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Appendix

The air war in Ukraine

What general conclusions can be drawn and which of these are applicable in a Swedish context?

by Magnus Liljegren

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Résumé

The war in Ukraine has clearly underlined the importance of air power, mainly by demonstrating what the result can be when no party succeeds in controlling the airspace. For the Russian side, the combination of strong Ukrainian resistance on the ground, together with the lack of control of the airspace has left them unable to advance, and their offensive has stalled. This even though, according to analysts, Russia initially had the second largest army in the world, with relatively modern equipment and a large personnel resource at its disposal. For Ukraine, on the other hand, the lack of controlling the airspace has meant that they are unable to fight back. Overall, the situation has transferred into a battle about resources. Apart from the brutal and illegal terrorist bombing of civilian targets, the Russian attacker can initially be said to have used air power in a way that mimics the way the West conducts an air operation. This paper analyzes the main reasons why the Russian attack, despite this, did not lead to Russia being able to establish control of the airspace and the overall conclusions have then been analyzed based on how relevant these would be in a Swedish context. By this it has been made clear that the situation prevailing in Ukraine, where the two warring parties have ended up in something like stagnant trench warfare, cannot be seen as probable. Instead, the most relevant and likely Russian attack will be based on surprise and with a great use of offensive air operations consisting of long-range weapons in various forms and this with the aim of quickly creating a state of shock. The experiences from the air war in Ukraine point out the importance of initially having the ability to resist the initial attacks and deny the other party establishing control of the airspace, but also the need to have the ability to subsequently create one's own control of the airspace. In all respects, a situation corresponding to the one that now prevails in Ukraine, with a form of war of attrition, must be avoided, and there, the air power component is decisive. Since it is important not to act too late, this paper also suggests some recommendations to consider: Analyze all conclusions from the war in Ukraine based on how they are affected by fitting into a Swedish context – Analyze the capability of early warning so that it is balanced with the capabilities of movement, dispersion and protection – Increase the ability for mobility and dispersion – Analyze the needs for fortification protection of critical capabilities, socially critical functions and population – Increase the number of ground-based air defense systems so that an increased surface, volume and target type coverage takes place – Analyze how attacking UAS should be handled – Analyze how UAS can be used in an offensive role, such as part of the long-range combat capability – Ensure that the defensive capability to survive the initial attacks is sufficient and that this capability does not require NATO support – Ensure that there is sufficient offensive capability to enable, within the framework of Article 5 of the North Atlantic Treaty, to take and maintain control of airspace – Ensure that sufficient supply capacity is available

within Sweden. Finally, and as a crucial take away, this paper underlines the importance of not underestimating the Russian ability to learn from the mistakes made. Instead, the West must assume that Russia will be able to carry out significantly more effective attacks in the future and this needs to be the basis for the defense planning that is done in Sweden, both linked to article three and five of the North Atlantic Treaty.

UNDER THE LEADERSHIP of Magnus Liljegren, member of the Royal Swedish Academy of War Sciences' Division of Air Warfare Science, this report has been produced, which aims to convey the conclusions, regarding the air domain, that are considered to be of particular importance to take away from the war in Ukraine, and which are applicable in a Swedish context.

If possible, the report should also provide support in the work that may affect the Armed Forces' organization, strategy and/or operational concept. It is also hoped that the report can form part of further discussions on the subject.

The document has been developed with the support of academy members and the topic has been discussed in seminars with participants from the academy, the Swedish Armed Forces, the Swedish Defence University and the defence industry.

Executive summary

The war in Ukraine has clearly highlighted the importance of air power, mainly by showing what happens when neither side manages to control the airspace. For the Russian side, the combination of strong resistance on the ground, together with the lack of airspace control, has made it impossible to advance and the offensive has stalled. This is despite the fact that Russia initially had the second largest army in the world, according to analysts, with relatively modern equipment and a large human resource at its disposal. For Ukraine, on the other hand, the lack of its own airspace control has meant that it is unable to fight back. All in all, the situation has become deadlocked, and a shift to a battle that is more or less about resources has occurred.

Apart from the brutal and unconstitutional terrorist bombing of civilian targets, the Russian attacker can initially be said to have used air power in a way that mimics the way the West conducts an air operation. Virtually all expected tasks, such as offensive and defensive air defense, strike missions, signals intelligence missions, reconnaissance and radar surveillance missions have been carried out. The Russians have also identified and attacked targets deemed relevant and based on the same theoretical air power framework as the West.

The reasons why the Russian attack nevertheless did not lead to Russia establishing control of the airspace were several, and the following six key conclusions have been identified that could provide explanations:

1. The planning was based on an excessive expectation of an easy victory.
2. The management structure was unclear.
3. The ability of air forces to carry out large, complex and coordinated undertakings,

consisting of all components, proved to be almost non-existent.
4. Cooperation between air and ground forces was poor.
5. The ability to manage more dynamic processes was low.
6. The attacks were generally carried out with too little precision, with insufficient weaponry and with poor analysis of results.

Based on how the Ukrainian defense forces have operated, the following four overall conclusions have been identified:

1. Early warning, combined with the ability to move and disperse, was central to surviving the initial attacks, which probably laid the foundation for the high level of resilience subsequently demonstrated.
2. The decision-making cycle has been faster than the Russian one.
3. A high level of adaptability and initiative has continuously put the Russian aggressor in difficult situations.
4. A seemingly prudent allocation of resources has avoided a culmination point.

Transferred to a Swedish context, the analysis has made it clear that the situation in Ukraine, where the two warring parties have ended up in something resembling a stagnant trench war, cannot be seen as likely. This conclusion is based on the differences that can be found in the geostrategic perspective, with longer distances, the Baltic Sea as a natural obstacle and most NATO countries as a buffer. The conclusion is also based on the Swedish Armed Forces' ability to meet a Russian attacker with ground forces being sufficiently high for Russia to be forced to move a large amount of materiel and personnel and that the Swedish air forces, and depending on the direction of the attack also the Finnish, can initially contest the opponent's ability to establish control of the airspace. Based on this conclusion, the work has pointed to that the most relevant and likely scenario is that a Russian attack takes place unexpectedly and with a large use of offensive air operations consisting of remote means of warfare in various forms, with the aim of quickly creating a state of shock.

The conclusions drawn from the war in Ukraine have then been analyzed based on how relevant they would be in this Swedish context. The importance of surviving the initial attacks must be considered central to creating the necessary resilience in the Armed Forces and society in general, and this requires early warning, high mobility, dispersion and protection capabilities, as well as the ability to provide effective air defense. Furthermore, the ability to adapt and innovate, and an organizational structure that allows for a rapid decision-making cycle and adaptation to the unplanned course of events are important components and, finally, a capability is required to initially, and probably on its own, deny the Russian attacker the opportunity to establish control of the airspace in order to establish control of the airspace in the next phase, and then probably within the framework of Article 5 of the North Atlantic Treaty, by means of offensive operations.

Both sides in the war have made extensive use of UAS. However, the experiences that can be drawn from the use of the systems used close to the front and in direct proximity to the fighting ground units, need to be analyzed primarily from a Swedish context. The assessment has been made that the use can also partly be seen as a consequence of the fact that neither party has established control of the airspace, which should also be taken into account when drawing conclusions. UAS have also been used as part

of air operations, and in an effective manner, which is considered relevant in a Swedish context. Not least the ability of these systems to saturate an air defense needs to be considered.

Making concrete recommendations based on conclusions that are in turn based on information from a war that is still ongoing is difficult, and a certain amount of caution must be exercised. At the same time, it is important not to act too late and, given the purpose of this work to, if possible, provide support in the various ongoing work that may affect the Armed Forces' organization, strategy and operational concept, an attempt is made here to summarize some recommendations.

1. Analyze all conclusions from the war in Ukraine in terms of how they are affected by being placed in a Swedish context.
2. Analyze the early warning capability so that it is balanced with the movement, dispersion and protection capabilities.
3. Increase the mobility and dispersion of capabilities that are strategically important for Russia to eliminate in the initial attacks.
4. Analyze the needs and opportunities for fortification protection of critical capabilities, critical functions and population.
5. Increase the number of air defense systems to increase surface, volume and target type coverage.
6. Analyze how to deal with attacking UAS, aiming to saturate our air defense system.
7. Analyze how UAS can be used in an offensive role, as part of the long-range combat capability.
8. Ensure that the defensive capability to survive the initial attacks is sufficient and that this capability does not require NATO support.
9. Ensure that there is sufficient offensive capability to enable, within the framework of Article 5 of the North Atlantic Treaty, the taking and maintenance of control of airspace.
10. Ensure that sufficient supply capacity is available within Sweden.

In conclusion, the experience of the air war in Ukraine points to the importance of initially having the ability to withstand the initial attacks and prevent the other party from establishing control of the airspace, but also to the need to have the ability to subsequently establish its own control of the airspace. In all respects, a situation similar to the now present in Ukraine, with a form of war of attrition, must be avoided, and here the air power component together with the threshold effect created by the ground forces' capabilities, is absolutely crucial in a Swedish context.

Underestimating the Russian ability to learn from past mistakes would be a big mistake. The West must assume that Russia will be able to carry out much more effective attacks in the future and this needs to be the basis for defense planning in Sweden, linked to both Article 3 and 5 of the North Atlantic Treaty.[2]

Need and purpose of this report

During an ongoing conflict or war, it is difficult to draw conclusions. There is a real risk that information is both difficult to assess, and influenced by the prevailing war of information, where the truth is not always allowed to emerge. At the same time, it is of great importance to learn from what is happening, in order to become more adaptive to a changing reality and thus better prepared for the future. With relatively long lead times expected between the time when

experience is gained and the time when a possible change takes place, for example in the form of new technology or a change in strategy, combat technology and/or organization, the time for gaining experience cannot be postponed any longer than absolutely necessary.

The purpose of this report is to try to convey the lessons, with regard to the air domain, that are considered to be of particular importance to learn from the war, and which are also applicable in a Swedish context. It is considered important not to wait until the war is over and the fog of war has lifted because there is already a need to gain experiences that can and should be used within the framework of future defense policy decisions and planning work within the Armed Forces. The report will thus aim to, if possible, provide support in the various ongoing work that can affect the Armed Forces' organization, strategy and operational concepts. The report also aims to form part of further discussions on the subject. The quotes below describe well the need not to wait and to draw the right conclusions.

> The United States and its allies and partners need to be sure they do not dismiss the Ukraine air war simply as an example of Russian ineptitude, but instead examine Ukrainian successes and Russian tactical improvements over the course of the war and modify their warfighting concepts, doctrine, tactics, and training.[3]

Delimitations and definitions

The report focuses primarily on the air operations part of the war. At the same time, it is not possible to completely isolate one arena from another, which means that borderlines will be touched.

The report is based on the war waged after the Russian attack on February 24, 2022, with a focus on the initial phase. This is because it was during this time that the air war was at its most intense and it was during this period that it is primarily considered relevant to analyze the Russian combat forces' use of air power.

The report does not claim to create its own description of the sequence of events but is based on other sources/analyses already carried out.

The term "control of airspace" is used in the text as a description of having some form of control that describes an advantage over an adversary. Air operational control is otherwise often divided into different levels, such as air supremacy, air superiority and temporal/local air superiority, which are different levels of control.[4] For the purposes of this work, the levels are not important, but merely the fact that one party has more control than the other and can therefore exploit the advantages that often come from this situation, such as greater freedom of movement in all arenas.

NATO may impose capability requirements on the Swedish Armed Forces that are not covered by the capabilities that this report considers necessary to possess within the framework of the Swedish context defined here. These NATO requirements are not discussed further in this report but are of course something that needs to be taken into account in the planning that is carried out.

Structure

The work begins with a description of the situation, the purpose of which is to provide a rough description of the course of events, after which this situation is discussed, and conclusions are drawn. The aim is to describe to the reader what the situation could possibly look like if Russia or Ukraine succeeded in taking control of the airspace, and this is done in the following chapter. The reason

for this description is that it is considered to be of interest to evaluate the importance of establishing control of airspace. An attempt is then made to analyze what would have been required of the Russian forces in order for them to have succeeded in establishing control of the airspace, with the aim of assessing whether it can be seen as reasonable that the Russian armed forces will pose a threat in the battle for control of the airspace in the future.

Based on the above, a description of and a transfer to a Swedish context is then made with the aim of evaluating which conclusions are reasonable to consider for Sweden. The work then ends with summarizing conclusions and recommendations.

The situational awareness, a description of the air war dimension

> Airpower should have been one of Russia's greatest advantages over Ukraine. With almost 4,000 combat aircraft and extensive experience of bombing targets in Syria, Georgia, and Chechnya, Russia's air force was expected to play a vital role in the invasion, allowing the Russian army to plunge deep into Ukraine, seize Kyiv, and destroy the Ukrainian military. But more than two months into the war, Vladimir Putin's air force is still fighting for control of the skies.[5]

Perhaps one of the biggest surprises of the war in Ukraine is the air war, and how it has been conducted and developed. At the time of writing, neither side has any real control of the airspace adjacent to the front. This lack of control affects the battle on the ground in a way that makes it very difficult for either side to break through the opponent's defense lines, and a scenario that resembles a more modern version of World War I trench warfare has emerged, with heavy losses on both sides as a result. For the attacking party, Russia, it can be assumed that this scenario was not the desired one and the question can therefore be asked: why they ended up where they are after all? Is it a general ignorance of modern air power theory and how this theory should be put into practice, or is it poor technology, inappropriate organization, training or deliberate choices that have led to the situation as it is? To answer these questions, one method can be to start from how a corresponding Western air operation (Air Campaign) would probably have been conducted, and what different components it would have contained. Once these components are accounted for, the next step is to analyze what went well, less well and why it turned out as it did.

The strategy behind a Western air operation is based on accepted air power theories, as described, for example, by John Warden in his book *"The Air Campaign—Planning for Combat",* where the enemy's weakest points are analyzed and targets linked to these weaknesses are selected.[6] Experience of how an air operation is planned and carried out, according to the West's way of looking at it, can be found, for example, from the Gulf War (1990, 2003), the war in the Balkans (1999), the operation in Libya (2011) and also from the Red Flag exercises in which the Swedish Air Force has also participated.

In brief, an air operation can be said to consist of various components and tasks to be solved. According to the Swedish regulations "*Tactics for Air Operations",* these consist of air defense, attack, collection, air transport and rescue.[7] Air defense in turn contains the parts, offensive (Offensive Counter Air, OCA) and defensive (Defensive Counter Air, DCA) air defense, the attack parts contain ground target and sea target combat, collection contains the parts aerial reconnaissance and surveillance and final-

ly air transport contains the parts airborne transport and air refueling.[8]

A successful offensive air operation is fundamentally based on an analysis that identifies the targets to be attacked in order to achieve the overall strategic objectives. During the first Gulf War, Warden's five rings theory was a cornerstone of planning (see Figure 1). The theory points to the ability of air forces, by virtue of their range, mobility and speed, to attack the inner ring directly, which consists of the adversary's leadership, rather than conducting time- and resource-consuming engagements with the adversary's combat forces first. Pape argued in his "*Bombing to Win*" that it is rather the opponent's combat forces that are the primary target because their loss deprives the opponent of the most important tool to continue fighting, which thus leads to surrender.[9] Although it is debatable which target choices are the most primary and appropriate to attack, it is central to a successful air operation that it is preceded by a thorough analysis of the opponent, considered as a system of systems, which in turn is based on a deep understanding of the opponent's weaknesses and critical vulnerabilities.

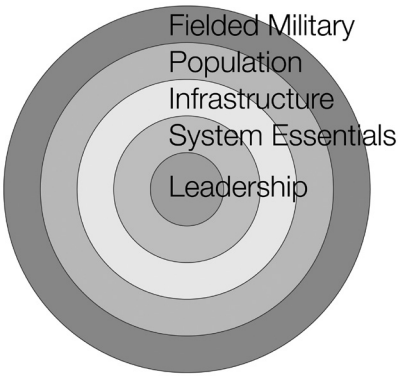

Figure 1: Warden's five rings, where air power, according to Warden, is best utilized by striking the inner ring directly, or several rings in parallel[10]

Target selection analysis is based on various intelligence, including aerial reconnaissance and space-based surveillance. The result generates a target list, which is then converted into an attack plan where different targets are prioritized. The targets are then assigned to the resource, such as fighter aircraft, cruise missiles or unmanned aerial vehicles, that is deemed most suitable for achieving the desired effects. Strikes against these targets are then planned and executed, after which the all-important battle damage assessment (BDA) is conducted. The ultimate aim of BDA is to verify the result of the attack, i.e. whether the intended target has been engaged in a way that achieves the desired effect. If the attack did not produce the desired effect, further attacks may have to be carried out. The pre-planned target list is continuously updated and adapted to the dynamics prevailing on the battlefield and the effects produced by the attacks.

The success of the above attacks requires different types of supporting resources. If the adversary has an air defense capability that needs to be penetrated in order to carry out the above-mentioned attacks, this requires different measures to reduce the risk of own losses. Offensive and defensive air defenses are designed to counter hostile aircraft in the air or on the ground, counter or suppress hostile air defense systems (DEAD and SEAD), counter runways or air defense command and control and logistics systems.[11] This requires careful synchronization with the operations conducting the attack strikes so that the adversary's effects systems are depressed or knocked out at the time of the attack strikes.

With the aim of increasing the availability of combat platforms in the air and thus being able to exploit the opportunities for attack that arise in a dynamic process, aerial refueling is an important resource. Without

aerial refueling, significantly more aircraft are required to achieve the same strike capability per unit time. In order to create endurance and to enable a mobile presence on the ground, a functioning logistics chain is required, where, among other things, tactical air transportation is central to, for example, being able to quickly move ammunition, spare parts and personnel to where they are needed. Finally, the rescue capability is an important part of maintaining a high combat value over time. For both moral and resource reasons, the ability to rescue crews forced to abandon their aircraft is important.

There are few sources that have independently analyzed the air war, and thus a risk that the facts cannot be verified. This work has largely relied on the RUSI report entitled *"The Russian Air War and Ukrainian Requirements for Air Defence"*.[12] This report is considered to give a good picture of the course of events regarding the air war. It can also be noted that several other sources that have been studied refer to this RUSI report, which supports the view that it is relevant to the purpose of this report.

When the Russian procedure is considered, based on the above theoretical framework, there is no doubt that the air war component was evident at the initial stage. Long-range combat capabilities were utilized in a manner that, at least in terms of the targets identified, largely follows the air power theories that the West has also adopted and used in various conflicts. To initially strike with high precision against the opponent's critical vulnerabilities, such as command and control functions, communication systems, radar systems, airfields, air defense systems and similar targets, in order to blind and make it difficult for the enemy to command and operate, is based on what can be said to be classic air power theory.

Initially, a large number of cruise and ballistic missiles were used, with an average of just over 20 missiles fired per day during the first three-month period. By the end of May 2022, more than 2 000 missiles of various types were launched. The missiles were launched from land, sea, both from surface combatants and submarines, and from the air, from the Tu-95 strategic bomber. The systems have proven to work well, with an accuracy within the range of 3-10 m. Initially, few of these missiles were successfully countered by the Ukrainian armed forces, mainly because they were subject to jamming and countermeasures by Russian attackers and because the Russian missiles themselves were difficult to counter. The targets for these missiles were primarily the Ukrainian air defenses.[13]

The coordinates of the targets had been obtained in various ways and over a long period of time, and target lists had been drawn up, prioritized and coordinated, with a clear link to the strategic objectives identified in the plan.[14] After the Russian forces failed to knock out the Ukrainian air defences, the choice of targets was changed to what can be said to correspond to the inner rings in Warden's theory. For example, TV and radio masts, government buildings and symbolically important buildings were hit. This was presumably a way of influencing the will of the population and President Zelensky in a way that would make them question the value of continuing to resist.[15] Other targets, which came to be focused on later in the war, consisted of fuel depots, railway hubs and the electricity grid.

The Russian Air Force had deployed in the order of 300-400 modern fighter aircraft in or near the area of operations, intended to provide support to the operation.[16] In the initial weeks, electronic jamming was effec-

tively used, which seems to have negatively affected Ukrainian air defenses in general, and the S-300 and SA-11 air defense systems in particular.[17] With cruise and ballistic missiles, Russia effectively attacked strategically important radar sites and air defense systems.[18] The attacks, carried out in conjunction with effective electronic jamming, left the Ukrainian MiG-29s and Su-27s to manage air defenses in the early days largely on their own and without any proper command and control function.[19]

The Russian Su-34 bomber and Su-30M and Su-35S multi-role aircraft initially flew around 140 sorties per day. They carried out attack sorties and fighter sweeps, as far as 300 km into Ukrainian territory. Their targets were, again according to the air power theoretical framework, radar stations, bases, ammunition dumps and air defense systems, aimed at enabling Russian airborne forces and helicopter units to advance. They used mainly unguided weapons, and the flights were mostly conducted at medium to high altitudes.[20]

As outlined above, acquisition capabilities are required to identify targets and determine target locations. For this purpose, Su-24MR (Fencer-E) reconnaissance aircraft were used, which consistently flew two to four passes per day during the period February to April 2022. Signals reconnaissance was also used, which was solved, among other things, through the use of Il20-Coot.[21] Alongside this, it can also be assumed that satellite imagery was included as an important component of intelligence gathering.

With the intention of protecting the offensive companies, CAP (Combat Air Patrol) missions were initially conducted with Su-35S and Su-30SM at altitudes around 30 000 feet. These CAP missions were able to effectively combat several Ukrainian MiG-29s, Su-27s, Su-24s and Su-25s and were technically superior to the Ukrainian aircraft. Among other things, the Russian aircraft had significantly better radar and active radar fighter missiles with longer range compared to the Ukrainian semi-active missiles.[22] Added to this major technical difference should be what has been mentioned above regarding the Ukrainian ground-based radar system, which at that time was heavily attacked, which probably meant that the Ukrainian pilots had great difficulty in obtaining good situational awareness (SA).

The above description, together with the fact that the Ukrainian pilots were often greatly outnumbered, sometimes as much as two to fifteen, meant that the Ukrainian pilots had to adapt their tactics to survive.[23] They adopted extreme low-flying tactics, aimed at avoiding detection by using the terrain as efficiently as possible. However, the disadvantages of this behavior are several. On the one hand, there is the obvious risk of flying in the terrain, on the other hand, there is the risk of being fired upon by man-portable weapon systems, and on the other hand, there is the disadvantage of significantly reducing the range of one's own fighter missile weapon.

To provide a good air situation picture, radar sensors are needed, preferably airborne ones. Also this capability Russia had in place. In Belarus and Crimea, long-range radar systems were in place that provided very good coverage, allegedly detecting targets flying as low as 15 feet and at a distance of 150 km.[24] Airborne radar in the form of the A-50M/U Mainstay flew in the order of two to three passes per day and was used to cover the radar shadows that existed, also in accordance with Western tactics.

The Russian forces also used SEAD and DEAD. Russian Su-35S and Su30SM were in CAP to lure Ukrainian radar systems to

open their radar. When the Russian pilots detected that they were being targeted by Ukrainian reconnaissance radar, they fired Kh-31P or Kh-58, which are signal-seeking weapons. At the same time, Russian Su-25s carried out attack missions with rockets against the Ukrainian radar stations when they were suppressed by the signal-seeking missiles.[25] A fairly sophisticated behavior that also reflects the West's tactics and combat techniques.

For targets, such as the Azovstal steelworks, which required heavier bombs, heavy bombers such as the Tu-22M3—Backfire were used.[26]

What is not included in the picture above is the activity that is usually conducted closer to the front and then in connection with ground units, i.e. close air support, CAS. CAS can be conducted with airplanes, helicopters or unmanned systems (UAS) and this ingredient has also been included, although at a much lower level than might have been expected, not least given that the ground units' need for air support was obvious.

It is highly likely that Russian ground forces requested air support on those occasions when they were pushed back, for example at Kharkiv, Luhansk and Kherson. At the same time, the RUSI report points out that there has been no increase in the intensity of Su-25 or Su-34 support aircraft as a result, which may seem remarkable.[27]

Initially, however, extensive and aggressive attacks were carried out against Ukrainian forces using helicopters such as the Ka-52, Mi-28 and Mi-24/35. The missions flown initially involved finding and eliminating enemy troops and materiel using rockets, guided anti-tank missiles or automatic cannon (hunter-killer sorties). Initially, these types of missions were flown as far as 50 km into Ukrainian territory, both day and night.[28]

The use of Unmanned Aerial Systems (UAS) has generally been very high during the war, but during the initial phase these systems did not, it seems, form a crucial part of the Russian plan. Nor is it likely that the use of UAS would have been a crucial part of a Western planned air operation during the initial phase, when airspace was not yet controlled. During an initial phase, strategic UAS resources could possibly be used primarily for intelligence gathering, but also for certain specific weapons operations, where, for example, the risks of using manned systems were too great. However, the larger strategic UAS resources cannot easily be protected from active air defense. At the same time, it can be noted that the use of UAS in a high-intensity conflict is largely uncharted territory for Western countries. The experience available has mainly been gained from conflicts where the asymmetry between the various parties has been evident, such as in Afghanistan, Iraq and Libya, which means that the threats to these UAS have not been particularly evident. It is more likely that the extensive use of UAS in the Ukrainian war was a consequence of the fact that no party had mastered the air, which will be developed further later in the report.

The Russian attacker can initially be said to have used air power in a way that mimics the way the West acts in the context of an air operation. Russia had some form of air operational plan and had a target catalog linked to this plan and, as it seemed, the targets were well chosen, where identifiable critical vulnerabilities can be found. The Russian target selections have been grouped and prioritized in what appears to be a theoretically correct manner, targeting the Ukrainian armed forces, critical infrastructure, systems important and critical to Ukrainian society, and the Ukrainian lead-

ership. Russian forces have also attacked these different targets in parallel and not sequentially, which is one of the strengths of the air force. The Russian forces have largely utilized the components that can be expected in an air domain operation and utilized them in a generally accepted manner. It can therefore be argued that there was basically a good plan and an implementation that from a theoretical and doctrinal point of view went right. Nevertheless, we know that the Russian forces failed to defeat the Ukrainian air defenses and thus were unable to take control of the airspace, which can be assumed to have been a crucial part of their plan. So, what went wrong and are there possible explanations for this?

Overall, a fundamental aspect to consider is probably that the planning was based on the belief that the operation would be relatively quick and limited, with no major difficulties expected. It is reasonable to assume that Russia underestimated the Ukrainian resistance, which may have led to inadequate strategic planning, incorrectly composed Russian forces and poor operational planning with unattainable goals for the Russian forces. The quote "Underestimation of the enemy is the first step to military catastrophe; this is the mistake that Russians made during the invasion of Ukraine and which we should not repeat"[29] indicates that this may be a correct conclusion to draw.

It is also questionable whether the planning was carried out by the military profession or rather by the Russian Federal Intelligence Service (FSB), which in turn based its plan on what appears to be questionable intelligence.[30] It is possible that there was something in this intelligence that led to a strong overconfidence that the Ukrainian people would turn against the Ukrainian leadership and side with Russia, which may explain why a plan based on the need for a more extensive operation was not considered necessary.

Looking at different events, it can be seen that the outcome is often about events on the margins, where a different outcome in many cases was probably not far away, whereby a completely different course of events could have taken shape. It is often a battle between means and countermeasures, the need for good intelligence, a fast decision-making cycle, good management structure and a generally creative organization.

The initial strike by Russian air forces did not have the full effect sought. One of the main reasons for this was probably the advance warning Ukraine had received, including from other countries, which in turn led Ukraine to redeploy what could be redeployed, such as mobile anti-aircraft systems and aircraft, before the first wave of Russian strikes was launched.[31] Russian forces were thus put in a situation where the pre-planned target locations were no longer accurate, requiring a more dynamic target selection process, which in turn required a rapid decision-making cycle. Taking on this more dynamic task would prove difficult for the Russian forces.

An important component of the more dynamic combat is the ability to quickly analyze the effects of the operations conducted, in order to decide whether the desired effect has been achieved, or whether renewed attacks are required. Russian air forces operated with few aircraft per operation, often individually or in small formations, rarely exceeding a handful of aircraft. This led to inadequate combat capability and performance analysis (BDA).[32] Added to this is the fact that the Russian system expects positive results and personnel risk being penalized for failure, which may have affected pilots' willingness to give an accurate pic-

ture of how the attacks went. The above is likely to have resulted in several targets not being engaged, even if attacked, and the subsequent impact analysis being based on incorrect reporting data.[33]

To cope with a more dynamic battle, a nimble organization with short decision loops is required, and it is generally accepted in the West that it is the pilot who should be provided with the correct data, with the aim of giving him a good understanding of the world around him and a basis for decision-making, thus allowing him to act when the opportunity arises and without time delay. If this is to work out, there must be trust in the people in the system and mission tactics must be a fundamental management principle. The lack of this in the Russian system is described by Dr Viktoriya Fedorchak in her book *The Russia—Ukraine War* with the text "The Russian tradition of using fear and firing squads in warfighting had not evolved much since World War II, nor had its organizational culture of rigid hierarchy and complete centralization, killing any initiative and unconventional thinking."[34] Herein lies possibly one of the most fundamental differences between the two systems, the Russian and the Western, which may have negatively impacted the Russian ability to manage a more dynamic course of events.

The Russian system is also in a completely different way than in the West centered around the battle on the ground and the air forces are seen more as supporting systems of the type "airborne artillery". "Russia has never fully appreciated the use of airpower beyond support to ground forces."[35] It is on the ground that the decisive battle is expected to take place and it is thus the army that constitutes the branch of arms that is put in focus, which in turn is reflected in how the Russian armed forces are organized and also how information flows. In the West, information from the AWACS aircraft is transmitted directly to the respective fighter aircraft, without delay, whereby the pilot can act according to the mission to be solved. In the Russian system, the A-50 Mainstay generally transmits its radar information to a command center on the ground, after which the information is converted into an order, which is then sent to the fighter aircraft and air defense systems, which presumably creates too much time delay, with a constant lag as a result when the time pace of the battle increases.[36]

Initially, there did not appear to be a designated military commander responsible for the entire operation, but the leadership was divided between several commanders.[37] After the Russian forces initially failed to achieve their strategic objectives, a situation seems to have arisen that was mostly a consequence of the possible lack of an alternative plan. The initial uncertainty meant, among other things, that Russian air defense systems risked shooting down their own aircraft and that Russian jamming also disrupted their own communications, thus reducing jamming. This chaotic situation allowed Ukrainian forces to regain some initiative and regroup their forces. Russian air forces also shifted their strategy at this time, with a clearer focus on providing more direct support to ground forces. Why the Russian forces made this strategic shift has not been determined, but it was probably because Ukrainian air defenses were still active and considered too dangerous to continue operating aircraft in the areas and at the altitudes they had done previously. Moreover, there is no getting away from the fact that air power is seen primarily as a support to ground combat, which may also have influenced the decision to change strategy.[38]

As a consequence of this change in Russian strategy, air operations were conducted at lower altitudes, which in turn exposed Russian aircraft to Ukrainian hand-held air defense systems (MANPADS), such as Stinger and Starstreak, with relatively high losses as a result.[39] The tactic of attacking at low altitude also posed completely different challenges than the attacks initially made against predefined targets from medium or high altitude. This type of attack requires a lot of training, good intelligence on the target and positions of both friendly and enemy units, and a good map base. Attacking dug-in troops during the day, who also largely use the same equipment as their own units, which makes target identification difficult, and who possess a large volume of MANPADS, made these attacks difficult and dangerous for the Russian pilots, and the tactic was therefore changed to carrying out the attacks under cover of darkness.

Attacking in the dark requires night-adapted systems, such as sensors, night vision devices (NVDs) and, not least, extensive training. This proved too difficult to implement and the target choices therefore shifted again to simpler targets, such as cities and other more easily accessible infrastructure, target choices that contravene international law and which also did not prove to provide the military effects sought.

Again, it seems clear that there was no clear strategy behind the change in target selection, but it seems to have been more of a reactive action to a lack of effect and perhaps also a desire to demonstrate success in some form. At this point, around April 2022, when the Russian side realized that the initial strategy of a quick victory had failed, the Russian forces reorganized to concentrate on the area around Donbas and Mariupol.[40]

Following the Ukrainian ground offensive and the subsequent cementing of the situation at the front, the air forces of the respective sides do not have sufficient capability to seize the initiative and establish adequate control of the airspace over the front area. The mere fact that Russian MiG-31s equipped with R-37M long-range weapons are patrolling the area has made it very difficult and dangerous for Ukrainian aircraft to operate there. The speed and altitude of the MiG-31s, combined with the range of the weapon, can put them beyond the reach of Ukrainian air defenses while posing a significant threat. The threat from Ukrainian MANPADS has made it too dangerous for Russian air forces to carry out CAS missions, which is why the attacks that are carried out are instead carried out from longer distances with less precision as a result.

For the Russian attack helicopters, too, the threat from MANPADS in particular, became too great in their initial "hunter-killer role", which meant that they were redeployed to carry out most of the attacks from their own side of the front. The attacks were carried out mainly at night and by "tossing" the rockets in order to increase the range and reduce the risks of friendly fire. This type of attack generally produced poor precision.[41]

As described above, Russian use of cruise missiles and ballistic missiles was extensive in the initial phase. However, the Ukrainian air force managed to redeploy its forces and build a relatively robust and well-deployed system around key cities and infrastructure, reportedly managing to defeat 50-60% of the incoming missiles and ballistic missiles by around June 2022.[42] Ukraine also appears to have deployed the different capabilities of its air defense systems wisely, with the longer-range and less mobile S-300 system being used in a withdrawn manner, mainly

to protect cities, while the shorter-range and more mobile SA-11 system was used more in a frontal role. The war evolved into a battle of numbers, where it became apparent that the Russian forces were running out of cruise missiles. This was possibly the main reason for the introduction of the Shahed-136 suicide drone as a substitute.

The Shahed-136 was imported from Iran and was used as a strategic long-range combat capability.[43] With these much cheaper weapons, the Russian forces switched to a tactic whereby they could saturate the Ukrainian air defenses in order to reach them with the more expensive weapons that also had more explosive power. This tactic has been successful, not least because the sheer volume of attacking threats means that the Ukrainian air force's missile inventory requires constant replenishment to keep up.[44]

Discussion on the presented situation

There are clear similarities in principle between the Russian air operation during the initial phase of the attack on Ukraine and the way a Western offensive air operation would have been assessed against a similar adversary. All the tasks that should be included were carried out, possibly with no rescue (no information on this has been found) and, it seems, with a much smaller volume of air refueling capacity than the West would have used. The target choices initially tended to be the "correct" ones from a system of systems perspective, where the initial aim was to blind and paralyze. The fact that, from a Russian perspective, things did not go as planned can probably be explained by both Russian inability and Ukrainian capability.

The Russian inability was found at all levels of command; strategic, operational and tactical/combat engineering. Below are those that are considered to have had the greatest impact on the outcome of the war.

At the level of military strategy, two things appear to be most influential on the outcome. First, there seems to have been no alternative plan after the initial attacks did not produce the expected results. Second, a crucial weakness was the seemingly unclear command and control environment, where the lack of a clearly identified cohesive military commander for the whole operation meant that the interaction between different elements and geographical areas did not work well enough. This led to a variety of tempo losses, mismatches and a generally inefficient use of the various capabilities at the operational level. The conductor was simply not in place when synchronization was most needed.

At the operational level, and probably partly as a consequence of the lack of clear command and control, the interaction between the ground and air arenas was generally poor, with the lack of synchronized support to the ground battle being conspicuous. The initial problems of interoperability between own air defenses and fighter aircraft are another example of this inability. Nor was it possible to establish the level of air control required to enable the ground forces to act more freely without risking heavy losses.

At the tactical/combat level, there are five notable weaknesses:

1. The weapons operations do not seem to have been carried out in a way that had the intended effect, resulting in several targets not being destroyed.
2. Insufficient implementation of BDA meant that the results of the attacks carried out were unknown, or alternatively a more positive picture of the result was given than was actually the case. This

meant that after a while there was a great deal of uncertainty as to which targets had actually been defeated.
3. It was unable to cope with a more dynamic targeting process, where emerging targets could not be dealt with at the pace required to enable an opponent to be dealt with dynamically.
4. The level of technology appears to have been unevenly distributed between the different types of aircraft and also not available in sufficient quantity, which meant, for example, that there were severe limitations on the ability to operate effectively in the dark and that there were limited possibilities for delivering high-precision weapons to the desired level.
5. The level of pilot competence appears to have been generally low, with the ability to operate in larger formations, in more complex environments, and in all weather and visibility conditions, including darkness, constituting some critical skill gaps.[45]

Although the inability of one actor affects the outcome, it is only when this inability is combined with the ability of the other to utilize these inabilities that the outcome is more clearly affected.

Successful defense is fundamentally based on a good plan that creates the best possible conditions, but after the process has begun, it is rather the ability to adapt to the developments that take place that decides, and therein lies possibly the most tangible ability of the Ukrainian defense. Summarizing the Ukrainian defence capability can possibly be done by addressing a number of concepts, such as early warning, movement, dispersion, rapid decision cycle, adaptability, resource adaptation and resilience. The concepts are chosen based on the perception of what has characterized Ukrainian defense and they are further developed below.

The early warning was crucial initially for the Ukrainian forces to be able to move the equipment that was otherwise expected to be targeted during the initial attacks. If this had not happened, it can be assumed that a larger number of Ukrainian air defense systems and fighter aircraft would have been engaged, which could have been sufficient for the Russian forces to gain control of the airspace, which in turn would have created a much greater freedom of action for the Russian ground forces to advance. Advance warning was thus crucial to the outcome.

The ability to *move* was also of key importance initially. Movement has also been used effectively by the Ukrainian air force after the initial attacks by moving between different air bases, having constant movement on the air defence systems that allow mobility and not least by having a large spread of MANPADS among the ground forces, which in itself creates built-in movement. Movement exploits the weakness identified above regarding the Russian armed forces' lack of ability to act in a more dynamic sequence of events.[46]

Closely related to movement is the ability to *disperse*. Ukraine's mobility has also allowed it to disperse its forces in a way that has made it difficult for Russian forces to achieve a sufficient level of engagement as they have been forced to spread their combat capability over too many targets or have failed to identify the new target locations that have emerged. The dispersion between airbases to avoid concentrations of aircraft has reduced the risks of large and decisive losses. The dispersal of MANPADS over the surface has created a constant scourge for the Russian pilots to deal with, where the uncertainty of their whereabouts must always

be taken into account. Dispersal capability cannot be said to be a direct consequence of having a high level of movement. Dispersal capability requires, in addition to movement, possible and prepared places to disperse to, such as alternative air bases and air defense system staging areas, which seems to have been an important prerequisite for Ukraine.

A *fast decision-making cycle* is required for the ability to act within the opponent's decision-making cycle in order to stay ahead. The way the Ukrainian forces have acted, they also seem to have this ability, where they have demonstrated in their organization the ability to disseminate information and decisions effectively, without unnecessary delay. By utilizing the possibility of distributing a broad situational picture, by allowing individual soldiers to take part in this situational picture and by having a management philosophy that seems to be based on mission tactics, it has been possible to create good conditions for a fast decision-making cycle.

Adaptability, under the subheading of inventiveness, has perhaps been the most outstanding capability in the war so far. Ukraine has consistently had the ability to constantly adapt, thus avoiding its own losses and inflicting losses on Russian forces. Adapting one's way of fighting to the opponent's actions is a fundamental ability of a nation's combat power, where it is important to quickly seize opportunities and strike at the critical vulnerabilities that arise in the opponent. In the context of the air war, some clear examples can be presented that underline Ukraine's ability to adapt. After the initial attack phase and the ensuing chaos, Ukrainian forces managed to adapt their air defenses in a way that forced Russian air forces to act much more defensively.

Ukraine can be said to have optimized the use of the air defense systems available, by arranging the various air defense systems in a way that provides overlapping altitude coverage.[47] In this way, Ukraine has forced the Russian air forces to operate at longer ranges to avoid their own losses, and the different systems have made it difficult to fight them. An optimally configured air defense system relies not only on sufficient volume to provide adequate surface coverage, a spread of systems with different capabilities in terms of target engagement and range, but also on an accurate situational awareness available to all actors without undue delay.

One of the tools used to create this situational awareness is an application called Kropyva, which can be installed on any Android tablet. The system links users on a large network where they can add Ukrainian and Russian forces. It is used to call in both artillery and air defense systems to complement the radar picture. The Ukrainian air defense systems appear to have had a significantly better situational awareness than their Russian counterparts, despite using essentially the same system.[48] In addition, open-source intelligence (OSINT) has been used to obtain satellite-based intelligence.

Ingenuity has been consistently demonstrated in the way Ukrainian forces have used UAS. Initially, when Russian forces had not established a coordinated air defense, the Turkish-built Bayraktar TB2 drones were used effectively to combat Russian troops and materiel.[49] In addition to military drones, Ukraine has very effectively used civilian drones for tasks such as surveillance, reconnaissance and artillery targeting, but also as bomb disposal units or suicide drones.[50] The use and deployment of civilian drones has enabled larger quantities to be procured in a short time and probably also at a significantly lower cost than would have been the case if more sophisticated and militari-

ly specified systems had been procured. To this end, two different solutions were created. One was centralized and involved contracting national industry to produce UAS, such as the Falcon-300 long-range attack drone and the PD-2 surveillance drone. The second solution was decentralized and relied on fundraising through crowdfunding to purchase commercial drones and distributed opportunities among civilian actors to repair broken drones in order to quickly reintroduce them into combat.[51]

Resource adaptation refers to the ability to balance the use of resources in a way that produces the intended effect on an adversary, while maintaining sustainability over time. This is a very difficult balancing act, not least because at any given moment it is very difficult to know what level is the most optimal and this because the future course and need is unknown, and because too low a level of effort has immediate negative consequences, which tends to drive decisions towards an over-utilization of resources at any given moment. The war in Ukraine tends to have evolved into a war over resources, and Ukraine has so far managed to balance the outflow with the inflow of resources, even if the margins are sometimes considered to be very small. The extensive use of UAS by both sides in the war has put the ability to adapt resources to the test. In a scenario where the opponent attacks with cheap drones in large volumes, it is not cost-effective to use the more advanced and thus more expensive, and probably fewer, missiles to fight these cheap targets. At the same time, they can do considerable damage and therefore cannot be completely ignored. To this end, the Ukrainian military has used different and less expensive ways to combat these UAS, such as electronic warfare, small arms and anti-aircraft systems strategically placed on the battlefield.

Another important element linked to resource adaptation has been Ukraine's ability to utilize domestic industry to create a greater degree of self-sufficiency. This has been particularly important as the war has evolved into a struggle for resources. Ukraine has managed to reorient its industries to produce what is needed to strengthen the defense of the country and the importance of this ability is underlined by Dr Viktoriya Fedorchak.

> From the perspective of sufficiency and effectiveness of the military equipment under high-intensity inter-state warfare, at least partial national self-sufficiency is required to satisfy the immediate needs of warfighting.[52]

Not surprisingly, *resilience* is central to the outcome, but should not be taken for granted, even if it involves defending one's own territory. In order to build and then maintain this resilience, it is crucial to be able to withstand the "first blow". If this first blow leads to systemic collapse and chaos, there is a greater risk that the prospect of continuing to resist will be deemed too costly, with the result that the people and/or the country's leadership will capitulate. Resilience and the will to fight have been consistently high in Ukraine and, although it is impossible to know for sure, it is likely that the initial failure of the Russian aggressor created an awareness among the Ukrainian people that they can resist, laying the foundations for the very strong resilience that exists throughout Ukrainian society. Here, air defense is perhaps the most crucial element in resisting the initial attacks, with early warning and the ability to move and disperse, as mentioned above, being key.

Conclusions based on the presented situation

The head of the Ukrainian air force argues that the war has clearly underlined the importance of air power in the modern conflict in a way that few other wars in modern times have done.[53] For the Russian side, the combination of strong resistance on the ground, together with the lack of control of airspace, has made it impossible to advance and the offensive has stalled. This is despite the fact that Russia initially had the second largest army in the world, according to analysts, with relatively modern equipment and a large human resource at its disposal. For Ukraine, on the other hand, the lack of its own airspace control has meant an inability to fight back. All in all, the situation has become deadlocked and a shift to a battle that is more or less about resources has occurred.

A number of conclusions can be drawn from the situation described above and, briefly, from the attacking Russian side, the following can be stated:

- The planning was based on an excessive expectation of a quick and relatively easy takeover of the country's leadership. When this did not work, there was no alternative plan.
- Due to the fact that, according to the above point, the plan was probably built on too high hopes, some weaknesses in the Russian action may possibly have been caused by this fact, rather than actual shortcomings in capabilities. At the same time, the weaknesses identified above have been more pervasive, suggesting that they do exist.
- The lack of a clear command structure initially made it difficult to cooperate and coordinate joint operations between different combat forces and geographical areas.
- The air operation contained the expected components, and the target choices can initially be considered logical based on how a similar air operation would have been planned by the West.
- Russian air forces had the technology that might be expected to be needed for a successful air operation, but it was not sufficiently implemented or disseminated.
- The ability of the air forces to carry out large, complex and coordinated undertakings, consisting of all the components involved, appeared to be almost non-existent.
- Interaction between air and ground forces was generally poor.
- The ability to manage more dynamic processes was low.
- The attacks were carried out with insufficient precision, with insufficient weaponry and with substandard BDA.
- Russia has failed to establish airspace control, but has managed to deny Ukraine airspace control, leading to a stalemate on the ground and a war of attrition.

From the defending Ukrainian side, the following can be noted:

The early warning Ukraine received was crucial to avoid excessive losses in the initial attacks.

The ability to move initially meant that several key targets identified by the Russian attacker were not fought. Furthermore, movement has been used continuously to complicate the Russian targeting process.

Dispersal has been used to avoid interdiction.

The decision-making cycle has been faster than the Russian counterpart.

Relative to the Russian armed forces, Ukraine has had a higher level of adaptability,

with a higher capacity for initiative, which has continuously put the Russian aggressor in difficult situations.

Ukraine has managed to allocate resources in a seemingly wise way.

A high level of resilience has been present throughout, probably because the initial phase was managed in a way that demonstrated the possibility of avoiding losses.

Ukraine has failed to establish control of its airspace but has managed to deny Russia control of it.

From an air power perspective, it can be concluded that neither party has had the ability to establish sufficient control over the airspace above and around the front. The capabilities are only sufficient to deny the other's ability to establish control of the airspace. The number of air defense systems at Ukraine's disposal has been a major factor in denying Russia control of the airspace, as the lack of sufficient offensive capability in the form of fighter aircraft and long-range combat capability has made offensive operations impossible. This situation has led to a stalemate on the ground where a war of attrition has taken shape. It is thus the lack of control of airspace that has strongly contributed to creating the situation that has prevailed on the ground. By analogy, it can be assumed that the first to succeed in establishing control over airspace can also act offensively, which in turn can lead to victory, "...the first to gain superiority will get the keys to victory."[54]

As the deadlocked situation on the ground is extremely costly in terms of human lives and materiel, it may be interesting to discuss what a situation would look like if either party actually managed to establish control of the airspace and also what would be required for this. This is developed in the next chapter in order to discuss how experiences and conclusions can be applied in a Swedish context.

Alternative situation where one actor controls the airspace

It is by no means obvious that total control of the air, air supremacy, will also lead to the attainment of the ultimate objective pursued. Thus, having control of the airspace does not necessarily lead to victory. Nevertheless, control of airspace is an important element in that it generates freedom of movement both on land and on water. In a conflict that pits one nation against another, where these nations contain nationally sanctioned, trained and resourced combat forces, control of airspace is more important to the outcome than in a conflict with a more guerrilla-like opponent, where the full potential of airpower cannot be utilized as effectively.

In modern history, there are not many examples of the former scenario, but the first Gulf War is perhaps the most telling example of what airspace control can mean, where the course of events, known in retrospect as the "road to death", demonstrates the effects of having and not having airspace control.[55] On the other hand, it was much more difficult to reach a decisive outcome in the Balkan Wars despite airspace control. An example of the difficulties associated with an adversary behaving more like a guerrilla is Afghanistan, where the Allies had air supremacy. Despite this, it did not lead to a decisive outcome. For example, the adversary's social structure was not a system-of-systems, which challenged the ability to identify critical vulnerabilities

and thus strategically crucial targets for the air forces to attack.

The reasons why there is limited correlation between controlling airspace and winning a conflict depend on a large number of factors. For example, one is the Rules of Engagement (ROE) under which the battle is fought, where the mandate to attack certain targets can be limiting, and another is geography, where open terrain favors the airspace dominator, such as in the Gulf region, and much more difficult terrain makes it easier for an adversary to hide, such as in the Balkans and Afghanistan. At the same time, it is difficult to argue that not having control of the airspace in a conflict is in any way more beneficial, as the link to freedom of movement over the surface is clear. Thus, a nation should seek full control of airspace in all respects. This is a conclusion also drawn by the Swedish Armed Forces in the report they published on behalf of the government, regarding experiences and lessons learned from the war in Ukraine; "Current Swedish doctrine expresses that it is not an end in itself to control the air. However, based on the experience of Ukraine, it can be argued that a high degree of air control is an end in itself. The freedom of action of our combat forces is a consequence of our control of the air domain. Controlling the air also provides operational benefits in terms of intelligence, warning, mobility and protection."[56] What is perhaps surprising in this conclusion is the fact that it was not previously considered an end in itself, but that the experience of the war in Ukraine seems to have changed this view.

Initially, the situation is described on the basis that the Russian forces had gained control of the airspace and then, on the basis of this, a counterfactual description is given in which Ukraine had control instead. Embarking on a counterfactual description is of course not without risk, nor does it claim to describe an accurate picture of a possible course of events. Instead, the important thing is to create an understanding of how different the situation could be if either party had control of the airspace and how this would affect the conclusions presented above.

In particular, control of airspace prevents the freedom of movement that otherwise exists for the ground forces engaged in combat. Russia's demonstrated ruthlessness and total disinclination to abide the laws of war has allowed them to bomb unrestrainedly, with no regard for civilian casualties. Had Russia controlled the airspace, all Ukrainian movement on the ground, especially in open terrain, would have been severely restricted. Attack helicopters would have been able to operate freely, and cluster bombs could have been used from fighter aircraft. Logistics supplies would probably have been cut off and the only way for Ukrainian ground forces to survive would be to hide or operate in darkness and bad weather. However, even this would not be possible in the long run, as it can be assumed that the Russian air forces would have severely damaged the Ukrainian logistics chain, which would probably starve the units out over time. Russian ground forces could then have been used much more offensively and probably also with greater effect, since the Ukrainian forces would not have been able to strike back, as they would have risked being routed.

The extensive artillery war had become increasingly one-sided as Russian air forces were gradually able to knock out Ukrainian positions. Russian UAS had been able to act freely as a reconnaissance and attack resource.

Ukrainian UAS of the smaller sizes, due to their size and number, would not have been easily countered by Russian forces, even if they had control of the airspace. However, it would be very difficult for the Ukrainian soldiers to position themselves in a way that would allow them to control these UAS effectively without putting themselves at great risk. Moreover, it is questionable whether the information gathered could have been exploited within the Ukrainian military system.

The same situation, but applied to the opposite party, would have arisen if Ukraine had control of the airspace. However, and in order to take advantage of the benefits that airspace control brings, it is assessed here that significantly more resources would have been required than those available to Ukraine. Among other things, they would have needed more attack aircraft and/or attack helicopters. They would also have needed good situational awareness of the battlefield, which would have required airborne reconnaissance resources, and they would have needed the ability to carry out attacks in depth to influence the supply of resources to the Russian units. The assessment is that the resources available initially would have been too scarce and that Ukraine would not have been able to fully exploit the advantages that control of the airspace would have provided. Resources had to be brought in from abroad. However, the result would be considerably better than the current stalemate, with considerable freedom of movement for ground forces and far fewer friendly losses than today.

Would it then have been possible for Russia to establish sufficient control of the airspace? If the answer is no, i.e. that Russia does not possess this ability to take and control airspace in an offensive operation, one conclusion may be that no such consideration needs to be taken in the planning done by the Swedish Armed Forces. The answer is probably yes, and this is developed further under the next heading.

Russian airspace control—what would be required and would it be possible?

Had the Russian forces succeeded in the initial attacks (first days/week) and thus knocked out the Ukrainian air defense, or reduced it to a level that they could later handle through repeated attacks, control of the airspace could probably have been achieved. In this short time, Ukraine would not have had time to receive support from partner countries with either MANPADS or longer-range air defense systems, and possibly Ukrainian resilience would have been broken, which would probably have reduced the willingness of the West to provide support.

To achieve this, Russian air forces would have needed to operate from a better and more realistic plan, in a more coordinated manner and with larger combined and coordinated units, including more SEAD/DEAD, jamming, command and control and air-to-air refueling aircraft. The technical level of both aircraft and munitions would have needed to be more spread across all systems and the capability of the pilots would have needed to be higher, in particular with regard to their ability to operate in larger composite formations, and in all visibility and weather conditions. Planning would also have needed to rely more on surprise to avoid targets being moved shortly before attack.

With the lessons that Russia has likely already learned or will learn from its failures, it must be assumed that the identified

shortcomings mentioned above, will be able to be addressed in the future and therefore the Russian ability to conduct complex air operations in the future should not be underestimated. The previously mentioned quote, "Underestimation of the enemy is the first step to military catastrophe; this is the mistake that Russians made during the invasion of Ukraine and which we should not repeat",[57] bears repeating here.

The conclusions drawn above need to be tested in a Swedish context before they are allowed to influence the development of the Swedish Armed Forces.

How does a Swedish context affect the above conclusions?

To answer the question posed in the heading above, a Swedish context needs to be established first. A crucial difference is the fact that the geostrategic situation is different, with greater distances and with the Baltic Sea and NATO allies as a buffer zone.

From a geostrategic perspective, three different areas of operation can possibly be defined:

1. *The northern area:* Consists mainly of the northern parts of Sweden, Finland and Norway and the Arctic Ocean. Russia's motives for striking this area may be to create flank protection for its own forces based in Murmansk, to influence NATO troop reinforcements to Norway and to influence the mining industry by striking Kiruna and the Ore Line.
2. *The Central Area:* Consists mainly of the southern parts of central Sweden, southern Finland, the Baltic States and the Baltic Sea area. This area needs to be protected primarily to prevent Russia from establishing control over the Baltic Sea, which would give it the possibility to completely or partially cut off the ability for Swedish and allied forces to operate effectively. The difficulty of providing support to the Baltic States would arise.
3. *The southern area:* Consists mainly of southern Sweden, the southern Baltic Sea, Denmark, the Western Sea and the southern parts of Norway. The area is of great importance to defend as it is, among other things, an important prerequisite for the flow of logistics to the west.

In all areas, it is essential to protect the possibility of using Swedish territory as a transit and base country for allied forces.

Since the war in Ukraine has largely been characterized by the fact that the countries' ground forces have ended up in a form of war of attrition and that conclusions drawn from this specific situation would not necessarily be relevant if this situation did not exist, it is interesting to discuss whether it is considered likely that such a situation could arise within the framework of the three areas described above.

For a similar situation to arise, the Russian forces would firstly need to succeed in moving their ground forces to Sweden and secondly, they would need to be able to supply their units with logistics over time. Moving large forces is a challenge in itself and to reach Sweden they need to be moved through Finland, across the sea, and/or by air.

Although it is not possible to verify figures with certainty, estimates suggest that Russia has lost more than 5 000 tanks and 10 000 combat vehicles, together with more than 300 000 soldiers.[58] The need to move a considerable amount of equipment and personnel is based on the fact that the Swedish, and for the northern area also the Finnish, defence capability to conduct ground combat is at such a level that Russia does not

dare to risk meeting these units with smaller forces. The Swedish and Finnish armies contribute to an important threshold effect in this respect.

The above figures are not relevant in a scenario where we assume a more unexpected attack, but Russia is nevertheless deemed to be obliged to make an assessment of what is needed if the process were to be more protracted. Moving these considerable quantities of troops through Finland is considered unlikely. This would probably trigger Article 5 of the North Atlantic Treaty, which is not considered desirable for Russia. Furthermore, this movement would be highly vulnerable to attack from the air domain, which would require Russia to establish sufficient control over airspace to secure the movement of its own forces.

Using the Baltic Sea to transport these resources over time is also considered unreasonable. This type of overflight would also require that the Swedish navy was no longer able to put up much resistance and that the Russian air forces had control of the airspace at the time of the overflight. One or more ports of debarkation would also be required, where extensive protection would be needed during the sensitive debarkation process. Moreover, the timeframe would be rather protracted and Article 5 of the North Atlantic Treaty would have to be initiated and implemented.

It is not realistic to move this large amount of material by air instead, since an An-124, for example, can load a maximum of 150 tons, which theoretically, and only if weight is taken into account, makes it possible to load two tanks or five combat vehicles per aircraft. More than 50 An-124s have been built and if all of them were operational and used for this purpose, around 100 tanks could be lifted at any one time. This would require support systems in the form of combat vehicles, personnel, logistics and, not least, an airport large enough to land and unload this large amount of equipment, after which the vehicles would be moved to the front to start the battle. The reasoning may be theoretical, but it points to the unreasonableness of using the air as a means of transporting the amount of equipment that the war in Ukraine clearly demonstrates would be needed. Moreover, such a transportation effort would require control of the airspace in order to avoid unacceptable losses.

Based on the above, it can be concluded that Russian forces in all areas of operation would require extensive control of the airspace to succeed and it can therefore be considered unrealistic that a Russian attacker would carry out an attack on Sweden with a large number of ground forces, at least as long as Sweden, together with Finland, has the ability to defend the airspace. It must therefore also be considered unlikely that a ground combat situation similar to that in Ukraine would arise in a Swedish context, which needs to be taken into account when drawing conclusions from the war.

Assuming that an attack on Sweden does occur, it is therefore more reasonable to assume that this would take place unexpectedly with the use of long-range combat capability together with air force operations, with the aim of quickly putting Sweden into a state of shock, which in turn affects the possibilities of solving the tasks found in the various areas of operation described above. It is this scenario that constitutes a Swedish context.

The Swedish capability to respond to this surprise attack will therefore be crucial, as the experience of the Ukraine war demonstrates. After the initial attacks have been dealt with, the Swedish Armed Forces also need the ability to act offensively, not only to deny the Russian forces control of the air, but also to create and maintain their own

control of the air. The initial, more defensive task is one that must primarily be carried out without the support of others, while the more offensive task can be carried out in cooperation with allies.

Based on the conclusions listed earlier in the text regarding the defending side, Ukraine, an assessment can now be made as to whether these conclusions are relevant or whether they should be modified in the Swedish context described above:

- The early warning Ukraine received was crucial to avoid excessive losses in the initial attacks.

For the defending party in a conflict, and especially when the attack is deemed to be based on surprise, early warning is crucial, and this also applies to a Swedish context. Sweden therefore needs to ensure that this advance warning is sufficient. One obvious advantage is that Sweden does not directly border Russia, which in itself creates extra decision-making time. At the same time, this affects Russia's planning, in that it is unlikely that there will be similar concentrations of ground forces as there were at the border of Ukraine, which therefore does not provide the same possible advance warning. What can be considered sufficient warning is entirely dependent on what the initial situation looks like and here a good plan should be based on the worst situation, which could then be that virtually all parts of the Armed Forces are in their peacetime formations, i.e. no dispersion measures have been taken. How long it then takes to deploy resources from this starting point thus stipulates the need for defense time.[59]

It is not possible to assess how well the Armed Forces can meet the need for early warning on the basis of open sources. Being part of NATO probably provides great advantages in the possibility of accessing more extensive intelligence information, based for example on satellite data, than would otherwise be possible.

- The ability to move initially meant that several key targets identified by the Russian attacker were not fought. Furthermore, movement has been used continuously to hamper the Russian targeting process.

The ability to move is just as important in a Swedish context, with the aim of avoiding combat. The number of air defense systems is small in relation to the area to be defended, which makes it crucial that these systems are not initially engaged. The mobility of military radar systems is something that needs to be taken into account, where airborne systems are considered to be very crucial as a complement.

The mobility of the Armed Forces needs to be reviewed, not least for our air defense systems, which must be able to deploy quickly and then have high mobility. With expected short notice, it is not unlikely that important defense systems, such as air defense units, tele-warfare units and other systems (e.g. counter-UAS) that can combat incoming missiles and UAS in various ways, need to be grouped in peacetime near the place where they will operate in the event of war. The same applies to the radar stations used by the Armed Forces. It must be assumed that their location is well surveyed in peacetime, which is why they must be able to be mobile or protected by fortifications in order to operate and survive.

- Dispersal has been used to avoid control in an effective way.

The philosophy of dispersal can perhaps be said to be in the DNA of the Swedish Air Force, which is a great strength. However, the important thing for this to succeed is that

the decision to disperse is made and that the time to disperse is allowed, i.e. there must be sufficient advance warning.

The Armed Forces' air force deployment capability probably needs to be improved. One weakness is the small number of air defence systems available and the need to deploy the systems to avoid combat, while at the same time ensuring that the systems provide as much overlap as possible. This is a very difficult equation to get right, and the solution probably requires an increase in the number of air defense systems. Combat aircraft can be deployed very quickly, but it relies on early warning, early decision-making and logistics, as well as regular training. The Ukrainian air force, for example, practiced frequently to get away from airports under simulated attack, which was probably very useful during the initial phase of the war.[60]

One difference from the situation in Ukraine is that Sweden is considered to have greater opportunities to create fortified protection for the type of its own capabilities that risk being exposed to these initial attacks, thanks to the bedrock found in Sweden. This is used to some extent today and has been used to a greater extent in the past for various command and control centers, hangars, radar equipment, shelters and also for critical parts of the defense industry and civil society in general. These protections can and should be an important complement to mobility and dispersion, especially if there is deemed to be a risk that sufficient advance warning will not be given. In this respect, an analysis is deemed necessary to assess the balance between movement, dissemination and protection.

- The decision-making cycle has been faster than the Russian counterpart.

Fundamentally, the battle to have a faster decision-making cycle than one's opponent is an important battle to win, also in a Swedish context.

Mission tactics with well-trained personnel who are thinking individuals with a "just-culture" philosophy ensure that the Swedish decision cycle is fast.[61] Nor are air forces seen in Sweden as primary support to ground forces; their main task is to limit or prevent the adversary's ability to control the airspace, thereby creating freedom of action for their own ground and naval forces. Swedish air forces participate in the Western air exercises where dynamic events are trained. This requires an organization from the political and strategic level down to the tactical level that is agile. Practicing the unexpected is possibly one of the more important things to practice, which then tests both personnel and organization.

- Ukraine has had a high level of adaptability, with a high level of initiative that has continuously put the Russian aggressor in difficult situations.

This conclusion is of course also relevant for a Swedish defense force. It is particularly the ability to adapt that can make the difference in a more dynamic sequence of events.

The Armed Forces' ability to do this must be practiced and, as with the decision cycle, practice is needed in dealing with the unknown. Personnel must be allowed to take the initiative, try, make mistakes and try again. The perception is that there are good conditions for this within the Armed Forces, but that there is more to do to increase creativity in the system. Time must be assigned to discuss contingencies and various measures, and this needs to be done together with industry and academia in order to find the most creative solutions to possible outcomes in war.

The use of UAS should be developed in particular, as it has been more extensive

than previously noted in other conflicts and as it also points to the innovative power that Ukraine has managed to mobilize. The question is then how UAS can be a factor in a Swedish context. A crucial difference between the war in Ukraine and a Swedish context is the initially longer distance between Russia and Sweden, which makes it much more difficult to use the smaller UAS. The use of UAS, as noted in Ukraine, can largely be seen as a consequence of the fact that no party controls the airspace and that the war is a war in which ground combat units are in direct contact with each other. The conclusion is that the systems used close to the units are not used in the same way in a Swedish context where, in the initial phase, it is mainly about operations with long-range combat capabilities. However, longer-range UAS that have a function as a reconnaissance or combat platform will be relevant. For Sweden, it is a matter of being able to defend against this type of platform, which is likely to appear in large numbers, with the aim of overwhelming our air defense. Sweden should also study the possibility of developing its own equivalent long-range UAS in order to enable offensive operations in depth.

- With limited resources, coupled with the trend towards a war for resources, Ukraine has managed to allocate resources seemingly wisely.

The resource dimension is important to manage for any defense force and not least for a defense force that basically has relatively limited resources available, such as the Swedish. Even as a NATO ally, Sweden must be able to withstand the initial phase so that system collapse does not occur before NATO has time to provide support, but also so that it can then be a contributing party in the alliance's continued fight.

The Swedish Armed Forces need to carefully analyze the Russian use of long-range combat capabilities in order to design a sufficiently good capability to meet this threat. This includes analyzing how to distinguish between different types of incoming systems, such as the more advanced and lethal systems from the cheaper ones, so that the effect can be optimized. Furthermore, the number of air defense systems, both long-range and shorter-range, and MANPADS, both ground-based and ship-integrated systems, needs to be reviewed in order to avoid a resource-critical situation. Finally, the ability to deal with initial attacks needs to be analyzed, including, for example, the protection of hangars, airports and radar stations.

Security of supply needs to be analysed, where the national defence industry's ability to supply the needs of the Armed Forces must be clarified. This work is deemed to require preparations that go further than what is perceived to be the case today. Industry needs to be clearly told what is expected and there should be ready-made plans on whether and, if so, how industry will adapt, what is expected to be produced and in what volumes, but also how long this transition will take. There is probably an opportunity to prepare this production already in peacetime, perhaps to the extent that small series are produced, after which production is paused and put on standby.

- High levels of resilience have been consistently present, probably because the initial phase was managed in a way that demonstrated the possibility of avoiding loss.

This conclusion is also highly relevant in a Swedish context, and it is a very important element for the whole society to achieve. The link to the importance of surviving the initial attacks is important, which is a consequence

of the above-mentioned warning, movement, dispersion, and the need for fortified protection. Thus, it is not only for the Armed Forces that this is of great importance, but it also affects the willingness of the population to resist. In a scenario where a large part of the Armed Forces' resources is initially knocked out, society's willingness to fight on would probably decrease.

- Ukraine has failed to establish airspace control, but has managed to deny Russia airspace control, leading to a stalemate on the ground and a war of attrition.

A situation with a stagnant front between the parties' fighting ground units is difficult to see as something to strive for on Sweden's part, regardless of whether the situation includes NATO. The costs and devastation of a war of attrition are great, not least in the loss of human life. Western countries' view of human life also means that this type of battle, especially if the battle is protracted, is likely to lead to a loss against a country such as Russia and overall, this situation should therefore be avoided and it is not enough to simply deny the other party control of the airspace, but the effort needs to be more forward-looking, where the quest to take and maintain control of the air should be a clear objective.

In a Swedish context, the ability to take and maintain control of airspace is primarily about creating a threshold effect that means that an attack with ground forces, as described above, should not be considered reasonable by Russia to carry out.

Summary conclusions and recommendations

The war in Ukraine has clearly highlighted the importance of air power, mainly by showing what happens when neither side manages to control the airspace. For the Russian side, the combination of being unable to advance and the offensive having stalled. This is despite the fact that Russia initially had, according to analysts, the second largest army in the world with relatively modern equipment and a large personnel resource at its disposal. For Ukraine, on the other hand, the lack of its own control of airspace has meant that it is unable to fight back. Overall, the situation has become deadlocked and a shift to a battle that is more or less about resources has occurred.

Apart from the brutal and illegal terrorist bombing of civilian targets, the Russian attacker can initially be said to have used air power in a way that mimics the way the West conducts an air operation. Virtually all expected tasks, such as offensive and defensive air defense, strike companies, signals intelligence companies, reconnaissance and radar surveillance companies were carried out. They have also identified and attacked targets deemed relevant and based on the same air power theoretical framework as the Western one.

The reasons why the Russian attack nevertheless did not lead to Russia establishing control of the airspace were several and the following six key conclusions have been identified that could provide explanations:

1. The planning was based on an excessive expectation of an easy victory.
2. The management structure was unclear.
3. The ability of air forces to carry out large, complex and coordinated undertakings, consisting of all components, proved to be almost non-existent.
4. Cooperation between air and ground forces was poor.
5. The ability to manage more dynamic processes was low.

6. The attacks were generally carried out with too little precision, with insufficient weaponry and with poor analysis of results.

Based on how the Ukrainian defense forces have operated, the following four overall conclusions have been identified:

1. Early warning, combined with the ability to move and disperse, was central to surviving the initial attacks, and probably laid the foundation for the high level of resilience subsequently demonstrated.
2. The decision-making cycle has been faster than the Russian one.
3. A high level of adaptability and initiative has continuously put the Russian aggressor in difficult situations.
4. A seemingly prudent allocation of resources has avoided a culmination point.

Transferred to a Swedish context, the analysis has made it clear that the situation in Ukraine, where the two warring parties have ended up in something resembling a stagnant trench war, cannot be seen as likely. This conclusion is based on the differences that can be found in the geostrategic perspective, with longer distances, the Baltic Sea as a natural obstacle and most NATO countries as a buffer. The conclusion is also based on the fact that the Swedish Armed Forces' ability to meet a Russian attacker with ground forces is sufficiently high for Russia to be forced to move a large amount of materiel and personnel, and that the Swedish air forces, and depending on the direction of the attack also the Finnish, can initially challenge the opponent to establish control of the airspace. Based on this conclusion, the most relevant and likely scenario is that a Russian attack takes place unexpectedly and with a large use of offensive air operations consisting of various forms of long-range means of attack with the aim of quickly creating a state of shock.

The conclusions drawn from the war in Ukraine have then been analyzed based on how relevant they would be in a Swedish context. The importance of surviving the initial attacks must be considered central to creating the necessary resilience in the Armed Forces and society in general, and this requires early warning, high mobility, dispersion and protection capabilities, as well as the ability to provide effective air defense. Furthermore, the ability to adapt and innovate, and an organizational structure that allows for a rapid decision-making cycle and adaptation to the unplanned course of events are important components and, finally, a capability is required to initially, and probably on its own, deny the Russian attacker the opportunity to establish control of the airspace in order to, and then probably within the framework of Article 5 of the North Atlantic Treaty, in the next phase establish control of the airspace by means of offensive operations.

Both sides in the war have made extensive use of UAS. However, the experiences that can be drawn from the use of the systems used close to the front and in direct proximity to the fighting ground units need to be analyzed primarily from a Swedish context. The assessment has been made that the use can also partly be seen as a consequence of the fact that neither party has established control of the airspace, which should also be taken into account when drawing conclusions. UAS have also been used as part of air operations and in an effective manner, which is considered relevant in a Swedish context, not least the ability of these sys-

tems to overwhelm an air defense needs to be considered.

The following recommendations are made:

1. Analyze all conclusions from the war in Ukraine in terms of how they are affected by being placed in a Swedish context.
2. Analyze the early warning capability so that it is balanced with the movement, dispersion and protection capabilities.
3. Increase the mobility and dispersion of capabilities that are strategically important for Russia to eliminate in the initial attacks.
4. Analyze the needs and opportunities for fortification protection of critical capabilities, critical societal functions and the population.
5. Increase the number of air defense systems to increase surface, volume and target type coverage.
6. Analyze how to handle attacking UAS where the aim is to overwhelm our air defense system.
7. Analyze how UAS can be used in an offensive role, as part of the long-range combat capability.
8. Ensure that the defensive capability to survive the initial attacks is sufficient and that this capability does not require NATO support.
9. Ensure that there is sufficient offensive capability to enable, within the framework of Article 5 of the North Atlantic Treaty, the taking and maintenance of control of airspace.
10. Ensure that sufficient supply capacity is available within Sweden.

In conclusion, the experience of the air war in Ukraine points out the importance of initially having the ability to withstand the initial attacks and deny the other party the opportunity to establish control of the airspace, but also the need to have the ability to subsequently establish your own control of the airspace. In all respects, a situation similar to the current one in Ukraine, with a form of war of attrition, must be avoided, and here the air power component, together with the threshold effect created by the ground forces' capabilities, is absolutely crucial in the Swedish context.

Underestimating Russia's ability to learn from its mistakes would be a big mistake. The West must assume that Russia will be able to carry out much more effective attacks in the future and this must be the basis for defense planning in Sweden, both in relation to Articles 3 and 5 of the North Atlantic Treaty.

And as mentioned in the introduction, the right lessons need to be learned from the war in Ukraine to be better prepared for future conflicts.

> The United States and its allies and partners need to be sure they do not dismiss the Ukraine air war simply as an example of Russian ineptitude, but instead examine Ukrainian successes and Russian tactical improvements over the course of the war and modify their warfighting concepts, doctrine, tactics, and training.[62]

The author is a colonel, an aviation safety inspector and a member of the RSAWS.

Notes

1. The booklet is part of *Project SV-A-R, Sweden in the EU and NATO—Deterrence and Response,* Royal Swedish Academy of War Sciences 2023–2025.
2. In Article 3, the Parties undertake, individually and collectively, through their own preparedness and mutual assistance, to maintain and develop their individual and collective capabilities to resist armed aggression. Article 5 contains the mutual defense guarantees that form the core of NATO's collective defense. It provides that an armed attack against one or more of the Parties in Europe or North America shall be considered an attack against all Parties.
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7. Reglemente Taktik för Luftoperationer, *2017*.
8. Ibid., p. 52.
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10. Image retrieved from *https://en.wikipedia.org/wiki/Warden%27s_Five_Rings,* (2024-04-04).
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14. Ibid., p. 27.
15. Ibid., p. 28.
16. Ibid., p. 6.
17. Ibid., p. 7.
18. Ibid., p. 7.
19. Ibid., p. 7.
20. Ibid., p. 8.
21. Ibid., p. 26.
22. Ibid., p. 8, 9.
23. Ibid., p. 10.
24. Ibid., p. 12.
25. Ibid., p. 16.
26. Ibid., p. 17.
27. Ibid., p. 19.
28. Ibid., p. 21.
29. Oleshchuk, Mykola; Shamko, Viacheslav and Antonov, Artem: "Air Power in the Russia-Ukrainian War: Myths and Lessons Learned", By Lieutenant General Mykola Oleshchuk, UKR AF (Chief of the Ukrainian Air Force), *The Journal of the JAPCC*, No. 35, Winter 2022/2023, *https://www.japcc.org/articles/air-power-in-the-russian-ukrainian-war-myths-and-lessons-learned/,* (2024-03-01), p. 20.
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31. Bronk, Reynolds and Watling, *The Russian Air War and Ukrainian Requirements for Air Defense,* p. 27.
32. Ibid., p. 8.
33. Payson O'Brien and Stringer, "The Overlooked Reason Russia's Invasion Is Flaundering".
34. Fedorchak, Viktoriya: *The Russia-Ukraine War,* Routledge, Abingdon 2024, p. 217.
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36. Bronk, Reynolds and Watling, *The Russian Air War and Ukrainian Requirements for Air Defense*, p. 13.
37. Dalsjö, Jonsson and Norberg, "A Brutal Examination: Russian Military Capability in Light of the Ukraine War", p. 9.
38. Bronk, Reynolds and Watling, *The Russian Air War and Ukrainian Requirements for Air Defense*, p. 14.

39. "Washington has sent over 1,400 Stinger antiaircraft missiles to Ukraine as part of the allied effort to prevent Russian occupation of the country", Thompson, Loren: "Sending Stingers To Ukraine Has Increased The Urgency Of Developing New U.S. Army Air Defenses", *Forbes*, 2022-06-13, *https://www.forbes.com/sites/lorenthompson/2022/06/13/sending-stingers-to-ukraine-has-increased-the-urgency-of-developing-new-us-army-air-defenses/?sh=7cbb812370a4, (2024-03-01)*.
40. Bronk, Reynolds and Watling, *The Russian Air War and Ukrainian Requirements for Air Defense*, p. 16.
41. Ibid., p. 22. To "toss" is slang for conducting the attack in a way that causes the weapon to create a throwing parabola in the air, which gives longer range, but significantly less accuracy.
42. Ibid., p. 29.
43. The Shahed-136 is propeller driven, has a range of over 1 000 km, flies at a speed of 150-170 km/h, can carry an explosive load of 20-40 kg and navigates using GPS and/or inertial navigation.
44. Bronk, Reynolds and Watling, *The Russian Air War and Ukrainian Requirements for Air Defense*, p. 34.
45. Fedorchak, *The Russia-Ukraine War*, p. 116.
46. "Employing 'shoot-and-scoot' tactics, Ukrainian air defense units fire their missiles and quickly turn off the radar and move away-making it difficult for the Russians to find and destroy them 2022", Bremer, Maximillian and Grieco, Kelly: "Air denial: The dangerous illusion of decisive air superiority", *Atlantic Council*, 2022-08-30, *https://www.atlanticcouncil.org/content-series/airpower-after-ukraine/air-denial-the-dangerous-illusion-of-decisive-air-superiority/*, (2024-03-01).
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52. Fedorchak, *The Russia-Ukraine War*, p. 210.
53. Oleshchuk, Shamko, and Antonov, "Air Power in the Russia-Ukrainian War: Myths and Lessons Learned", p. 22.
54. Ibid.
55. "Road of Death" refers to a road between Kuwait and Basra, where the retreating Iraqi army was attacked by the US Air Force on the night of February 27, 1991. Wikipedia, retrieved from *https://sv.wikipedia.org/wiki/Dödens_motorväg#:~:text=Dödens%20motorväg%20(English%3A%20Highway%20of,-to%20the%2027th%20of%20February%201991*, (2024-03-01).
56. Försvarsmaktens lärdomar från kriget i Ukraina, FM2023:2379-9, 2023-11-02, p. 16.
57. Oleshchuk, Shamko, and Antonov, "Air Power in the Russia-Ukrainian War: Myths and Lessons Learned", p. 20.
58. As reported by SVT on 8 December 2023. The figures are in turn based on Kyiv Independent's data and have not been verified by third parties. In this context, the exact figures are not important, but it can be stated that there is no doubt that the quantities are extensive, which is the important input value in the above reasoning.
59. It is debatable whether an attack could occur without warning. There will probably be indications, but the question that must be asked is what events are required for various decisions to be taken. The Russian attacker's plan, which is fundamentally based on surprise, requires just that, i.e. that it succeeds by surprise. Regardless of reasonability, a good plan should deal with this uncertainty by planning for surprise to succeed.
60. Fedorchak, *The Russia-Ukraine War*, p. 114.
61. "Just culture" means a culture where individuals are allowed to make mistakes, are allowed to admit it, and are not retaliated against, which in turn leads to a learning organization.
62. Wetzel, *Ukraine air war examined: A glimpse at the future of air warfare.*

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