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Realising Ukraine's military potential in the Space Domain

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Abstract. Whilst conventional assistance (such as artillery, tanks, fighter jets etc) has been widely discussed, the most indispensable asset has gone largely unrecognised even whilst it shapes all of Ukraine's operations. From the essential communications role of Starlink to the 'space-powered targeting information and processes underpinning Ukraine's strike capabilities, space is the decisive supporting element. During the current war, the leverage provided by the west's decisively superior space capabilities has proved to be vital in allowing Ukraine to resist an ostensibly more powerful force. However, both the need for and potential of Ukraine's own sovereign space power is evident. Ukraine has the history and resources to be a leading space power in Europe and worldwide.

In order to further this aim, once there is the conceptual space to do so, Ukraine must begin the process of renewing and developing a National Space Strategy. This should be followed by, or be concurrent to the development of formal space doctrine. There are many excellent examples of national space strategies which provide much food for thought. These ae resources from which to draw. Ukraine like all countries has a unique set of resources and experiences which must be reflected in such strategy and doctrine. The process of drafting this guidance itself promotes thinking and planning and the product can and must be a guide to all military officers as to what the space domain can offer. It can also promote and drive essential co-operation.

Keywords: space domain, scientific and industrial enterprise, NATO, defense space strategy, Ukraine's military potential.

Introduction

Since the beginning of the space age in 1957, space has been an arena of military activity, offering military and political leaders access to the 'ultimate high-ground'. Space activities were also used to promote ideology, demonstrating the superiority of the US or indeed USSR. All of these factors a still the case, and indeed it is certain that access to space and the use thereof is more important than ever and its importance will only increase. As French defence Minister Florence Parly said in 2021 'If space was the new frontier in the 1960s, there is no doubt that today it is a new front on the battlefield' (French Defence Minister, 2021). The key importance of space activities was confirmed when NATO added it as its fifth combat domain in 2019 (NATO, 2023) and outlined its approach to that new domain. Civilian life in most contexts today, certainly in Europe, relies upon satellites for every major function of life. As in the military world, the importance of – for example – GPS systems in governing bank transactions, supply chains, weather forecasting, agricultural surveying and planning or the use of the internet is rarely considered. Space is absolutely vital however in all of those and many, any more contexts. There are tens of thousands of satellites now in orbit of all sizes

This article will not discus in detail contemporary space operations, partly because such matters are rightly claissified, and partly because they take place – as far as is known – at the tactical level, whereas this brief study is concerned largely strategic and policy matter. However, in general we can state with confidence that space has been an absolutely vital domain in Ukraine's successful efforts

to resist Russia's invasion. Currently, today, the US is by far the dominant space power. There is no Premier League of Space Powers, there is the United States and – in various degrees – everyone else. However, the US is seriously concerned about the rise of China which is placing vast investments into its military space programme. The significant of this for Ukraine may not be immediately apparent, but it is nonetheless great. If Ukraine, or indeed any other allied power is to be sure of gaining the advantages of 'the ultimate high ground' there must be no complacency. Retaining the west's edge is a matter of urgency. As former Commander of US Space Command Lt General Stephen Kwast has put it 'China is on a ten-year journey to operationalise space, we're on fifty years journey' (CNBC, 2017). Ukraine has a major part, if it wants it, to play in helping our side. This short paper outlines how Ukraine may begin, or as we will see, continue to do so. On the way, we will look at the basics of space power, its role in the Ukraine war, Ukraine's role as a leader in space power the importance of strategy and doctrine and finally what partnerships Ukraine can utilise into the future.

The First essential requirement is building awareness at all levels of military operations – beginning by ensuring that all officers are trained in the basics of space power. In turn Ukraine's approach needs to be based upon a sound, NATO compatible doctrine and above all a considered, well-planned and realistic strategy. Second is building Ukraine's already formidable military space skillset. Finally, by leveraging existing skills, knowledge and infrastructure, Ukraine is well-placed to become a leader in European space infrastructure and operations.

Space and its vital role in Defence

Generally, during civilian life or indeed military operations, despite the centrality of space its importance is usually forgotten as an individual gets on with his task. However, almost all military operations have a space element to them. In deed very many would be impossible without them. Most basic space manuals outline the five main tasks and roles fulfilled by space. NATO's 'Approach to Space' (NATO, 2023) outlines them: they are

1 Positioning, Navigation and timing (in English 'PNT'). Of all the functions of space, this is the most founds all others, including communications. The main role of GPS (USA), Galileo (Europe), Glonas (Russia) and Baidou (China) is PNT. The purpose for which GPS was designed and deployed in the 1980s was to assist targeting, and this allowed the development and use of precision-guided weaponry. The direction and protection of these assets is a major role of all space forces.

2 Early warning; this is probably the most strategically vital function after PNT. It allows for the detection of enemy missile launches. Equally importantly it can also determine whether missiles have NOT been launched or prepared for launch and therefore can act in reducing tension. Accordingly, access to space can act as a major factor in threat reduction and assurance

3 Environmental monitoring, extremely useful of course in civilian roles for agricultural and scientific work of various kinds. These kind of applications can, for example, be used for meteorology and therefore mission planning for air forces.

4 Secure satellite communications are absolutely vital for armed forces of all kinds, particularly those deployed worldwide. So for example the UK – not a major space power – has forces globally and has developed the Skynet system (now into its sixth generation) to ensure security of all forms of communications. At the more local level, Starlink – which very different in design and concept from the large older-format communications space craft has proved to be decisive in Ukraine for the same purpose.

5 Intelligence, Surveillance and reconnaissance. All of these functions are of course critical for situational awareness, mission planning and decision making at tactical, operational and strategic levels. Because of its strategic importance, the space domain, as NATO puts it is 'congested,

contested and competitive – the last two imply conflict. Consequently, military space forces are now, for major military powers that can afford or have the expertise to operate or exploit space assets vital component of defence forces. It must be stressed that a power need not have spacecraft in orbit to exploit what space can offer as a vital enabler of military operations. The ability to exploit space is just as important as the ability to build or operate satellites. In deed the latter is useless without the former. Much, indeed some might argue most space technology might be termed 'dual-use'. That is to say that they can be used for civilian or military use. The most obvious example of this is imagery, which can be sued, to take one of hundreds of examples, the assessment of agricultural plantation or the identification and targeting of military formations. As we saw above, GPS and its Chinese, Russian and European equivalents are as much – if not more – useful for civilian applications than military (Defence). Indeed, it is certainly the case that it is *civilian* technological investment and research that drivees military development now. Of course there are many roles of satellites that are entirely military in nature, notably the crucial role of missile defence, where satellites identify the launch of missiles by adversary powers. All of these applications, civilian and military require vast amounts of analytic capability. This role is a crucial aspect of space power (Maxar, 2023).

Significance to the Ukraine war

Whilst all of the roles of space power played a part in the Ukraine war, the key, perhaps even decisive role of space in the Ukraine war, was first appreciated in the early days of the war. This was particularly true concerning its contribution to the Intelligence Surveillance and Reconnaissance picture. This was most publicly visible when pictures of the 'traffic jams' of Russian army vehicles were released. These were produced and delivered to a large extent by the commercial company Maxar. In deed even before the war, the elements of transparency available due to extensive commercial surveillance made it far more difficult for Russian disinformation to develop any degree of credibility. Even ten, and certainly twenty years ago this kind of imagery was available only to those with the highest security clearance. In deed your author recalls using such imagery in planning operations in Iraq when fairly primitive (by today's standards) pictures used for target identification required extensive justification. Now, images of a far higher degree of clarity and resolution are available on anyone's computer or indeed telephone. This ability to access civilian applications which work at or around military specifications highlights what the current commander of the US Space Force calls 'the commercial augmentation of space capabilities' (Breakingdefense, 2023).

No platform demonstrated this more than Starlink, which whilst it started as what amounted to a ex tempore gift from Elon Musk to replace some of the benefits of the communications systems lost to Russian cyber attack, become a crucial enabler – perhaps the only true crucial enabler in Ukraine's arsenal. Whilst there have been controversies over its deployment and use, this remains a vital part of the connective tissue holding Ukraine's Command and Control systems together at the operational and tactical level. It has largely (not entirely) proved resilient to Russian attack (Connell, 2023) and is likely to remain so now that Starlink over Ukraine has now evidently come to some extent under the responsibility of US Space Command (Defenseone, 2023). The various controversies over Starlink, as well as the undoubted decisive edge that it provided highlights the need to caution over the military outsourcing of communications or other space technology.

Clearly products of NATO and especially US space assets are being extensively used to assist Ukraine. Much of this use is rightly classified and only history will be able to tell us what difference it made. One might speculate tht this was particularly useful in the Intelligence, Surveillance and Situational Awareness roles, but confirmation must wait until long after the war.

In addition to services and functions leased or donated by foreign states or companies it is important to recall that Ukraine has also been highly active in its own right in space. Its own 'Sich' Erth observation satellite. Further here is evidence that it has leased services from the Finnish

company ICEYE which has a constellation of synthetic aperture radar satellites (Mike Wall, 2022). Ukraine ahs been successful in conducting cyber attacks against Russian satellite communications (Connell, Michael, 2023). We do know, from extensive open sourcing, that the access to commercial imagery from such companies as Maxar, PlanetLabs and Blacksky have given Ukraine 'a select advantage in the space domain', particularly in the imagery intelligence aspect.

Against the background of the Soviet Union's impressive performance during the Cold War it is important to realise that Russia is most certainly not the power it once was. To put this into context as of May 2022, Russia had 172 operational satellites. Chona had 451 – making it the second space power. Overwhelmingly the leading space power is the United States with 3433 operational satellites in orbit. The situation for Russia is even worse than it initially seems, since many of its spacecraft are coming to the end of their lifetimes. This lack of numbers and presence placed Russia at a significant disadvantage relative to the assets deployed by Ukraine's allies. The military demands of Russia's space assets 'significantly exceeded the supply'. The situation is such as Russia's civilian space agency, Roskosmos, has been required to supply imagery at – by modern standards – very low resolution and low revisit-rate Resurs and Kanopus family of satellites (Connell, Michael, 2023). The practical result of this is that Russia is losing the war in space and until Russia can access some Chinese commercial (or more unlikely military) satellite imagery for targeting and other intelligence purposes, it will remain at a significant disadvantage. It is worth mentioning that a Chinese firm Spacety was sanctioned by the US for providing imagery to the Wagner mercenary organization (Connell, Michael, 2023).

In summary, as Connell puts it 'the performance of the KV in Ukraine significant gaps remain in its capabilities, especially in the areas of earth imaging and reconnaissance (Euspa). In the medium and longer term, there is no doubt that Russia will continue on its trajectory as a declining space power. Its launch services will no longer be attractive or-due to sanctions-legally viable to US and European interests. In the commercial sector there is equally no doubt that Ukraine will be well placed to full part of the gap left by that country. Fortunately, Ukraine has a history and space culture that places it in Europe's first division of space-faring nations.

Ukraine as a spacefaring nation past and future

It is often forgotten, not appreciated or ignored that Ukraine is one of the major European spacefaring nations. This is not the place for a recital of why this is, its deep historical heritage or a detailed survey of its contributions to the exploration and exploitation of orbital space. It is sufficient to state that during the Soviet Union, Ukraine was the heartland of rocket and satellite engineering of all kinds. This industry was centred, and will again be centred in the 'Rocket-city' of Dniepro where the rocket and design facilities of Yuznoye and Yuzmash were based. Ukraine's pre-eminence was still, indeed even more the case before the large-scale invasion in 2022. Indeed, an argument can be made that aside from France, Ukraine was the pre-eminent space-industrial power in Europe aside from France. It constructed and deployed major elements of US and other national space systems, notably the highly successful Zenit, Cyclon (both derived from ICBM designs) and Antares rockets and rocket structures (Nkau).

'Ukraine a country of engineers' and Ukraine's pre-eminence in space-engineering only reinforces this precept. The design, construction and operation of spacecraft may be described as the pinnacle of engineering skills, given the environmental extremes and temperatures within which they operate. Many opportunities for startups like Israel. The applications are not of course confined to the public or state sector. Ukraine has many fine space companies, many of which are adjusting to the needs of the war (Tereza Pultarova, 2023).

All of this demonstrates the potential inherent in this aspect of Ukraine's scientific and industrial enterprise. There is clearly vast potential for investment and development, to assist in the reconstruction of the country's economy. However, the potential does not stop there. There is also

the prospect of leveraging all of this experience, knowledge and infrastructure into the wider and at least equally vital field of military space. As Ukraine further develops as a space power, building on its fine history and current skills and experience it will be vital to get the political and organisational basics right. This implies a number of factors. First, Ukrainian military leaders and space experts will need to establish what its assets and potential in space are, and how that potential might be applied to its military power. There fore a military space strategy will need to be developed. The next section will deal with why this is and what elements it should contain.

Planning the future – Strategy and military doctrine

Serious space powers need a number of institutional basics. First, is a strategy. Ideally a strategy for space security and defence should be subordinate to an overall national space strategy. This is certainly the approach of some countries such as the United Kingdom an ambitious and growing space power, if at the moment somewhat underfunded (see below).

The second, which should follow and be subordinate to a military space strategy, is workable doctrine. As we will see, doctrine is a driver of thinking but also informs operators and allows them a common frame of reference.

Crucially, Ukraine already has defined its ambitions for integration into European and western security structures, the European Union and NATO. Ukraine's future contribution in these areas will be subordinate to their approaches and strategies. NATO has no strategy for space as such. This is as it should be, as it leaves it open to member states how they approach the issue by reference to national priorities. However, NATO does have what it calls its 'Approach to Space' (NATO, 2023) and which is itself subordinate to the NATO 2022 Strategic Concept. The 'Approach to Space' outlines the development of some NATO organic capabilities such as what it calls the 3SAS (Strategic Space Situational Awareness System) be based in Luxembourg and a virtual constellation of national satellites to provide faster data-integration and therefore intelligence. This will be called 'Aquila'. All of this will, it is supposed, be overseen by the NATO Space Centre in Ramstein.

As matters stand, there is no 'common approach' to space strategy. This is currently the responsibility of individual nations; chief amongst them is of course the United States.

United States Space Strategy

The US has of course been developing strategies for its defence activities in space for six decades, and a vast amount of thought goes into each one. It is of course in this respect, as in so many others, in a class of its own. It has a vast space defence system, and each of its now six services have operational contributions and requirements involving the space domain. As matters stand the overrising strategy is the US Defense Space Strategy of 2020 (Defence, 2023). Most of it is classified but a public summary declares that it sets out 'four priority lines of effort to achieve the desired conditions while addressing identified threats, opportunities, and challenges:

1) Build a comprehensive military advantage in space.

2) Integrate military spacepower into national, joint, and combined operations.

3) Shape the strategic environment.

4) Cooperate with allies, partners, industry, and other U.S. Government departments and agencies' (Spacecom, 2020).

From Ukraine's perspective It is worth noting the latter priority of co-operation with allies and partners. It must be stressed once again that the US is in a class of its own. As we saw above it is not only peerless with respect not only to its thinking and experience, but also to its capabilities and number of platforms. It is worth stating her that the US Defense establishment now has its eyes firmly directed to the nation it regards as its 'pacing threat' which is China.

Of more use to any senior military official concerned with thinking about space strategy from a practical perspective, it may be worth looking at how two similarly sized European nations have looked at the development of their space strategies, Europe's current leader in space which is France, and a rather less ambitious United Kingdom.

France's Space Strategy

France has certainly the the most significant space industry and expertise in Europe. In terms of its experience France is in some ways comparable to Ukraine in its long history and focus on the space domain in both its civil and military contexts. Indeed, reflecting its European pre-eminence in space France was the first country in Europe to rename its air force the 'Air and Space Force' ('Armee de l'air et de l'espace') in 2019 if one excepts Russia (VKS renamed in 2015). France in space, as it does in nuclear weaponry and indeed across its military capabilities, prioritises strategic autonomy. Indeed, this is explicitly and firmly dealt with in its Space Defence Strategy (Gouvernement, 2020) which is well-written and is clearly the fruit of extensive and detailed consultation and consideration. It is a model national space strategy, brief (only 36 pages) to the point and clear. I Its space ambitions as described in the Strategy are modified by a realistic assessment of its capabilities. These are considerable, it is important to recall that France is essentially at the centre of the European space industry. which whilst considerable may not be compared to the major space powers. He area around Toulouse is the powerhouse of European and French aerospace activities and ESA has its main launch facilities in the territory of French Guyana, which is a part of metropolitan France. This is reflected in its strategy which sets out an ambitious but achievable set of policies and investments.

The Strategy describes the challenges and opportunities offered by military space, and vitally from the perspective of Ukraine (i.e., as an example of how Ukraine might set out its ambitions) sets out a useful roadmap delineating how France will achieve its strategic objectives. This includes relevant objectives for the development of defined capabilities and indeed equipment, complete with timelines with the overall and overriding objectives of France's wider plans set out in its Military Planning Act. The importance of partnerships is stressed, with clear descriptions of how France sees the contribution other states such as Japan, Germany, the UK, Italy and of course the United States can make to the achievement of its overall strategy. Importantly, it outlines explicitly that the next stage is the formation of doctrine, incorporating the technological and scientific developments with the following principles at their heart: autonomous assessment and decision-taking; France as a driver of the space sector in Europe and developing the means to defend our capabilities and ensure compliance with international law, including self-defence. All of these, and a great deal more within the strategy provides clear guidance for those developing the doctrine for how France does and will operatioalise its space capabilities.

The United Kingdom Space Defence Strategy

In the words of one leading UK space expert, the UK has a lot of catching up to do with its allies' (Juliana Seuss, 2022) UK Space Strategy – less impressive and comprehensive than either France or of course the US – lacks specificity save for budget which is unimpressive for comparison France spent 646million Euros in 2022 (Defensenews, 2022) alone on the space domain. The UK aspires in its space defence strategy – which rightly followed the Space Strategy - to £1.4 billion spread over this decade (although a previously committed 5 billion to the main UK communications satellite system should also be taken into account (RUSI, 2022). Priorities are far less ambitious than France's aspirations focussing first on SATCOM and second on Space Domain awareness, leveraging already existing platforms and facilities on the ground. Various other data support and surveillance satellite constellations are planned (notably the ISTARI system of low earth orbit spacecraft. However, there is an evident lack of specificity and – frankly – ambition in the document and it compares unfavourably to that of France.

The European Union's Space Defence Strategy

The nature of the military alliances and relationships, matters such as security guarantees, NATO membership and so forth are all matters of extensive debate and discussion. Huwever one relationship which will certainly exist and expand is that with the European Union. In the area of humanitarian support from space, the EU has already at least one initiative the '#EUSpace 4Ukraine, the idea of which is to match innovators with humanitarian requirements. This has proposed a number

of applications invoilving the ESA's Copernicus and Galileo systems in humanitarian tasks such as agricultural surveys and EHNSS enabled drones for search and rescue (Euspa). It is worth saying that earth observation and ENSS-enabled drones are potentially dual-use.

However, dual-use or not, there is a significant difference between an ad hoc series of projects and a strategic and operational co-operation between partners for the purpose of defence and security. What then is the EU approach to the space domain and its security implications? Clearly the Ukraine war triggered off some thinking in the EU Commission.

In order to exploit the lessons offered by Starlink, the EU is planning to develop a megaconstellation called Iris (Politico, 2024) which of course will have predominantly civil use, but equally obviously will have a dual-ue. EU now see space as a significant priority and there is no doubt at all that this new sense of urgency was driven by the Ukraine War.

Accordingly, the EU have made a start in becoming active as a player in the space defence world. They have drafted a military space strategy (Eur-lex, 2023). This is similar in some respects to other strategies it sets out to take 'action to protect its space assets, defend its interests, deter hostile activities in space and strengthen its strategic posture and autonomy'.by laying out a shared understanding of space threats', resilience and protection of space systems, Responding to space threats, the use of space for security and defence and most importantly for Ukraine, partnering both with multilateral bodies, close allies such as the US and 'likeminded third countries'…

Over all the EU Strategy is rather more descriptive than prescriptive and so may struggle to be seen as a true strategy. This view may be reinforced by its advocacy of 'exploring synergies' and 'modalities' and unlikely ambitions for ensuring that 'all available EU tools can rapidly e mobilised thereby improving its space response architecture' All of this and more seems somewhat unlikely and rather bureaucratic in nature. Given that this is the EU Commission, this is not surprising. It is an organisation not built for rapid action. Huwever it is blunt that the EU and the Commission lack expertise in space. This is certainly not true overall the EU contains excellent expertise if one defines it as composed as states. As a quasi-state itself, certainly less so. Nonetheless, there is a stress on education and training which is essential in any spacefaring polity. Its lack of specificity in some respects has its advantages from Ukraine's perspective as it may allow for Ukraine to take the initiative whilst being compliant with the strategy, especially aas Ukraine moves towards the EU.

Operationalising Strategy – Military Doctrine

At the same time, as developing strategy. military space experts, once they have established the nature and extent of Ukraine's capabilities now and into the future, will need to decide upon and draft a military space doctrine.

The development of doctrine has several roles. It forces thinking, coheres approaches and provides common standards, A good simple and clear definition of military doctrine is as follows:

'The principle purpose of military doctrine therefore, is to provide the armed forces with a framework of guidance for the conduct of operations. It steers military forces in their actions while also situating the context in which those actions will be taken (UK Army Doctrine Primer, 2011). From that, it should be clear that space operations lend themselves to the development of a common understanding of what they do.

The Role and Function of Military Space Doctrine

The country which has applied by far the most thought to the use of space in military operations is the United States. A close second, is Russia. US Space Readiness and Training Command (STARCOM) set out the function of space doctrine as; establishing a common frame of reference on the best way to plan and deploy space forces as part of a broader joint force'. The US has produced a hierarchy of doctrine publications which taken together provide a comprehensive introduction and guide to military space operations (Starcom).

These are divided into three levels. First there is the 'Capstone' composed of one doctrine note'. This sets out the fundamentals of pace power. Subordinate to that are seven other 'keystone' doctrine publications, at the operational level. These deal respectively with Personnel, Operations, Training, Sustainment, Planning and Mission Command (Starcom). Space Situational Awareness, space battle

management and Joint All-domain Operations sit under the Operations heading.

Finally, there are the documents comprising the tactical element. Below is a diagram of US space doctrine (Ibid).

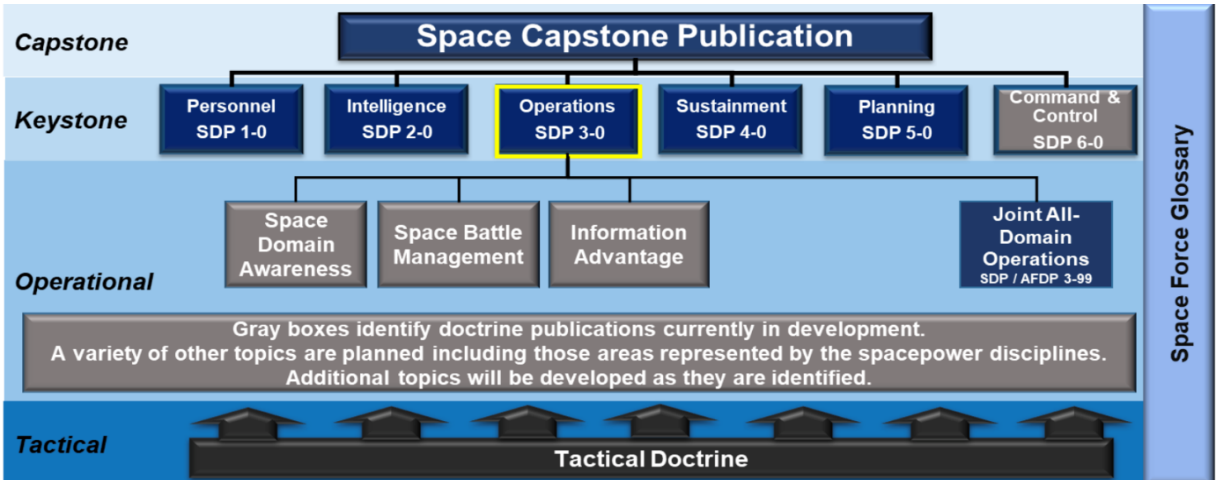


Figure 1. Space Force doctrine hierarchy

These documents et out definitions of terms as understood by the relevant military authorities, competencies and roles, the 'why, how and who' of each of them, the various relationships at the institutional level s that are desirable to build and above al how and with what assets various tasks are carried out. The threats to space assets, in orbit and on the ground as well as in the various electromagnetic spectra are also described with information as to how to counter them. As well as requirements for training and sustainment of on-orbit equipment there are also indications as to the legal and other constraints which apply to space operations.

All of this requires a good understanding of what resources are available or might become available. In the context of space operations these documents also serve as a primer or introduction to how military space assets work within the context of the relevant country. In deed the STARCOM publications provide a comprehensive outline of how the US does space operations. Importantly, it must be stated and recognise that this is the gold standard for space doctrine produced by a state whose space assets are, as observed above, in a league of their own. No other country will match the US in the comprehensiveness of its doctrine and it would be counterproductive to attempt to do so. The importance for Ukraine of these documents is simply that they contain the full spectrum of space operations from which much practical advice can be drawn.

However, is this full systematisation of space power useful to a country with the limited resources of Ukraine? As Ukraine moves towards building and systematising its military space it is important to realise that hat matters most is not the equipment one has, but how one uses it. The last two years of war have demonstrated this principle as a continuing reality. US doctrine is a repository of best practice drawn from many decades of experience and development. For an example of the doctrine of a smaller, experienced but significantly less resourced space power it is worth looking at the United Kingdom.

The United Kingdom' military space doctrine

As we saw above, the UK has a far more limited military space programme than the US or indeed France. However, it has closely followed best practice in developing its strategy alongside its doctrine. Until 2022, UK space doctrine was always published as a component of air operations (UK Ministry of Defence, 2017). In 2022 the first separate UK Space Power doctrine was produced (UK Space Power, 2022). Clear and relatively brief (at just over 104 pages) it is well constructed, well-written and provides a clear account of how the UK sees space operations, particularly with its stress on seeing it as part of an integrated approach. Like all good doctrine, it also provides a very sound introduction to how space power work in the military context. It also provides a clear direction on

how partners inside government and UK industry, echoing the UK National Space Strategy; as it says 'This strategy is about more than capabilities; it is about partnerships; government working as one with industry and international allies' (Ibid). There is also emphasis on academic partnerships.

Conclusions and recommendations

The following simple recommendations require a minimal outlay of any funds, save for the time of the participants for consideration. Both are vital preconditions for the development of Ukraine's potential as a significant space power. Ukraine will require the drafting of a space defence strategy and in due course space doctrine. An essential prerequisite for both of these activities is extensive discussion amongst military space commanders, other commanders, political leaders and diplomats as to the shape of Ukraine's space defence approach. The way other European countries have approached this will provide excellent guidance. The process itself of developing strategy and doctrine is as important as the product. In deed a process without the product of a defence space strategy is far more constructive than the production of a poor strategy without a process.

Those who are convinced of the importance of space to Ukraine need to be conscious that very many people either do not understand or indeed have little or no idea of the importance of military space capabilities. There fore awareness raising is essential. This has been a struggle for many western countries, both for civilian leaders as much as for senior military officials. Convincing decision-makers of the centrality of space to defence is a prerequisite to decisions concerning procurement of investment. Equally important is the necessity of educating more junior officials not only of the centrality of space to defence but how practically it can help them in their day to day work; answering the question so space is important; so what? Ukraine should consider developing a programme of education both for senior officials – military and civilian, and a series of courses for operational officers. At the very least, good doctrine provides the basis for the provision of currucula for such courses.

References

1. French Defence Minister 'Shifting from a new frontier to a new front'. (2021). *Defense News.* December 6. Available at https://www.defensenews.com/outlook/2021/12/06/french-defense-minister-shifting-from-a-new-frontier-to-a-new-front/
2. NATO's approach to space 23rd May (2023) available at https://www.nato.int/cps/en/natohq/topics_175419.htm.
3. URL : https://www.cnbc.com/2017/11/10/usaf-general-steve-kwast-china-in-space-five-times-faster-than-us.html.
4. NATO's Approach to Space available at https://www.nato.int/cps/en/natohq/topics_175419.html.
5. There is an excellent video primer on military GP functions here: https://www.defense.gov/Multimedia/Videos/videoid/906449/
6. See for example https://blog.maxar.com/earth-intelligence/2023/the-game-changing-role-of-commercial-satellite-imagery-and-analytics-in-ukraine.
7. Interview with General Chance Saltzmann Breaking Defense 13th January (2023). Available at https://breakingdefense.com/2023/01/ukraine-spotlights-criticality-of-space-in-conflict-saltzman/
8. Michael Connell; 'The Role of Space in Russia's Operations in Ukraine'. (2023). (Center for Naval Analysis – CAN, November 2023) available at https://www.cna.org/reports/2023/11/Role-of-Space-in-Russias-Operations-in-Ukraine.pdf. at p. 9.
9. 'Pentagon buying Musk's Starlink for Ukraine; *Defense One*. June 1 2023. available at https://www.defenseone.com/policy/2023/06/pentagon-buying-musks-starlink-ukraine/387022/
10. Mike Wall; 'Ukrainian Charity buys radar satellite service sto help fight Russian invasion' (2022). (Space.com 19 August) Available at https://www.space.com/ukraine-radar-satellite-services-russian-invasion.
11. Connell, Michael. 'The Role of Space in Russia's Operations in Ukraine' (2023). Center for

Naval Analysis – (CAN), November. available at https://www.cna.org/reports/2023/11/Role-of-Space-in-Russias-Operations-in-Ukraine.pdf at p. 15.
12. Connell; p. 9.
13. Connell; p. 11.
14. Ibid p. 25.
15. For more information see https://www.nkau.gov.ua/ua/launches-of-ukrainian-lv-ua/
16. For more see Tereza Pultarova 'Ujraine's space start-ups recalibrate to adjust to the challenges of the war'. (2023). (via Satellite 23 November) available at https://interactive.satellitetoday.com/via/december-2023/ukraines-space-startups-recalibrate-to-meet-the-challenges-of-the-war/
17. 'NATO's Approach to Space'; last updated 23rd May (2023) available at https://www.nato.int/cps/en/natohq/topics_175419.html.
18. An unclassified summary (2023) is available here: https://media.defense.gov/2020/Jun/17/2002317391/-1/-1/1/2020_ DEFENSE_SPACE_STRATEGY_SUMMARY.pdf.
19. US Space Command Press release June, 17 (2020) available at https://www.spacecom.mil/Newsroom/News/Article-Display/Article/2223891/department-of-defense-releases-defense-space-strategy/
20. 'Armee de l'air et de l'espace'
21. See 'Defence Space Strategy; Report of the Space Working Group' (2020). available at https://www.gouvernement.fr/sites/default/files/locale/piece-jointe/2020/08/france_-_space_defence_strategy_2019.pdf.
22. Juliana Seuss; 'The UK Defence Space Strategy' RUSI February (2022) available at https://www.rusi.org/explore-our-research/publications/commentary/uk-defence-space-strategy.
23. https://www.defensenews.com/global/europe/2021/09/22/next-gen-tech-investments-platform-upgrades-lead-frances-2022-defense-budget/
24. 'The UK Defence Space Strategy' (2022). RUSI, February. Available at https://www.rusi.org/explore-our-research/publications/commentary/uk-defence-space-strategy.
25. See https://www.euspa.europa.eu/euspace4Ukraine#:~:text=Country%3A%20Ukraine&text=Their%20key%20objective%20is%20to,Tech%20Hub%20in%20Eastern%20Europe.
26. Spac Wars; Europe's mater plan to counter Elon Musks Starlink' *Politico* January, 25, (2024). available at https://www.politico.eu/article/space-wars-europe-masterplan-counter-elon-musk-starlink/#:~:text=But%20there%20are%20problems%20with,Volodymyr%20Zelenskyy's%20calls%20for%20aid.
27. Full text (2023). available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023JC0009.
28. UK Army Doctrine Primer (2011) available at https://assets.publishing. service.gov.uk/media/5a79b6c540f0b63d72fc7eac/20110519ADP_Army_Doctrine_Primerpdf.pdf.
29. See Space Doctrine Publication 4-0 'Sustainment' available at https://www.starcom.spaceforce.mil/Portals/2/SDP%204-0%20Sustainment%20(Signed).pdf?ver=jFc_4BiAkDjJdc49LmESgg%3D%3D#:~:text=United%20States%20Space%20Force%20(USSF,of%20a%20broader%20joint%20force. At p. 3.
30. See STARCOM wire diagram and linked publications at https://www.starcom.spaceforce.mil/Resources/Digital-Library/
31. Ibid.
32. See for example JDP 0-30 'UK Air and Space Power (UK Ministry of Defence 2017) available at https://assets.publishing.service.gov.uk/media/5a8238bd40f0b62305b9320c/doctrine_uk_air_space_power_jdp_0_30.pdf.
33. UK Space Power (September 2022) available at https://www.gov.uk/government/publications/uk-space-power-jdp-0-40.
34. Ibid p. 56.