrine of the challenge that must be met if they are to deliver military space power successfully.

Defining the space domain using a conceptual rather than a geographical approach does not compromise the 'checks and balances' of battlespace management used in partnership with geographically bound areas of responsibilities. US Space Command's area of responsibility is 'the area surrounding the Earth at altitudes equal to, or greater than, 100 kilometers above mean sea level.'[45] Whether defining the space domain conceptually or geographically, activities undertaken by an organisation outside of their designated area of responsibility would still require authorisation and deconfliction.

As an initial proposal, definitions for the space environment and space domain are provided below.

Space environment

> The area above the altitude where atmospheric effects on airborne objects become negligible, where that altitude is above the highest point at which an aircraft can maintain aerodynamic flight but below the lowest possible periapsis [the point of an orbit closest to the celestial body being orbited] of a satellite in orbit.

Space domain

> All conditions, areas, activities, systems, infrastructure, people, and forces relating to space that can operate to, in, through and from space.

Is total understanding realistic or required?

Finally, similar to the level of space control that a military force might require at any given moment, the level of SDU needed at any given moment should be viewed as changeable and dynamic: not all aspects of all space operations need to be understood all the time. Some activities may not have any influence or impact on friendly or adversary military space operations, and as such can be overlooked. And assuming that decision is justified, there would be no value in assigning resource to develop nugatory understanding; it would be better to assign limited resource to investigate those factors that have the potential to influence or impact ongoing or future operations. The challenge remains deciding what is, and what is not, going to be influential. And, for those factors that are likely to be influential, which are to be afforded the greatest attention. Realistically, a space force's ability to develop SDU is likely to be limited by available resource rather than the scope of the task.

Summary

Since Major General Shaw's direction in 2019, the military space community has embraced the use of SDA as a doctrinal concept. The intent behind Shaw's direction being that SDA describes those activities designed to provide timely assessment of threats, risks, and events within the space domain. While the UK and US definitions of SDA go some way to describe the range of activities identified by the author as necessary when developing and delivering SDU, the overarching term itself fails to recognise the critical role analysis, assessment and judgment has with respect to expanding on, and reaching beyond, basic awareness. To that end, in place of SDA, it is recommended that military space doctrine should adopt SDU as a critical core competence or role of military space power. And in so doing describe the need for SDI and SDF, that are themselves reliant on SDA and SSA (once re-defined), and underpinned in part by SST and SEM.

Rather than defining the space domain via geographical boundaries, defining it conceptually would also be beneficial. Doing so would allow all segments and dimensions used by a space system or space force to be viewed collectively, and as such would make it clear that developing SDU is a far-reaching and challenging task, and not one achieved solely by focusing on spacecraft orbiting the Earth. Adopting a conceptual approach would not undermine the use of geographically defined areas of responsibility, and the critical need for coordination, deconfliction, and authorisation of activities undertaken across area of responsibility boundaries.

Finally, when discussing SDU, doctrine should make it clear that the level of 'understanding' required at any given moment is likely to be changeable. It is unlikely that any commander would ever need total SDU, and even if it were, the likelihood of delivering it with limited resource is minimal. What will remain a critical challenge is that those tasked with developing and delivering SDU will need to identify what and what is not going to be most relevant to ongoing and future operations and apportion their resource accordingly.

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The Freeman Air and Space Institute is an inter-disciplinary initiative of the School of Security Studies, King's College London. The Freeman Institute is dedicated to generating original knowledge and understanding of air and space issues. The Freeman Institute seeks to inform scholarly, policy and doctrinal debates in a rapidly evolving strategic environment characterised by transformative technological change which is increasing the complexity of the air and space domains.

The Freeman Institute places a priority on identifying, developing and cultivating air and space thinkers in academic and practical contexts, as well as informing, equipping and stimulating relevant air and space education provision at King's and beyond.

The Institute is named after Air Chief Marshal Sir Wilfrid Freeman (1888–1953), who was crucially influential in British air capability development in the late 1930s and during the Second World War, making an important contribution to the Allied victory. He played a central role in the development of successful aircraft including the Spitfire, Lancaster and Mosquito, and in planning the wartime aircraft economy – the largest state-sponsored industrial venture in British history.

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