

BEYOND THE BUBBLE: A WIDER VIEW OF A2/AD IN MODERN WARFARE

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BEYOND THE 'BUBBLE': a wider view of A2/AD in modern warfare

Introduction

A2/AD has flourished, limiting Western ability to intervene at will in strategic locations and posing a major threat to our strategic thinking. The affordability of A2/AD systems will probably see them spread. This is particularly significant given the renewal of great power competition (GPC) and the end of the West's freedom of action.

Our great power adversaries, China and Russia, use A2/AD for roughly the same goal: to deter and paralyse Western operations by delaying our ability to perform a military campaign and by raising its cost. Russia and China have studied our strategic weaknesses during the past decades to create or reinforce their own strategies and to build up a cost-effective response. Both seek to divide the Western allies, to deter us from meddling in their perceived backyards, and to weaken our will to fight them.

During the conflicts of the last 30 years, the West has grown used to conducting operations with a huge freedom of action. There were often few threats to our air and naval assets. Moreover, the different phases were clear and simple: seize the initiative, suppress the main threats with air and naval firepower, gain and maintain the air supremacy, dominate the opponents through a massive use of tactical air power, project forces, impose a high pace of joint campaign thanks to the use of technology. *A2/AD interferes with all these phases.*

A2/AD thus calls into question the West's military dominance, in two ways. First and most evidently, it threatens some of our rare and expensive military assets providing critical capabilities. Solutions in the specialised press show a plethora of tools that the West "needs" to develop or improve. Yet the increasing cost of weapons exerts constant pressure on the size of armed forces, reducing our ability to intervene at will. Our competitors have seized the opportunity to rush into the empty spaces we are leaving in the Middle East and in Africa. Our past strengths have become our current weaknesses.

Furthermore, and more importantly in our view, this focus of the West on A2/AD has generated a problem for us which is of our own making. *We have presented adversaries with an opportunity to tie up our thinking, resources and military actions.* This has created a persuasive Western mindset – a 'Bubble' – that is not just A2/AD defence *per se* but also *and mainly* a set of western misconceptions about modern war. Until the West can burst this bubble, it will be limited in its strategic thinking and its response to Russia and China.

This change in mindset implies re-assessing assumptions about achieving "zero-casualty war" in a contested environment. Since Desert Storm the West has been able to wage war without massive risk and the need to mobilise national will. Yet this approach has been challenged in Former Yugoslavia and by Russia's interventions and could well be again in the South China Sea. Waging war with limited risk-taking was an exception. The Western will to wage war needs to be reignited within a holistic approach that balances the costs against desired outcomes.

This paper proposes that we counter an adversary's strategy that forces us to focus on the tactical level and reliance on technology by stepping back and looking from a strategic view down to the tactical issue of handling A2/AD bubbles and by making better use of limited resources.

I- EXPLAINING CONTEXT OF A2 AND AD, FROM THE SEMANTIC TO THE OPPONENT'S STRATEGY

Anti-access and area denial are two different notions, and when merged into A2/AD remain vague, designating systems as well as strategies dealing with the six domains¹. Taking into account only a part of the system is misleading: as an example, to consider the submarine for going around a bubble is also to forget the sea-mines spread in the area as part of the system. Our thinking towards A2AD must encompass all the six domains.

The term of A2/AD appeared for the first time in 2003, in a study commissioned by the "Center for Strategic and Budgetary Assessment"².

However, the study highlights that the origins of the concept are older. Already at the end of the 1990's, several US senior military leaders had noted that the projection of US forces would become more and more difficult, because of enemy saturation ballistic missile attacks.

The study also quotes the former Deputy Secretary of Defence Paul Wolfowitz, in an official testimony in 2002 that indicates some foreign bases are "*creating incentives for adversaries to develop "access denial" capabilities to keep us out of their neighbourhoods.*"³

Considering the major changes taking place from the end of the Cold War, and particularly after the first Gulf War (growing contestation of US military dominance and diffusion of military technologies), the authors of the study proposed two-tier definitions, that they combined into the acronym "A2/AD":

- Anti-Access (A2), that they define as strategies which "*aim to prevent US forces entry into a theatre of operations*».
- Area Denial, defined as "*operations aim to prevent their [US] freedom of action in the more narrow confines of the area under an enemy's direct control. AD operations thus include actions by an adversary in the air, on land, and on and under the sea to contest and prevent US joint operations within their defended battlespace.*"

1.1 "A2/AD": why we have to grasp this term in a more global way.

The acronym "A2/AD" itself is problematic.

Firstly, because it is an assemblage of two acronyms which does not cover the same concepts, areas of responsibility or means. Ask any military or civilian strategist about their idea of what A2/AD is and it is almost certain that you will get different definitions. To quote the former Chief of Naval Operations, the Admiral John Richardson, "A2/AD" is "*a stand-alone acronym that can mean all things to all people or anything to anyone*".

Secondly, the definition of A2/AD does not cover the full range of strategic effects that a country wants to (or could) produce facing an adversary by employing A2/AD systems.

As a result, we have to define how we understand A2/AD here.

First and foremost, beyond the tactical means set up to contest the access or the freedom of movement into an area, we propose a wider comprehension that highlights three strategic effects made possible by A2/AD systems.

1 Six domains : Land, Air, Maritime, Space, Cyber and Information warfare

2 <https://csbaonline.org/uploads/documents/2003.05.20-Anti-Access-Area-Denial-A2-AD.pdf>

3 https://avalon.law.yale.edu/sept11/wolfowitz_004.asp

1.1.1 The legitimacy of protecting the national territory.

Defending territory against a hostile force is the first and most important mission allocated to military forces. In most cases, the defence of an undisputed territory is not called into question, due to international agreement on national boundaries. However, there is a high probability that the legitimate use of A2/AD systems in a specific area will be contested by nations where possession is the subject of international competition. Note that the notion of "territory" must be understood to include the maritime borders (12 Nautical miles from the coast) and national airspace (from the ground to the limit of outer space) to the ground borders.

Although not considered part of a national territory but as an economic area of interest, Exclusive economic zones (EEZ) are nevertheless a source of potential tensions. In the majority of cases the economic and political stakes linked to EEZ are so important that countries would defend them as they would their homeland territory.

All in all, the defence of a national territory is frequently presented as an indisputable argument to buy, sell and deploy A2/AD systems. Russia, amongst others, has used and abused of this defensive rhetoric to disseminate its latest A2/AD systems (sales of S-300 systems to Iran⁴, S-400 to Turkey, China, Pakistan, K-300P Bastion-P to Vietnam and Syria...).

1.1.2 The establishment of a "fait accompli"

A2/AD systems and strategies are not exclusively employed within the framework of a formal national defence policy. In fact, deploying these kinds of systems overseas, for example in a disputed area, is a highly effective method to enforce its influence on all the surrounded areas, control a territory *de facto*, and deter potential dissenters.

This employment policy of what are supposed to be strictly defensive systems is expanding, particularly in the hands of Russia and China.

More precisely, once a country has set up A2/AD systems in an area there are two effects:

- *De facto* the country takes control of the territory where the systems are deployed. Deploying huge systems such as ground to air "S-series" (S-300, S-400), ballistic system 9K720 Iskander or coastal defence K300 Bastion implies that the user controls at least one of the critical infrastructures, depending on the access provided (by air, sea, ground) such as an heavy air carriers (AN-124...) airport or airbase, a deep-draught cargo ship harbour, or a 40-tons class vehicles⁵carriage road.

This strategy is mainly used by China, as illustrated by the construction of military bases on artificial islands in the South China Sea. Fiery Cross reef (Yongshu Island) is a typical example of a *fait accompli*. Located on the west of the Spratley islands, it has been occupied by China since April 1987 under the guise of a UNESCO program (GLOSS - Global Sea Level Observing System⁶). But in late 2016, satellite imagery showed that Fiery Cross reef had been armed with anti-aircraft (HQ-9 system, a Chinese version of the Russian S-300P) and close-in weapon systems (CIWS). The reefs of Gaven, Hughes, Johnson, Cuarteron, Mischief, Subi, parts of the Spratley Islands, have welcomed the

4 Public statement of Sergey Lavrov, Foreign Minister of Russia, on the 15th of April 2014, where he explained that S-300 system It is not designed for attacks and that the sale to Teheran "will not put at risk the security of any state in the region, including Israel".

5 Standard weight of a S-300 missile launcher truck: <http://www.ausairpower.net/APA-S-300PMU-TEL-TL.html>

6 https://en.wikipedia.org/wiki/Global_Sea_Level_Observing_System

same type of military facilities since 2016⁷. Historically claimed by Taiwan, Vietnam and Philippines, we can hardly imagine how these countries could recover authority on these reefs now that China has transformed them into fortified bastions.

- By extension, this strategy creates a wide area of influence bounded only by the capacities of the A2/AD systems. Detection systems, such as long-range radars, provide an extended overview of any type of air and naval activity, and can be used to lead any type of interceptions (by fighter aircraft or military vessel). Kinetic destruction systems (missiles, guns, torpedoes) deter any potential intruder to enter the defended area. By taking the control of what is now a big piece of rock of 2,31 by 0,62 miles (1,43 sq mi) China is now able to threaten any air activity within an area of 48.494 sq mi (the maximum coverage of a HQ-9 system). Russia drives the same kind of strategy in the Kaliningrad enclave: ideally placed in the middle of NATO countries (Poland, Baltic states), in front of Sweden and at the entry of the Baltic Sea, the A2/AD systems deployed there are able to counterbalance the influence of western countries in a wide area. However, contrary to by China Sea reefs, the ownership of Kaliningrad is undisputed. And a side effect of the huge range of the Kaliningrad weapons (S-400, K-300 Bastion) is that the "defence" system user is able to threaten air, naval and ground forces within their neighbours' own territories. The latter the face another kind of *fait accompli*: the existence of a direct and permanent threat that will force them to devote a part of their armed forces to monitor and contain it.

1.1.3 Forcing the adversary to make a mistake leading to an intractable problem.

Once in place, A2/AD systems become more than the expression of a will to possess and defend a specific area. At a strategic level, the dissemination of this type of systems is a thorn in the foot for the West, which will have to choose between two opinions, but neither is satisfactory:

- accept and deal with this new constraint, or
- assume the danger of triggering an armed conflict.

Option 1 involves monitoring and containing the risk.

First and foremost, intelligence capabilities will have to determine what kind of systems are deployed and how (permanent or non-permanent, part of an integrated defence system or stand-alone), what are their capabilities (and thus their range, destructive power), and so on. This monitoring must be permanent to guarantee an up-to-date picture. Furthermore, because modern A2/AD systems use the latest technologies (active radar, radar with intrapulse capabilities, active homing systems, etc.), the monitoring systems must be at the same, which implies massive investments.

But monitoring A2/AD systems is not sufficient. Once the situational awareness is established and maintained, the second thing will be to prevent any expansion of other A2/AD systems in the area enabled by a mutual protection. The first A2/AD systems can protect the deployment of a second one, which will cover the deployment site of a third one, and so on. That is why a military force which want to contain the spreading of A2/AD systems in its AOR (area of responsibility) will be obliged to dedicate forces to this task. The case of Gotland island in the Baltic Sea, is a good example. Close to the Kaliningrad enclave, in an area where Russian and western countries have many economic and military interests, this island was remilitarized in 2018 by Sweden to face Russian forces. *De facto*, Sweden had to choose between the

redeployment of a part of its present forces (at the expense of another area) and increasing its military budget and staff. It has chosen the latter.

Option 2 for facing the spread of A2/AD system is clearly more offensive. It consists of an armed response to the perceived threat of A2/AD systems in an area, by engaging offensive assets in military action. Notwithstanding the risks, some specific cases could lead any country to so engage:

- Danger of losing face as a matter of national priority: the adversary A2/AD restricts the access to a claimed land, or part of the national territory.
- Danger of losing critical or vital resources: the adversary A2/AD systems threaten access to water resources, petroleum, rare earths metals.
- Danger of the adversary paralysing a vital area (like a strait) or a major military facility.

The risk of a "laissez-faire" approach could see the enemy taking control of more and more space within the disputed area, by deploying ground forces or another A2/AD system.

As a consequence, the last resort to keep control of an area and counter a policy of "fait accompli" supported by A2/AD systems will necessarily trigger a military action given that diplomatic negotiations have proven ineffective during recent decades (Russia in Ukraine, Turkey in the Oriental Mediterranean, China and the Senkaku Islands, etc.).

Pushing the limits of an adversary by the use of A2/AD systems which, incidentally, are considered as defensive systems, is finally an excellent way to drive him committing errors with a minimum of risk:

- The adversary will probably lose high technology assets trying to destroy or neutralize the A2/AD system.
- The adversary becomes the offender, and so will have to assume this position when facing the international community.
- A military offensive opens the way to a "counterattack" for A2/AD user.

All in all, there are few options for a country directly threatened by A2/AD systems to neutralise the threat. Not acting places it in a position of submissiveness, while military action risks of losses and being ostracized by the international community.

1.2 Is denying the enemy access to, and freedom of manoeuvre in an area realistic and attainable?

The A2/AD concept spreads the idea that the controlled area becomes inoperable for an adversary force. Either the enemy assets are supposed to be destroyed or neutralized as soon he goes through a virtual bubble, or it becomes almost impossible for them to achieve their missions under of the A2/AD threat.

This widespread idea of the A2/AD as an invisible and impenetrable "iron dome" is the result of a combination of factors. We highlight some of them.

First an abusive overselling of the systems capabilities, mostly for being understood by the civilian elites. The latter are, mostly of them, not familiar with military technologies, tactics and constraints, and their schedules are rarely compatible with long and detailed presentations. Military staff have to use simple and impactful data and graphical representations to pass their messages towards the head of State. As a result, technical details that could temper the effectiveness of A2/AD systems are often evaded.

Second, risk-aversion when planning military operations leads to the most significant sensory capability of an A2/AD system being focused on threat assessment. This could lead planners to considerably overestimate the actual tactical effect, and therefore threat, presented by the A2/AD system.

The third point is a result and compound of the two previous points. We could name it "the ring on the map syndrome". The map below demonstrates the idea:

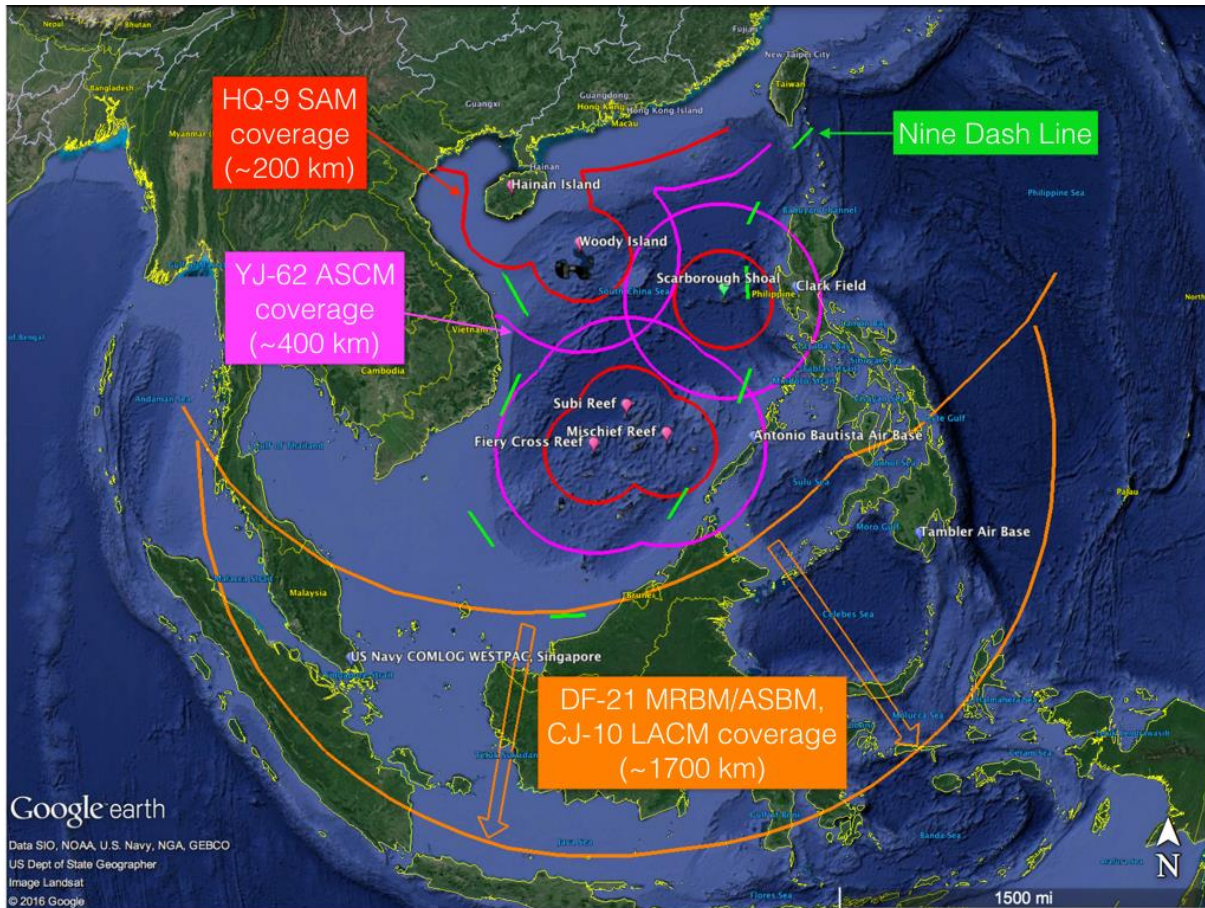


Figure 1 : source <https://warontherocks.com/2016/09/chinas-artificial-islands-are-bigger-and-a-bigger-deal-than-you-think/>

What do we see? That China can destroy any military assets which enter the coloured areas. No nuance, no interpretation, just the idea that entering one of the rings implies immediate destruction. Unfortunately, these kinds of "ring maps" are the most common way to represent A2/AD systems, both in military and civilian thinking.

Last but not least, A2/AD capabilities are often exaggerated because of massive disinformation campaigns. These campaigns are a good way to deter a potential enemy or to catch the attention of a potential customer. The military industry is used to taking liberties with the A2/AD systems: exaggerating distance of effectiveness, speed and target discrimination capabilities, or systems supposed to have reach their full operational capability (FOC) while they are still in development. True or false, such information plants doubt in the minds of adversaries.

There is no denying that facing an adversary protected by A2/AD systems is a significant challenge. First of all, for the political decision-makers, who will have to assume the risk of military losses, and a potential defeat. Secondly for the military strategists, who will have to

take into account multiple scenarios including strong A2/AD capabilities. And finally, for the servicemen and women who will risk their lives facing A2/AD systems.

However, the threat represented by A2/AD must be weighed against the real capabilities of the system, the ability of the enemy to operate it, and the willingness of states to escalate the conflict.

All in all, current A2/AD systems are not able to guarantee the inviolability of a territory or area. The balance between the capabilities of defensive and offensive systems places, for now, a permanent burden on both the "defender" and the "attacker".

1.3 The Russian strategy

Russia sees the A2/AD systems mainly in its defensive posture organisation⁸. Its global strategy is the consequence of the vulnerability of the Russian territory and, in parallel, with the challenges Russia is confronted with. A2/AD is an asymmetric answer to an identified threat, which is part of the "nedopouchtchenie pobedy"⁹, meaning the "hampering victory" principle, an extended version of deterrence.

Furthermore, Russia is well aware of the qualitative capabilities of NATO and the USA and that it will not measure up in the event of a high intensity conflict against the West. Its bastions (in its logic of establishing forts around its immense territory) of Kaliningrad, Crimea and the Far North (Kola Peninsula) are only pledges on access zones.

For Kaliningrad, it is a matter of hindering and dissuading NATO forces from intervening in Crimea, of covering the vulnerability of Russia's southern flank; in the Far North, of putting down pawns in a space and arousing the active curiosity of NATO and the United States.

In addition, Russians know their history, especially of the Crimea. The battles held there in the mid-19th century (1853-1856) and the Second World War (1941-1942) left traces in Russian memories, making Crimea a very sensitive area. Enemy amphibious operations are the most possible scenario there. The Russian response is therefore to establish an A2/AD cordon that allows it to face any threat from the Black Sea (in addition, the coastal defence and artillery regiments have been completely reorganised).

In defining their strategy and the perception of threat, the Russians reason by theatre: Far North, Baltic Sea Region, Black Sea, and Syria:

- Far North: this area presents a real vulnerability to which is added an increase in American capacities to operate in the Arctic. Russia intends to continue strengthening its capacities there but shows no sign of wanting to expand. There is a diplomatic agenda, and important economic agreements for Russian gas and oil reserves that would make any attempt to expand completely counterproductive. The investments already made (in Yamato Nenets LNG terminal more specifically)¹⁰ are so enormous (several \$billions) that Russia will not do anything to jeopardise them. Even the dispute with Norway over Spitsbergen has been resolved. It is therefore more a question of locking down the area in order to remain the master of the game than of conquest.

8 All the information within this part are based on an interview with Dr Igor Delanoë, 27 October 2020, *Historian at Nice-Sophia Antipolis University and post-doctorate in 2013 at the John F. Kennedy School of Government (Harvard University), within the National Security Program*

9 La communication dans le domaine de la « dissuasion stratégique » : le cas de la Russie / Fondation pour la Recherche Stratégique / décembre 2018.

10 Conference at Ecole de guerre, 18 February 2021, Mikaa Mered a Pole geopolitics expert – "The economic challenges of poles" from his book "Les mondes polaires". According to Mikaa Mered, Yamato Nenets, a GNL Terminal, is playing a key role in the Polar Silk Road that the federal Russian government initiated in 2011

- **Baltic Sea Region:** the balance of power is unfavourable the Russians in this area. They have strengthened their defences but have no will to carry out forcible attacks (except perhaps in those parts of the Gulf of Finland that the Russians covet). Paradoxically, the countries of the zone - members of NATO - feel in danger. This facilitates the Russian game, which has only to wait and fidget a little to keep NATO on edge.
- **Black Sea:** the posture, as seen previously, is very aggressive with the aim of making it a maritime stronghold. It offers Russia access to the southern seas.
- **Syria:** a more recent case, it is considered an outgrowth of the Black Sea stronghold and a way to counter Turkey (if necessary) or other states in the event of tensions in the Atlantic.

The Russians enjoy great technical and technological mastery of missiles (supersonic, hypersonic, etc...) both in the anti-surface and anti-aircraft fields. Added to this is the densification of the network of systems and the deployment capacities of ships armed with cruise missiles (mainly patrol boats armed with a dozen missiles for non-nuclear strategic Deterrence¹¹) as well as EW assets such as the Krasukha.

In essence, Russian A2/AD is a defensive posture (mostly). This is the "economy of force" principle of France's Maréchal Foch. The ultimate goal is to raise the cost of entering a theatre to such a level that it is unacceptable to any power attempting an operation. The A2/AD thus participates in inhibiting the decision-making of an adversary.

1.4 The Chinese strategy

In China there are articles on military strategy, international relationships and geopolitics, but they focus primarily on the US and very little if any on A2/AD and how the Chinese view it¹².

A2/AD must be seen in the context of China's comprehensive strategy towards the world. The vision by concentric circles expresses Chinese strategy very well. At the centre is the Party-State with imperative need to maintain the CCP¹³ in power as well as to guarantee internal stability. The PLA thus has a dual function, of exerting military force and to ensure stability and internal order in China.

Understanding A2/AD comes down to the second concentric circle: Taiwan. The interlocking A2/AD matrix is designed to counter a US intervention by imposing such an entry cost that the Americans strategic decision makers would think twice before coming into conflict with the PRC¹⁴. Then by adding the third circle, related to the territories on which the PRC has officially made its claims (and even others for which it has not made any official demand), the deterrent aspect of A2/AD is clear. This exerts pressure on the countries bordering China and the region and keeps the USA out of the areas which the PRC wants. Keeping Japan out of the picture is also part of this (Senkaku Islands). Everything must remain below the nuclear threshold and is dictated by the various challenges that the PRC must face (demography, social protection, immigration (ageing population and failure of the new birth policy...) and maintaining domestic stability).

A2/AD is not the alpha and omega for the PRC. The use of influence is "common currency" to enable it to achieve its ends and gain influence/pressure on countries in the area. For example, in Okinawa, the PRC exerts influence by supporting NGOs that demand the independence of

11 [Note: the reader will note that there is no mention of "Deterrence" as we Westerners understand it because the Russian meaning of the term covers a much wider use. Indeed, this notion encompasses all the tools and means including a nuclear dimension but not only confined to the strategic level, the Russian notion goes down to the tactical level.]

12 [Interview with Dr Paul Charon (Date: 26 October 2020) IRSEM research fellow]

13 [CCP: Chinese Communist Party]

14 [PRC: People's Republic of China]

Okinawa or the departure of the American forces. This would indeed allow the PRC to gain space in its north-east, always with a view to preserving a comfortable buffer against possible American action. The PRC does the same in South Korea and wherever the US has sway. The ultimate desire is to push back, or even drive out the Americans in order to exercise very broad control over this part of the Indo-Pacific – China’s “backyard”.

In addition to influence, the PRC acts through hybrid means. Thus in the China Sea, it relies on its fleets of frontline fishermen who are used as spoilers, to avoid formal action of the Chinese state by presenting these acts as popular nationalist demonstrations; the Coast Guard then comes into play, upholding the law of the PRC in its areas of sovereignty. The Chinese navy intervenes only as a last resort. Moreover, the navy’s impressive development in recent years should not hide its potential weaknesses and little experience. The vocation of the Chinese navy is to project force by the means of disembarkation, thereby justifying the threat to Taiwan that Western strategists foresee.

The PRC also intends to play the Thucydides trap in two different ways, positioning itself on the weak side of the US, and using both hybrid and asymmetric means. Moreover, internally at the FPA, there are differences of view as to the real limits of the FPA vis-à-vis the USA. Overall, the FPA is not at the level of the US armies simply because the PRC is still growing and only part of the PLA units is operational, hence its need for hybrid to counterbalance its shortcomings. But if the PRC plays the role of the weak vis-à-vis the United States, it also places itself in the role of the strong vis-à-vis neighbours and the rest of the world.

If China plays this ambivalence permanently with the USA, it remains no less fascinated by US. In comparison, Europe is seen as a declining continent of little influence towards which the PRC feels in a position of relative strength (setting up its BRI¹⁵). At the heart of its area of interest (the ‘Middle Kingdom’ idea of imperial times), the PRC considers itself to have clear superiority over all the sinicised countries (a form of cultural hegemony?).

If a confrontation between the two great powers were to occur, the PRC would currently not be able to protect its supplies of resources mainly because not all its armed forces are yet ready and operational. A2/AD is included in China’s strategic vision, but it is not a pillar in the sense that China is not currently using A2/AD to gain territories additional to those it already covets or claims. Its desire for domination remains centred on its vision of concentric circles, it does not want to be expansionist but wishes to facilitate its ability to manoeuvre as it pleases throughout the China Sea that it claims in entirety.

II- RESHAPING OUR MINDSET...

2.1 How to define the best approach to counter A2/AD

Overall, China and Russia share two common points on A2/AD.

The first is that they both consider A2/AD as a way to win localised/local defensive wars in terms of very high-intensity offensive strikes (mainly coming from the US).

The second is that they have raised the entry cost to a theatre of operation to an unacceptable level, even for the USA. This inhibits the decision making of the adversary, or at least slows down or delays the reactions of the enemy or distracts from the core goal or exploiting the adversary’s weaknesses. In this sense A2/AD can be seen as a strategy or part of a global strategy, coming from a broader approach that is much more offensive and reactive.

Some could argue that A2/AD is not a strategy. It is definitely not a pillar within the Russian and Chinese global strategy, but it is always a part of it, because of its high deterrent effect on

Western militaries. A2/AD systems could be seen as an ersatz of strategy because their goal is to achieve military effects on any opponent trying to intervene in a sovereign area.

Wherever it has been put in place (Russia, PRC, Iran, Syria...) A2/AD is certainly a strategy in the sense that it is part of a comprehensive concept that brings together different technical systems complemented by doctrine, logistics nodes, and networks.

There are different ways to consider A2/AD strategy:

- As purely defensive, a conventional full-spectrum deterrence or influence system, when linked with sovereignty: territory, troops (deployed, near borders), interests (resources: energy), and political regime survival. The Kaliningrad enclave illustrates this.
- As aggression, to protect a sanctuary, mainly for nonvital interests (otherwise it crosses the nuclear threshold). Which is exactly what China is doing in the China Sea as well as Russia in Eastern Europe.
- As a containment strategy for a nation, when forcing it to run an arms race and its corollary of technological overbid, or limiting it to an occupation strategy (i.e., Swedish islands in the Baltic Sea, Japanese islands in the North-East China Sea) or driving it to make choices by multiplying the fronts and obliging it to choose which one to prioritise to the detriment of others.

Looking at the Western model of armies faced with more and more exorbitant costs of high-tech equipment (F35 for instance) which the 16th Augustine Law is well depicting, their biggest weakness is clear: the mass reduction in equipment. The nation then finds it has less effectors and it is difficult to cover all fronts or meet every crisis in those countries it should be involved in – the USA withdrew from Africa for this reason.

Finally, A2/AD is like winning without vanquishing in accordance with Sun Tzu's precepts: "The supreme art of war is to subdue the enemy without fighting" because in the end "the greatest victory is the one which requires no battle".

2.2 Preventing A2/AD from a strategic perspective.

The main reasons for war according to Thucydides are honour, fear, interest and hate. The Clausewitzian trinity explains that each war is an interaction between three elements:

- (1) primordial violence, hatred, and enmity;
- (2) the play of chance and probability;
- (3) war's subordination to rational policy.

Most recent conflicts were mainly driven by self-interest and rational policy, as well as the play of chance and probability. Thus, potential adversaries will assess potential benefits against costs, and will adjust their risk acceptance accordingly. It is highly subjective and is always a matter of perception, but those precepts can easily be linked with the role devoted to A2/AD.

China in its concentric circles approach strategy in the China Sea, has spread A2/AD's in this area to hamper the USA to intervene if China decided to invade Taiwan or even to dispel the American presence in the area (Guam, Okinawa...).

According to Michael Kofman¹⁶, A2/AD appears to be a concept that does not even exist in Russia. "The result is a general misreading of the Russian military's operational concepts and

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In an article published in the War on the rocks website, named "it is time to talk about A2/AD rethinking the Russian military challenge"

strategy for large scale combat operations". Russia is using the A2/AD at key bastions such as Kola Peninsula, Crimea, and Kaliningrad enclave, as an overall defensive posture with few exceptions in the Black Sea and the Caspian Sea¹⁷.

Western countries need then to reconsider their approach in case of high intensity conflict because focusing on A2/AD is simply misleading us and allows Russia and the PRC to exploit our weaknesses.

First and foremost, the West needs to recover the sense of the **"dialectic of wills"** dear to Carl von Clausewitz in his famous book "On war". This is compulsory if we are to modify our perceptions about modern wars without betraying our values. The "happy peace" earned during the Nineties is definitely over. Nations must sweep away some inherited concepts such as "zero casualty war" and instead consider Risk Management. This means rediscovering "to hit metal" with the associated casualties, collateral damage and material losses. They do have to work on their risk appetite and acceptance not only at a strategic level, but also encompassing public opinion about the real risks at stake in war.

The situation appears to be clear for the military but unclear for the politicians. Indeed, looking for example at the COVID-19 crisis, the large mortality figures in a country (France, the UK) do not appear to have had a commensurate impact on popular support for the political leadership. In a survey¹⁸ conducted by IPSOS (a French survey institute) only a year prior to the next French presidential election, Emmanuel Macron's approval rating was at 41%: at the same level as shortly after his election in 2017 despite the pandemic and its resulting dead. Of course, it is a challenge for politicians to accept that with high-intensity conflicts there will be losses, and potentially heavy losses, both material and human. Public opinion looks more mature than politicians when it comes to death, having not so much an aversion for the dead as recoiling from the unnecessary waste. "Humans get used to everything" as seen with daily reports about military dead in action in a specific theatre of operation, and it becomes like an ambient noise. It is the same for the current pandemic. This is perhaps more a matter of sociology than a strategy analysis, but it seems to be the situation in France and some other countries such as the UK¹⁹.

In the end, to change the mindset about losses there must be a willingness from the key leaders to share their political vision with the population. This vision needs popular adhesion to combat and to its trials and casualties. In WWII, despite Hitler thinking he could break the Brit's will by bombarding London he only strengthened their resolve. Not only had Churchill given them and the country a clear goal²⁰ but also their resilience was reinforced by a vital sense of agency, intense social connection, laughter, moral purpose, and equality, according to Erik Larson in his book "The Splendid and the Vile".

17 Interview with Dr Delanoë at Ecole de Guerre

18 Baromètre politique Ipsos-Le Point : la popularité d'Emmanuel Macron progresse nettement du 10/03/2021 - <https://www.ipsos.com/fr-fr/barometre-politique-ipsos-le-point-la-popularite-demmanuel-macron-progresse-nettement>

19 <https://yougov.co.uk/topics/politics/articles-reports/2020/03/27/covid-19-support-government-reaction-swells> showing the rally-round-the-flag effect of the pandemic.

20 See the article "The Atlantic": How to Survive the Blitz. Five lessons from 1940s Britain about national resilience and social solidarity during a crisis. March 29, 2020, David Brooks (<https://www.theatlantic.com/ideas/archive/2020/03/virus-and-blitz/608965/>) and the podcast on NPR: <https://www.npr.org/2020/03/30/823830284/how-winston-churchill-pulled-britain-through-the-early-years-of-wwii?t=161668387732&t=1616963840167>

Second, the **technological advantages**. Not all the focus should be on the technological lead in new systems, assets and materials. We need to think about mass, resilience, less dependence on satellites, and multi-domain agility especially when budgets are constrained. As an example, China, in its defensive posture and with its tremendous military growth during the last decade, is driving the USA to depend increasingly on high technology. This forces the USA towards deploying fewer materials. If the USA had to intervene in the China Sea, the USA might have to shift to a different kind of action (perhaps Soft Power) unless it were looking for a military clash. One tends to look in all directions except the one in which high-intensity conflict is leading us. When AI arrived it became, and still tends to be the answer for many things we had not even been looking for a solution to. But here again we just look at things with a focus on technology and with two important biases: unreasonable expectation and dogmatism²¹.

Another point is the "low-cost" wars. Some could argue that such wars lead to more dead, but we think this is not always true. Of course, if the comparison is done between air assets, Rafale vs MIG21 for instance, there is a key advantage to the Rafale because we are comparing two different generations of fighters. If the technological gap were reduced, the advantage would be less obvious. What is important here is the "off set" rule, as shown by using a drone swarm to saturate enemy air defenses. Using a low-cost mass of tools, equipment or assets to destroy, saturate or even degrade highly expensive weapon systems is a good illustration of the advantage of "off set".

The aim is always to weigh the relative benefits of asymmetric and hybrid ways of operating prior to engaging in frontal combat or as a way to stay under the threshold of open conflict.

Lastly, how to **inverse the costs/benefits and risks/stakes ratios** to the West's advantage worldwide. Since the USSR's collapse, the West has been involved in wars where stakes, benefits and costs were all quite low (compared to high-intensity wars). Risk acceptance has similarly been low for almost 30 years, to the point that the concept of "zero casualty war" came into prominence. The situation has now changed. The West needs to reconsider its dialectic of war because there will be more and more asymmetric/hybrid means in the next conflicts. This trend started with the cyber-attacks perpetrated in the Baltic States in 2007 as a response to statues from the former Soviet age having been knocked down.

In 2008 in Georgia, the West failed to react firmly to the Russian action. There were protests but no military actions. No one had even the will to intervene due to the imbalance of the costs/benefits and risks/stakes ratios. The same happened in 2014, when the "little green men" with no visible nametags or flags entered Crimea. A referendum had been organised by Russia, but it was not accepted by the West.

Looking at different cases where A2/AD might be used may help better to understand what is at stake, the risks involved, and what is our appetite for action.

Our potential adversaries' (China or Russia) territories.

Here, the risk of escalation is huge because our action might be perceived as a threat to their vital interests, and both are nuclear powers. Honour, fear and hate might exceed a cold analysis of interests, hatred may take precedence over rational policy. In such a case, no one would be able to achieve gains or benefits. The probability is really low that Russia or China would use A2/AD against assets which respect international laws and do not threaten them. It would contradict their diplomatic and economic interests. In this way, A2/AD remains a defensive tool.

"Aggressive sanctuarisation" scenario.

In Ukraine, the play of chance and probability, rational policy, assessment of costs and benefits are key factors. Crimea has always been of major strategic significance for Russia, and the potential costs and risks were low, the potential benefits were high; for the West it was the opposite, especially after A2/AD had been put in place. Now that the Crimea has been annexed by Russia, any attempt to intervene might lead to the use of nuclear weapons.

The lessons from such scenarios are to be able to intervene before A2/AD's are in place. To do so, the West needs a legitimate reason such as threat against national citizens or defence agreements, and a clear assessment of the situation before the costs and risks become too high. **Military presence** helps to solve those issues. That is why the NATO enhanced Forward Presence (eFP) strengthens both deterrence and defence postures in the eastern and south-eastern part of its territory. Military presence helps to engage public opinion who will not tolerate that national soldiers die without any response. Such "retaliation" is a legitimate reason to project quickly power and forces without being accused of threatening neighbouring countries. Russian strategy has always been to keep defensive depth. It would be against their interest to have many western forces and capabilities in neighbouring countries. On the other hand, reasonable numbers of "defensive" assets is probably a good bet: not enough to be interpreted as a threat so that interest and rational policy maintain precedence over fear and honour. Furthermore, any Russian invasion, even "under cover", would strongly increase the probability of a strong answer from the West. The risk for Russia is to have even more West military assets in the neighbourhood; the worst-case scenario would be to lose Kaliningrad, especially if it holds A2/AD weapons. If Russia maintains its sovereignty over Kaliningrad, what kind of benefits could Russia obtain from an invasion of the Baltic states? Potential risks and costs are high, benefits are low.

Without the NATO military presence, it would be easier for Russia to play the same kind of hybrid war in the Baltic as it does in Crimea: a "just" intervention to help people of Russian origin, using political subversion to help put Russian boots on the ground, then installing A2/AD to raise the potential risks and costs if we respond militarily.

As described, military presence helps to reduce two of our major weaknesses: the need to legitimate our intervention and to have the support of our public opinion. Thus, it might be sufficient to deter potential adversaries from invading Alliance territory and defending it with A2/AD deterrence. As assessment is a matter of perceptions, the West has to be seen to get tough and decisive in its talks about respecting its Alliance and to fix red lines. Moreover, despite failure to act in Syria in 2013, the West has to intervene any time a red line is crossed: the Crimea invasion occurred one year later.

The **indirect approach** is also a way to consider the A2/AD in its entirety. Whichever opponent has an A2/AD system it can be smarter to try to frustrate him rather than try to engage in a frontal clash to penetrate the "bubble". When facing an enemy using A2/AD, a detailed analysis of its weaknesses (systemic, environmental) may reveal a key answer. According to Thomas X Hammes, breaking down the Chinese A2/AD bubble is probably the least economical way the USA could prevail in a war. It would be much cleverer to blockade the Strait of Malacca rather than wanting at all costs a kinetic clash²². A blockade will weaken the adversary, but it takes time.

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On February 6, 2018, as part of the Johns Hopkins APL Rethinking Seminar Series "Rethinking Future Environments and Strategic Challenges" (2017-18), Dr. Thomas X. Hammes of the National Defense University spoke on "The 4th Industrial Revolution, De-Globalization, and its Effect on International Security." https://www.youtube.com/watch?v=g_k9WGCN0rE

Mark Gunzinger and Chris Dougherty have defined ²³ this kind of indirect approach for the Iranian A2/AD posture in the SOH²⁴. They show how it can be smarter to get into position at different locations and split one's forces so as not to offer an easy target but compel the adversary to use multiple missiles, to complicate its operational planning and deter him from establishing a clear picture of the battlespace. In addition, this reduces his ammunitions stocks while allowing us greater flexibility, agility to intervene simultaneously from different locations. Those locations can be used as reinforcement and support bases (artillery, missile, logistics...) before and during the engagement. It is a way to shift the effort of war from one side to the enemy. This concept can be easily transposable to other potential conflict areas.

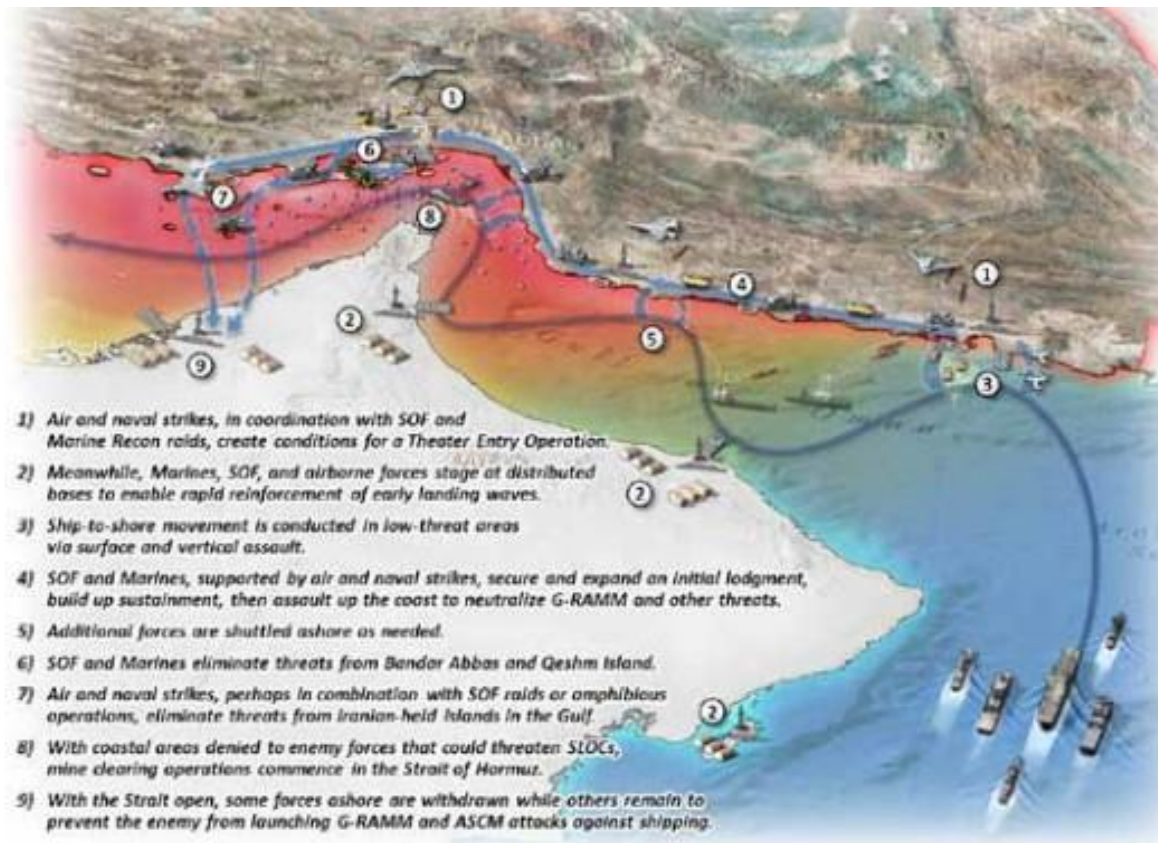


Fig. 2 Illustration of a US Joint Theatre-Entry operation under Iranian A2/AD umbrella²⁵ in the SOH.

23 [From a document written by Mark Gunzinger and Chris Dougherty for CSBA untitled "Outside-in, Operating from Range to Defeat Iran's Anti-Access and Area-Denial Threats", 2011, p.120]

24 SOH = Strait of Hormuz

25 [From a document written by Mark Gunzinger and Chris Dougherty for CSBA untitled "Outside-in, Operating from Range to Defeat Iran's Anti-Access and Area-Denial Threats", 2011, p.120]

III- OPERATIONAL PERSPECTIVES AND OUTCOMES

3.1 Planning and conducting operations in A2/AD environments

John Frederick Charles Fuller, a British general during the First World War, argued that “the potential strength of an army lies in its organization, controlled by its brain. Paralyse the brain and the body stops to work”. We will show how A2/AD systems may paralyse our brain (planning and command) and disrupt our nervous system (control and communications).

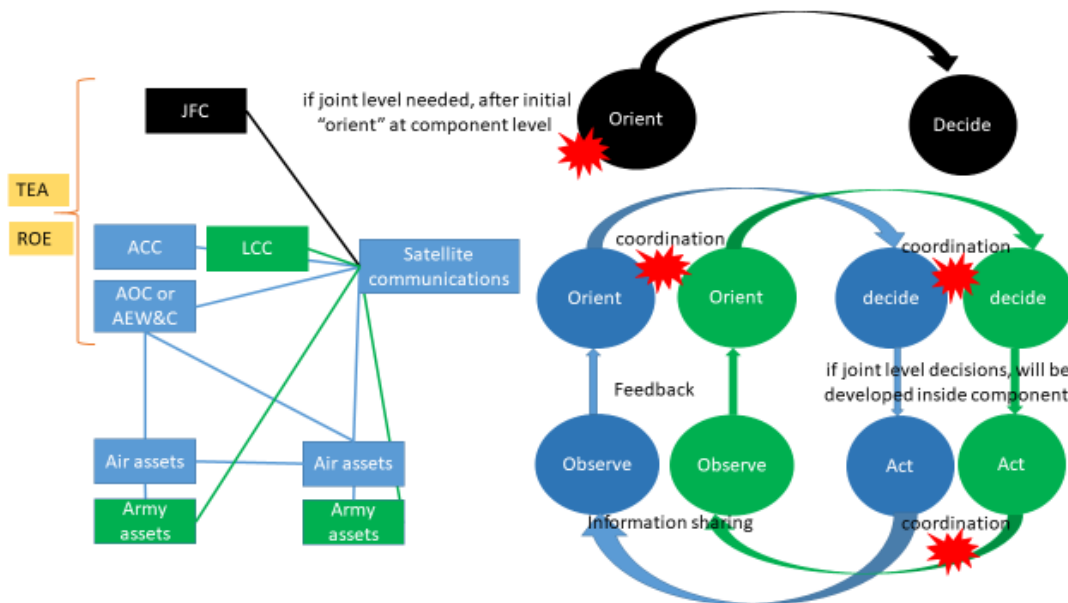
3.1.1 Command and control

The tenet of centralized control and decentralized execution is a cornerstone of many Air Forces’ doctrines²⁶. It enables the balanced and optimised use of assets, which are limited in number. During the past 30 years our networks, data links and communications have been unchallenged. It will not be the case anymore in an A2/AD environment. Our command and control (C2) suffer a lack of resilience and agility. It is important to highlight some key points about a centralized C2 organisation and its targeting processes. Then we will show all the impacts of A2/AD systems on our C2 processes, referring to the OODA loop (see Annex 3).

Our C2 architecture relies on scarce key nodes: Joint Force Command (JFC) headquarters, Joint Operations Centre (JOC), Air Component Command (ACC), Land Component Command (LCC), Air Operations Centre (AOC), and so on. Even if they are not forward deployed in a centralized C2 organisation, they need to communicate with forward assets.

A joint mission of opportunity (neither planned nor previously tasked) will be usually coordinated at the component command level or at the joint level. Consider the targeting process. The “targeting phase” includes ensuring a positive identification (PID), a collateral damage estimate (CDE), and a check of the surroundings (transients, patterns), to establish approvals for rules of engagement (ROE) and Targeting Engagement Authority (TEA). This kind of procedure commonly takes several tens of minutes with assets loitering over the target. Joint or component command level usually retain the TEA and the decision to use offensive ROE.

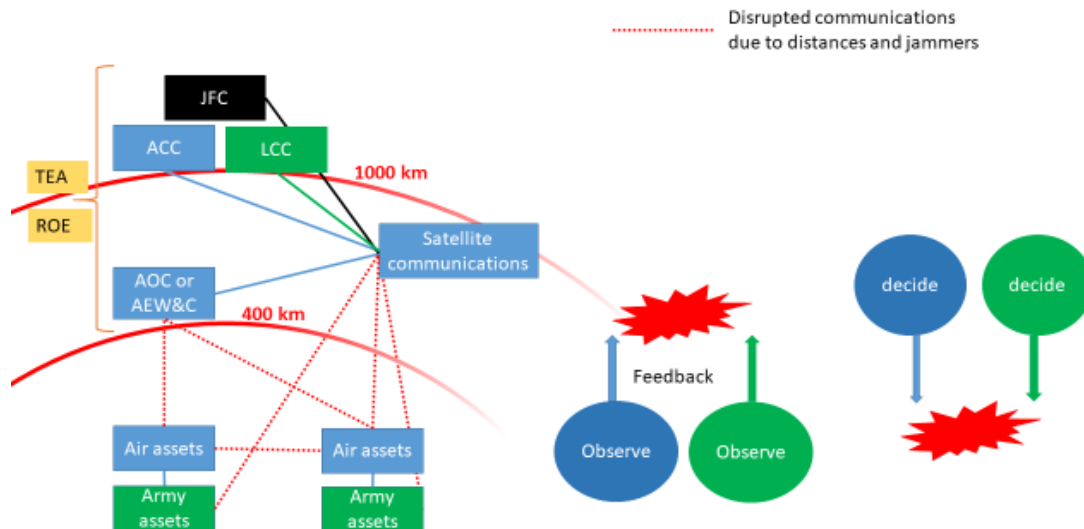
The graphic below represents a notional centralized C2 organisation during a joint mission of opportunity, with its communications links on the left. On the right side, the graphic shows the different steps of the OODA loop:



- *Observe*: an army asset finds a target of opportunity;
- It reports the situation within the army chain of command;
- *Orient*: The LCC analyses the situation, compares different options, coordinates with ACC for air support. ACC has its own *orient* phase in coordination with LCC; any coordination implies friendly friction, depicted in red. If LCC and ACC disagree on a common option the JFC may arbitrate, creating further friendly friction;
- *Decide*: a decision is made (either at the joint or component level). Each chain of command will give detailed orders (task and framework) to its respective units;
- *Act*: army and air units will receive their orders and will need to coordinate for action;
- After the action, the units observe the result and initiate another loop.

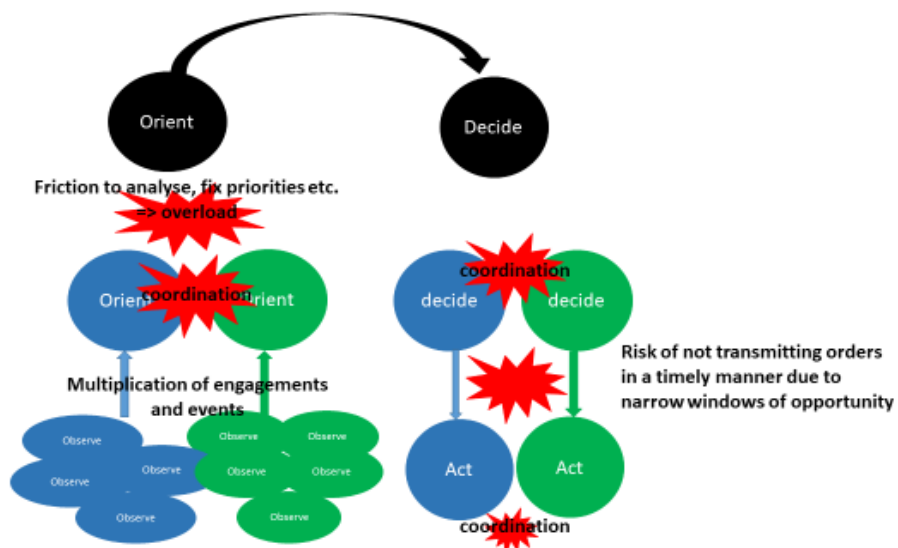
In an A2/AD system contested environment, the different command centres (JFC, ACC etc.) operate further away from the area of operations (AO) because of long-range surface-to-surface missile (SSM). To be efficient, this centralized C2 thus relies on satellite communications or a relaying asset such as an airborne early warning and control system (AEW&C).

The problem is that A2/AD systems include also jammers and long-range surface-to-air missiles (SAM). If an AEW&C flying at 30000 feet wants to stay out of range of S400s, it will operate 400 km away. It is able neither to communicate with a low-flying friendly aircraft nor to detect any low-flying target beyond this S400. The received power of a signal decreases inversely as the square of the distance. The weaker a signal is, the easier it is to jam it. The extended ranges of A2/AD systems will act as a force-multiplier for jammers. For a fighter jet for instance, it is easier to jam its communications with the AEW&C as they get further apart, and the jet nears the jammer. Satellite communications face the same issue; A2/AD systems also include anti-satellite (ASAT) weapons (Annex 2). Consequently, A2/AD systems would probably disrupt our communications, the long-distance ones in particular. In a centralized C2 organisation, this could lead to the collapse of our decision-making process and operations cycle.



This OODA loop relies also on the availability of scarce key nodes (like JFC, LCC, ACC). These are vulnerable to increasing cyber-attack capabilities. The more centralised our decision process, the less resilient it is²⁷.

In a high-intensity war, we can expect large-scale engagements. However, the availability of experts in the C2 centres will remain limited. In the case of numerous and simultaneous engagements with many assets to *observe*, the C2 structure will be overloaded, and a lot of friendly friction will occur at the *orient* phase while synthesizing the abundant and allegedly relevant information and fixing priorities, etc... A2/AD systems are highly mobile and elusive, and air assets will not be able to loiter in the area so windows of opportunity will be narrow. The OODA loop's completion must therefore be fast. Overload at the Centres and friendly friction generated by coordination all along the process might lead to missed opportunities.



For an efficient and resilient organisation, control has therefore to be distributed to forward assets. If long-distance communications work, upper levels will still be able to balance and optimize the use of assets.

The tenet of distributed control is far from new. John Boyd summed up its philosophy:

*To minimize friendly friction, one must act and react more quickly than one's opponent. This is best accomplished by the exercise of initiative at the lower levels within a chain-of-command. However, this decentralized control of how things are done must be guided by a centralized command of what and why things are done. This shared vision of a single commander's intent ensures strategic and operational harmony among the various tactical actions and reactions.*²⁸

Here is an example about how to implement this philosophy in our C2 organization. The commander has vision and intents. Command centres (JFC, ACC etc.) translate these into priorities. These priorities can be related to areas of operations, types of target or desired effects. The acceptable risk can be in accordance with the different types of task or target instead of evolving with the campaign's phases. Unlike what is usually done, the acceptable risk level (ARL) can change without upper-level approval. It will still be consistent with the commander's intents because it will only change in precise circumstances previously determined by upper levels. If tactical units share the commander's vision about *what* and *why* things are done, if they understand the priorities and when a task is worth a higher risk, then it is possible to empower the initiative by allowing the units to decide mission change, use of ROEs, TEA, ARL change, etc... These are prerequisites for efficient distributed control. Empowering the initiative will help tactical units to seize volatile opportunities; it will be paramount against elusive A2/AD systems.

Looking at the Scud-hunting experience in Iraq confirms this and provides the following lessons learned (Annex 4):

- The delay between a Scud detection and a strike was too long (also called into question the efficiency of stand-off weapons, due to their flight-time).
- Joint operations brought many advantages.

If a Special Operations Forces (SOF) team find a mobile SSM, a nearby aircraft should be able to strike without wasting time through the chain of command. Therefore, our C2 organisation should also allow flexible handover of control (or tactical functions) at the lowest level and between units from different components. Once again, this kind of "automatic" control handover can be limited to precise circumstances, such as detection of an elusive high value target (HVT).

In such a C2 organisation, two kinds of OODA loops will coexist:

- An operative loop that will orient and decide midterm priorities, type of missions, etc.
- A tactical loop, some planned, others automatically generated to seize opportunities thanks to flexible handover of control (or at least tactical functions).

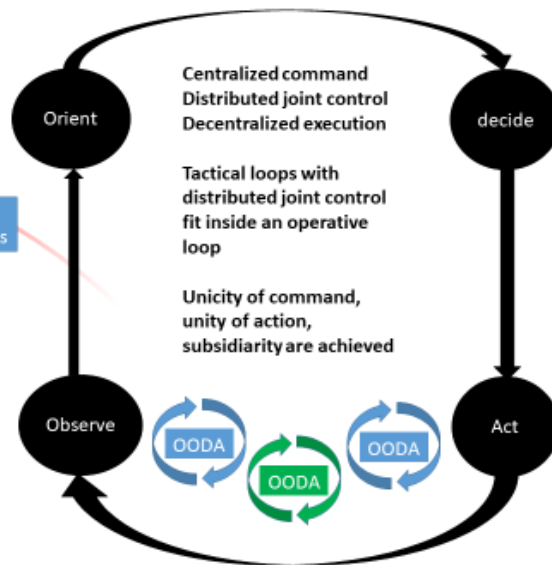
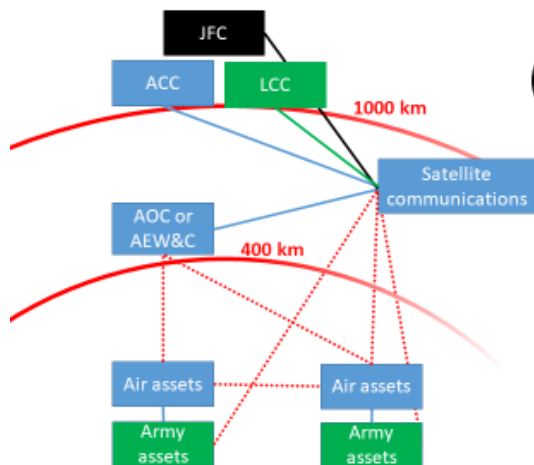
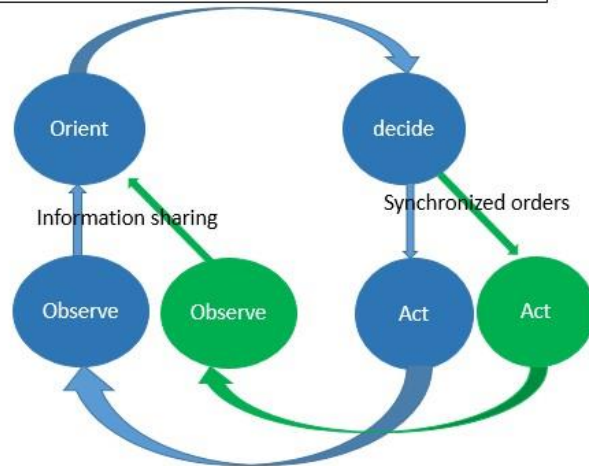
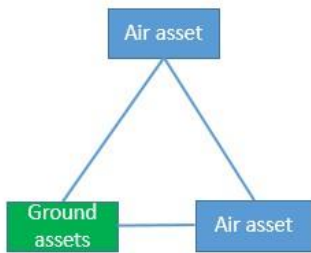
These tactical loops will fit inside the operative loop and will work in accordance with the vision and intents of the commander. Consequently, an organisation applying "centralized command – distributed and flexible joint control – decentralized execution" will still respect the

fundamental principles of a chain of command: unicity of command, unity of action, subsidiarity (which will be improved).

Tactical loop illustration

This tactical OODA loop is:

- More resilient to jamming (due to distance)
- Less subject to friendly friction
- Less subject to overload (with appropriate joint datalink)



The issues previously discussed also call into question the efficiency of a C2 structure that uses Artificial Intelligence (AI). While AI will probably speed up the tactical loops, if the data collected cannot be sent in real time to the component command or joint command, the benefits for short-term decisions and actions of the operative loop will be limited. Furthermore, AI needs reliable data. Confusion and deception would probably be cheaper than an efficient AI-based C2. It could lead us, once again, to be subject to a cost-imposing strategy from our adversaries. Finally, according to Jean-Gabriel Ganascia (a French AI expert), AI cannot change its taught paradigm by itself. Yet being able to change paradigm has always been crucial in warfare and is exactly what we suggest in this article.

3.1.2 From predictable time-phased to multi-domain operations

Over the past thirty years, the West has intervened at will in different locations. The West especially demonstrated its military superiority during operation *Desert Storm* which, to some

extent, created our current operations paradigm. During *Desert Storm*, satellites and aircraft allowed intelligence collection. The enemy was deeply analysed to create the most appropriate time-phased target list in an effect-based approach:

- We destroyed the main Iraqi air threats to achieve air supremacy and their key elements to create paralysis.
- Air supremacy and enemy paralysis allowed us total freedom of movement.
- We dominated through the massive use of tactical airpower (with precision munitions) and a high-paced joint campaign.

The operation was quick with few losses. This success shaped some of our subsequent beliefs about how to plan and conduct operations:

- First, air and naval firepower suppress the main threats and shape the environment before any further step.
- Once conditions are favourable, land operations can start; naval and air components then mainly act to support these.

Russia and China studied and understood this approach. Air and naval supremacy are prerequisites to our predictable time-phased campaigns. This one and single first step option for our interventions created a single challenge for our opponents: how to deny air and naval supremacy. A2/AD systems directly contest this supremacy and consequently deters us from intervening. History has taught us that persisting in a way of thinking can lead to defeat. Before the Second World War, France believed that avoiding the mistakes of the previous war while repeating the same successful methods²⁹ would be the keys of future success. French forces invested its main resources in fixed defensive systems (Maginot line) supported by fixed or low-mobility artillery at the expense of aircraft and battle tank. This left them unable to compete against the highly mobile *Blitzkrieg*. That lesson should put into question our current quest to maintain our air and information dominance at any cost.

Multi-domain operations (MDO) suggest precisely the opposite concept: *employing capabilities across all domains to pose multiple and compounding dilemmas on the adversary*³⁰. MDO and Mission Command concepts acknowledge the new situation of war: we will not be able to gain and maintain superiority in a chosen domain, everywhere and permanently (as in the airspace during *Desert Storm*), to then enable superiority in the other domains following a precise plan.

Mission command is not a new idea. It is similar to the *Auftragstaktik*, developed in 1801 in Prussia; it played a central role in the *Blitzkrieg*³¹ and is enjoying a resounding success in recent years, especially in US doctrine³² and publications³³. Mission Command advocates the empowering of initiative to gain a position of relative advantage. While our current C2 assesses compliance with a plan to reach predetermined time-phased objectives, Mission Command aims to assess the adequacy of the plan and the actions continuously.

The objectives of MDO and Mission Command are less ambitious and more realistic:

- Manoeuvre to positions of relative advantage.

29 L'étrange défaite, Marc Bloch

30 The US Army in multi-domain operations 2028, TRADOC pamphlet 523-3-1, 6 December 2018

31 Le « mission command », de la théorie aux pratiques, Rémy Hémez, 4 septembre 2015, ultimario-blog.org

32 US Army Training and Doctrine Command (2014). The US Army Operating Concept. Win in a Complex World. TRADOC Pamphlet 525-3-1

33 Joint Publication 3-0 joint operations, 22 October 2018, under the direction of the Chairman of the Joint Chiefs of Staff (US)

- Project power across all domains.
- Create windows of domain superiority.
- Exploit temporary domain superiority to achieve advantages.

MDO provides multiple options and avoids dependence on a single method. This increases the number of dilemmas for the enemy and imposes complexity, slowing down their own OODA loop.

A defender has a fundamental weakness. They have to balance their efforts between domains and locations. On the contrary, an attacker can decide where, when and in which domains they will put their main efforts.

Here is a simple example to show how it could work. Facing an adversary equipped with A2/AD systems, we assess that we can achieve a position of relative advantage in the land and cyber domains at a given location. It is difficult to locate A2/AD systems due to concealment, decoys, and emission control procedures. Thanks to the exploitation of cyber and the electromagnetic spectrum, we disrupt our adversary's communications and track gatherings of targeted mobile phones. We manoeuvre to strengthen a land-favourable ratio, penetrate and move forward, while being ready to project power across all domains. Our adversary's SAM now faces a dilemma: they can move, or they can support their ground troops trying to achieve air superiority, but they will have to emit and shoot. In both cases, they risk detection and destruction, but if they remain inactive and steady, they leave their ground troops without support and risk becoming isolated and later destroyed by our ground fire. This example shows that MDO allows land forces to first step in and act as an enabler for other domains. Land forces can manoeuvre, threaten surface-to-air systems and create favourable windows to allow temporary air operations. This is a continual process.

However, some statements of the US Army MDO's concept are questionable. For Instance, in the TRADOC publication: *The key to penetration is the neutralization of the enemy's long-range systems in decisive spaces enabled by Army long-range fires.* During a conference in Georgetown (TRADOC Mad Scientist in 2017), General Perkins stated that *while air and naval are likely to be dominated by long-range system, land forces provide the key attributes of resilience, persistence and sustainability.* Envisioning MDO in this way is not a change of paradigm. It is similar to our current approach but using a different tool. Land forces just replace air power in its role of "first in" and "key enabler". It contradicts the tenets of multiple options and avoiding dependence on a single domain. Furthermore, it is not applicable everywhere. Geography is a highly significant criterion. While it is possible to send land forces first in a European theatre, it will not be the case in Taiwan, which is surrounded by sea. We will need to adapt our plan to circumstances and enemies.

3.2 Choosing key technologies and weapons

3.2.1 Tenets and criteria

John Warden advocates parallel attack against the enemy's key operational and strategic nodes to produce paralysis. This refers to the Clausewitzian concept of an enemy's centre of gravity (CoG), defined by Warden as "that point where the enemy is *vulnerable* and where an attack will have the best chance of being *decisive*³⁴." We must keep in mind that our enemies can do the same. If our military capabilities rely on scarce key elements, and if our enemy is able to target them, then we become critically vulnerable. A2/AD systems have turned this situation to reality.

This is not only a matter of vulnerability but also of cost. Our military superiority relies heavily on fighter jets; they have become more and more expensive and therefore we can afford fewer. Currently, the West seems stuck in an arms race with both unsustainable costs and cost-imbalance, in which a missile costing less than one million euros can shoot down a 100-million-euro jet. Aircraft carriers and large satellites face the same issue. Protecting these key assets at all costs would lead to a vicious circle of rising costs and reduced numbers. This reduces our ability to intervene in different locations and our competitors rush into the empty places we leave in the Middle East and in Africa.

A2/AD systems exhaust munitions and therefore raise the question of stocks and production times. Yet complex weapons demand a lot of time to be manufactured and the more expensive they are, the more limited are their inventories.

In contrast, if our operational capabilities are distributed and shared among numerous assets, the only way for an enemy to paralyse our operations is to start a long attrition process, with uncertain outcome. It is harder to fight an enemy who does not have any key nodes, as terrorist groups illustrate. Their independent cells with loose connections pose huge difficulties for targeting, let alone destroying or dismantling their networks. Even the targeting of their leaders does not produce sufficient results.

Taking this tenet further, if our operational capabilities rely on numerous consumable assets and if their cost is lower than our adversaries' weapons, we may inverse the costs/benefits ratio to our advantage. For instance, if our adversaries waste their one million dollars missiles against cheap decoys, they will experience cost overbid and inventory issues.

To conclude, our current approach is to develop assets that gather many capabilities. They are complex, expensive, few in number and their manufacturing is long. In case of attrition this in turn endangers our resilience.

This dependence on scarce expensive assets has other disadvantages. They rely on advanced technologies that are held by few countries. And it creates a lack of balance between allies, some of whom do not benefit from a return of investment in their military and so depend on allies with the biggest budgets. Such dependence weakens our alliances.

Furthermore, the threshold effect is significant. For instance, allies with only a few expensive fighter jets tend to utilize them for national defence only. This deeply adds to the issue of mass, which is paramount to saturate A2/AD systems.

One of our key ideas is that the West should inverse the costs/benefits ratio of A2/AD to its advantage. One solution might be to stretch the principle of dual-use technology which can be used for both civilian and military purposes. For instance, the GPS project was launched by the US military but then has had huge positive impacts on the economy, it was a profitable investment. Furthermore, there are different ways to use a given weapon. The missile *Sparrow* was initially an air-to-air missile. Nowadays it is also used as a ship-borne short-range anti-aircraft and anti-missile weapon. This shows that some technologies or weapons can provide capabilities in different domains. If some technologies or weapons can be useful in the civilian and military domains, for attack and defence, in air-sea-land domains, during peacetime and wartime, in low threat and high threat environment and so on, it will reduce the overall cost.

A better approach to the attrition problem of A2/AD systems, would be to divide the various tasks that enable our capabilities between numerous distributed assets. The emergence of "a system of systems" in the specialized press shows that this paradigm looks promising.

This is not intended to be an exhaustive iteration of principles but only a reflection to better address the issues related to A2/AD. In appendix 5 there are comparisons of key technologies to illustrate some of our remarks, in the last paragraph in particular.

3.2.2 Artificial Intelligence and Autonomous Lethal Weapon Systems

Artificial Intelligence (AI) and Autonomous Lethal Weapon System (ALWS) are specifically addressed in this chapter because they highlight two hazardous behaviours: *unreasonable expectation* and *dogmatism*.

AI is enjoying great success. Articles and studies about it are flourishing, and this technology promises limitless advantages in a conflict. With a proper use of big data and AI, it seems possible finally to dissipate the fog of war, to predict enemy behaviour, and to decide and act faster than he does.

First, exploiting such technologies implies being able to store massive amounts of data. As these will have to be classified, they will be gathered in protected data centres. The same is true for computers running the AI software. In other words, such technologies would probably be centralized, as previously discussed, and centralisation creates centres of gravity that are the opposite of resilience.

Second, cognitive bias and “chaos” should not be underestimated. Once an apparently unpredictable or unlikely event has occurred, it is always possible to find weak signals or faint evidence that might have helped to anticipate this event. This is a major promise of AI: finding weak signals from huge amounts of information. This is usually related to the confirmation and hindsight bias. If you are looking for weak signals that announce an event, you may find them. But what if you are looking for weak signals that announce that such an event will *not* occur? In other words, it is usually possible to find as many weak signals that confirm an “unpredictable” or “unlikely” event would occur as that it would not occur. Even the most rigorous science, mathematics, teaches us that the simplest equations can lead to stochastic results. The logistic map equation only has two variables and is a perfect example of a stochastic equation. Currently, we are far from being able to model or map human behaviour in war and AI seems unlikely to advance this concretely. And we should keep in mind that statistics and correlations are very different from prediction and causalities.

Finally, it is not because people know what they should do that they actually do it. For instance, climate change is not called into question anymore, yet this does not prevent some people from acting as if it is not happening. There is sometimes a huge step between being aware of useful information and then taking appropriate actions: completing the process requires first and foremost strong willingness. That is all the more important in warfare, in which the “dialectic of will” is paramount.

AI is a promising technology, but it is obviously not the answer to all the uncertain areas in tomorrow’s wars. Relying solely on the potential mastery of a disruptive technology is a form of blindness.

Debates about ALWS pinpoint another hazard: *dogmatism*. ALWS offer many opportunities, especially against A2/AD systems as the Nagorno-Karabakh conflict showed. The HAROP drone for instance, is a loitering munition that can be either remotely controlled or fully autonomous, and had good results against SSM and SAM. However, some western countries simply refuse to envisage a weapon that can operate without human intervention. The French

MoD recently decided that there must always be a human in the decision loop when it comes to engaging a target. This should close the door on Autonomous Lethal Weapon System (ALWS)³⁵. The main objection then, is ethical.

It is important to keep in mind that perceptions change with time. Ten years ago, it was impossible because of ethical issues to envisage a French drone carrying and delivering weapons. After several years fully involved in operations in Mali, the benefits have become clear to the French military of being able to deliver a weapon in areas where no fighter aircraft were available or being able to take advantage of the playtime over a target area. Nowadays Reapers are fully engaged in Mali, using their payload when needed. Is it still an issue? Are there any protests? No, it is now part of the ambient noise.

Ethical issues are complex and require more than a Manichean approach. At first sight, an economic sanction sounds ethically more acceptable than war. Nevertheless, even if the real figures are still subject to debate, the number of Iraqi victims during the Gulf War is estimated between 70 000 and 150 000, while the number of indirect victims of the follow-on embargo and economic sanctions is estimated between 500 000 and 1 million³⁶³⁷³⁸, half of whom were children. With ALWS, it is not so much a question of whether it is a bad concept to kill people *with robots*, but whether what will happen if we do *not* develop and deploy them if our potential adversaries are doing so. Is it humane, moral or just to send our troops to confront foreign armies that use ALWS? Do we accept that we would lose people in combat while our adversaries would only lose machines? How many of our troops would we be prepared to lose?

In spite of the appearances, ALWS might be in some circumstances ethically more acceptable than using a manned system. In a highly contested environment full of IADS, where remote control is only possible from a close distance due to the risk of jamming and the pilot's life is on the line, how long will a human pilot be given to check a possible target prior to engaging it? In contrast, an ALWS does not feel fear and can be programmed to check a target from different angles, taking its time to remove doubts.

Choosing key technologies and weapons on which to invest can be decisive. There are no perfect choices a priori. In any case, it is vital to avoid unreasonable expectation and dogmatism.

³⁵ A French parliament report distinguishes five level of weapons autonomy. According to this report, only the highest level is considered ALWS (a cruise missile is not considered as an ALWS for instance). *Rapport information sur les systèmes d'armes létaux autonomes*, présenté par les députés Claude De Ganay et Fabien Gouttefarde, 22nd of July 2020.

³⁶ Le Monde diplomatique, Manière de voir, numéro 120, décembre-janvier 2011

³⁷ John Pomfret, Violence Increasing in N. Iraq, The Washington Post, 4 juin 1991.

³⁸ Michaël Lessard, Les sanctions économiques globales contre l'Irak (1990-2003) étaient-elles compatibles avec le respect effectif de la Charte de l'ONU, des droits humains et du droit international humanitaire ?, Laval, Institut québécois des hautes études internationales, 13 mai 2004

Conclusion

For years, our military superiority was achieved thanks to our constantly improving systems and assets and the relative condition of our adversaries.

Now the return of Great Power Competition is changing the game. This will lead without doubt to human losses when hitting the metal again. The West must urgently prepare for this, using as much as possible decentralized and cross-domain organisations. The West needs to take up again the *dialectic of will*, especially when facing a near-peer or peer adversary. It is also time to talk less about military superiority and more about the cost-effectiveness of fighting in highly contested environments.

We inherited our thinking from the Desert Storm Operation and the Military Affairs Revolution. Military superiority allowed us to apply the same combat-proven methods and strategies, yet the increasing cost of weapons led to a reduction of armed forces. One of the main issues created by A2/AD systems is the increasing vulnerability of some of our key assets, which are expensive and therefore scarce. It is not enough to apply Warden and Boyd's principles to the enemy; we should apply them also to ourselves. If we fail to do so, we risk being paralysed in the first days of a high intensity conflict.

Protecting or improving continuously our key assets would lead to a vicious circle. It will once again increase their costs and reduce their number, and thus limit our ability to last in a conflict when suffering heavy attrition. We intelligently exploited the cost-imposing strategy after World War II; since the USSR's collapse, however, we have been trapped by our adversaries in this same strategy, which is now challenging our own resilience. Furthermore, all our weapons stocks are limited and would take long to rebuild. We again risk being paralysed shortly after a conflict starts due to attrition. Our study shows that 'bursting the bubble' leads to an intractable problem of running an arms race to acquire more and more technology and stretching to breaking-point our resources to face a peer adversary in the near future. Bursting the bubble with such a mindset cannot work anymore in a high-intensity conflict involving A2/AD. Investing in so-called disruptive technologies like AI and hoping for the best is not a reasonable choice.

"War is more than a mere chameleon", wrote Clausewitz. Even if chameleons change their colour, they remain chameleons. Not only have we examined only a portion of the chameleon, we also have not analysed its colour changes. The **nature** of war remains the same. Grasping the issues of A2/AD and finding solutions must encompass a study of the will and purposes of our potential adversaries and all their possible strategies. Our study shows, however, that the **character** of war has changed: and so must our paradigm. We suggest a new approach based on the triad of dialectic of wills, resilience through robustness and mass, and balancing the costs/benefits and risks/stakes ratios.

This paper has set out a way to plan and conduct operations, and the relevant criteria for choosing and balancing our limited military budgets. Thus, the new colour scheme of the chameleon – a new paradigm – has appeared. Some of these are:

- The ability to project power by a direct approach will no longer be sufficient or affordable. The Ukraine-Crimea crisis showed blurred lines, mixing conventional means and proxies within a permanent crisis from competition to localised war, while playing

with conventional deterrence and nuclear thresholds. Our strategy must combine approaches and methods: indirect approach, deterrence, military presence, asymmetric costs, and so on.

- Future operations must not use a single linear path approach based on predictable time-phased operations but will have to be flexible to adapt to circumstances (enemy, aims, risks...) within the conflict.

- Command and control will no longer be optimized by centralization alone but on the contrary, by distribution and empowering tactical initiative in order to overcome the paralysis.

- Resilience will rely less on the protection of key assets than on mass and the distribution of capabilities among numerous, cheap and quickly built assets.

The renewal of great power competition will encourage this paradigm change. Nonetheless, the great challenges that the West has to face can only be met collectively. The biggest challenge that A2/AD systems have created might well be how to forge a new and common vision between the Western allies.

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Annexes

APPENDIX 1 : Reflex sheet:

Russia and China strategy: win without fighting		
Target our will to fight Challenge our operational approach Drive us to seek for unaffordable solutions (cost-imposing strategy)		
A2AD systems effects		
Increase cost Hamper our linear time-phased operations Challenge our beliefs Challenge our communications	Target our scarce assets Exploit our dependance on key technologies Turn costs/benefits ratio to their advantage	Deny resilience in case of attrition Divide allies exploiting unbalance contribution and dependance

Our strategy : change of paradigm, keeping in mind three key ideas		
Recover the sense of the "dialectic of wills" to modify our perceptions Change the way we use our technological advantages Invert the costs/benefits and risks/stakes ratios to the West's advantage		
Current Paradigm		New Paradigm
accessible readable peace/crisis/war defined use of source of power steady	ENVIRONMENT	contested unreadable blurred lines peace/crisis/war simultaneous use of multiple sources of power constantly changing
Information accessible Intel collected, gathered, analysed then broadcast	INTEL / INFORMATION	confusion deception fake news influence / manipulation intel/info shared real time at lowest level
Superiority in each domain Air supremacy Naval supremacy technological advantages in all fields	MILITARY BALANCE	superiority denied, contested
Direct approach	STRATEGY	mix of direct, indirect etc.
By ability to intervene	PREVENTION	by presence
by plan/directives/orders	COMMAND	by intent
Analyse study focus on COG (a single source of power) plan in details risk level mainly IAW operation phases linear (even if parallel) located target list	PLANNING	understand-visualize-describe to share a vision plan big picture overview at operational level tactical level : preplanned priorities, risk level IAW task present multiple dilemma initiative / opportunities
OODA (observe, analyse, orient decide) at centralized levels (mainly strategical or operative levels) Centralized command, centralized control, decentralized execution assess compliance with the plan	CONDUCT	tactical OODA loops which fit into operationnal and strategical ones centralized command, distributed control, decentralized execution assess adequacy of the plan
Predictable sequenced joint by coordination, synchronization gain and maintain advantages/status	ACTION	unpredictable saturation joint by essence seize and exploit initiative to gain and maintain a position of relative advantage
Centralized scarce high value assets (to be protected)	CAPABILITIES	Distributed among numerous cheap assets
Optimization at the expense of resilience expansive, scarce interdependance complex, long to build high end technologies	ASSETS	Robustness numerous cheap (consumable) assets resilience easy and fast to build costs and technologies affordable by all allies

APPENDIX 2:

Common errors about A2/AD evaluation

- ⇒ Range of efficiency estimated with few intelligence data or based on industrial's announcements: significant risk of error or intoxication
- ⇒ Take into account the capabilities of the system against large scale targets, so is not significant for all the range of possible threats
- ⇒ Does not take into account the intervisibility, which is limited by obstacles (mountains, buildings,)
- ⇒ Does not make sense for small and mobile systems, which can be moved in few minutes (SA-15, tactical offensive jammers, mobile ballistic launchers...)
 - A depiction which skews the real danger and coverage of A2/AD systems
 - The "wow" effect: "Where will I pass?"
 - A representation system commonly used in official presentation, at politic and strategic level
 - Based on a precautionary principle: maximized the visual impact rather than taking the risk to minimize the threat
 - Designed to be apprehended by non-specialists whom, in most cases, will be the decision-makers
 - Does not represent the tactical capabilities of the systems:
 - an 80's Russian-made fighter could have long range capabilities but being unable to engage efficiently a 4th generation fighter.
 - The rate of fire as well as deployment, reaction and reloading time are not mentioned: SA-5 missile systems represent a long-range threat but are commonly known to be inefficient against small and highly maneuverable targets and need several minutes to be reloaded.
- ⇒ Final (unexpected) effect: the perception of an impenetrable wall, or, to quote Admiral Richardson, "a fortress of red arcs".³⁹

⇒ The systems

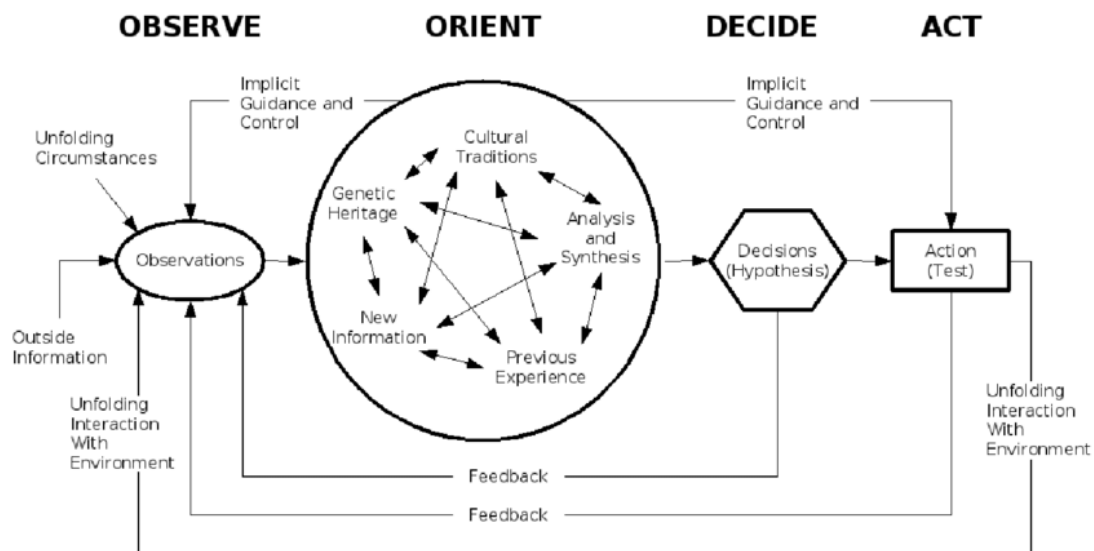
ENVIRONMENT	PRESENT THREATS	FUTURE THREATS	REFERENCES
AIR	<p>"Double digits" ground-to-air systems (SA-15, SA-17, SA-20, SA-21...)</p> <p>Jamming of Communication and navigation systems</p> <p>Integrated Air Defense Systems</p>	Laser weapons	US successfully tested a laser weapon that can destroy aircraft mid-flight (May 2020): https://edition.cnn.com/2020/05/22/asia/us-navy-lwsd-laser-intl-hnk-scli/index.html
		Increase of the range and the efficiency of the missiles and associated radars	
		Hypersonic missiles	https://www.popularmechanics.com/military/weapons/a35217288/army-hypersonic-missile-darpa-operational-fires/
		Cyber-attacks against <u>tactical</u> assets (aircraft, MBT, ships)	Piracy of a F-15 fighter jet by a group of hackers (2019): https://www.washingtonpost.com/news/powerpost/paloma/the-cybersecurity-202/2019/08/14/the-cybersecurity-202-hackers-just-found-serious-vulnerabilities-in-a-u-s-military-fighter-jet/5d53111988e0fa79e5481f68/?noredirect=on
		Collaborative targeting: automated (AI) and fully integrated detection and defense systems. Capability to dissociate detection and effector.	https://www.objectivity.com/wp-content/uploads/Objectivity_CS_L3.pdf
		Non-traditional detection capabilities: cooperatives and passive radars, disturbance in the GSM networks...	https://www.researchgate.net/publication/332119662_Passive_Radars_and_their_use_in_the_Modern_Battlefield
		High-resolution heat-seekers, able to discriminate friends or foe (and to avoid any type of flares)	
		Anti-aircraft ground UGV (Unmanned Ground Vehicle)	Poland: fusion of the IBIS® robotic platform and GROM/PIORUN anti-aircraft missiles: https://www.defence24.com/mspo-2019-anti-aircraft-robot-and-polish-pgms0
NAVAL	Coastal defense systems	Railguns	Coming Soon: A U.S. vs. China Railgun Arms Race? https://nationalinterest.org/blog/reboot/coming-soon-us-vs-china-railgun-arms-race-163933

	Long range anti-ship missiles Static Mines	Extra-long range/hypersonic anti-ship missiles (with terminal active radar homing, ARH)	Russia's 3M22 Tsirkon Hypersonic Missile Trials Enter Final Stage: https://www.navalnews.com/naval-news/2020/03/analysis-russias-t-sirkon-hypersonic-missile-trials-enter-final-stage-part-1/
		Loitering mines deployed by underwater UUV (Unmanned Underwater Vehicles)	US Hammerhead mines: https://breakingdefense.com/2020/10/navy-plans-hammerhead-mines-to-box-in-chinese-russian-subs-bottled-up/
		Anti-ship USV (Unmanned Surface Vehicles)	
		Anti-submarine USV	Chinese Copy of US Navy's Sea Hunter USV: https://www.navalnews.com/naval-news/2020/09/new-intelligence-chinese-copy-of-us-navy-s-sea-hunter-usv/
		Space-based detection systems (detection of submarines, particularly SSBN)	
GROUND	Artillery Land mines Ground obstacles	Ground defense systems: sentry guns or UGV	
		Advanced detection systems (infrared, ground control radars)	
SPACE	Antisatellite missiles (ASAT)	Satellite-to-satellite attack	Russia Tests a Satellite That Rams Other Satellites, US Says: https://www.defenseone.com/technology/2020/07/russia-tests-satellite-rams-other-satellites-us-says/167154/
		Antisatellite laser weapon (destruction, blinding)	
INFORMATION WARFARE			
CYBER WARFARE			AI

Annex 3: OODA loop

Extracts from *John Boyd and John Warden: air power's quest for strategic paralysis* by David S. Fadok

In what is perhaps the most well-known feature of Boyd's theory, he contends that all rational human behaviour, individual or organizational, can be depicted as a continual cycling through four distinct tasks-- observation, orientation, decision, and action. Boyd refers to this decision-making cycle as the "OODA loop."



Using this construct, the crux of winning vice losing becomes the relational movement of opponents through their respective OODA loops. The winner will be he who repeatedly observes, orients, decides, and acts more rapidly (and accurately) than his enemy. By doing so, he "folds his opponent back inside himself" and eventually makes enemy reaction totally inappropriate to the situation at hand. The key to attaining a favourable edge in OODA loop speed and accuracy (and, hence, to winning instead of losing) is efficient and effective orientation.

In his theory of conflict, Boyd highlights the psychological and temporal aspects of war and argues that one can paralyze an enemy by operating inside his observation-orientation-decision-action (OODA) loop. This can be accomplished by "tightening" friendly OODA loops and/or "loosening" enemy OODA loops. Thus, the key to winning in conflict lies in establishing a relative advantage over one's enemy in terms of both OODA loop speed and accuracy. Ultimately, this edge allows one to penetrate the opponent's "moral-mental-physical being" to negate his capability and will to resist through moral alienation, mental disorientation, and physical deprivation.

Boyd proposes that success in conflict stems from getting inside an adversary's OODA loop and staying there. The military commander can do so in two supplementary ways. First, he must minimize his own friction through initiative and harmony of response. This decrease in friendly friction acts to "tighten" his own loop (i.e., to speed up his own decision-action cycle time). Second, he must maximize his opponent's friction through variety and rapidity of response. This increase in enemy friction acts to "loosen" the adversary's loop (i.e., to slow down his decision-action cycle time). Together, these "friction manipulations" assure one's continual operation within the enemy's OODA loop in menacing and unpredictable ways. Initially, this produces confusion and disorder within the enemy camp. Ultimately, it produces

panic and fear which manifest themselves in a simultaneous paralysis of ability to cope and willingness to resist.

In addition to being a governance loop, the OODA model represents the process of information collection, analysis, and dissemination. In this sense, Boyd clearly reflects the influence of Sun Tzu on his thinking by highlighting the importance of information to successful combat operations. He does so by tying it to the speed and accuracy in the decision cycles of strategic, operational, and tactical commanders. He who has better control of the information flow can observe, orient, decide, and act in a more timely and appropriate manner, and thereby operate within his adversary's OODA loop. This control provides the opportunity to deny and/or exploit the information channels of one's adversary while simultaneously protecting access to one's own channels.

To minimize friendly friction, one must act and react more quickly than one's opponent. This is best accomplished by the exercise of initiative at the lower levels within a chain-of-command. However, this decentralized control of how things are done must be guided by a centralized command of what and why things are done. This shared vision of a single commander's intent ensures strategic and operational harmony among the various tactical actions and reactions. Without a common aim and similar outlook on how best to satisfy the commander's intent, subordinate freedom-of-action risks disunity of effort and an attendant increase in friction.

Annex 4: Scud-hunting

Extracts from: *Special Operations Forces and Elusive Enemy Ground Targets Lessons from Vietnam and the Persian Gulf War* by William Rosenau
Coalition SCUD-hunting in Iraq, 1991

The Iraqi military went to great lengths to ensure that their country's adversaries were unable to determine the precise number or location of the mobile TELs. High-fidelity decoys, some of East German origin, were widely employed. Iraqi missile crew tactics and procedures, such as the extensive use of gullies, wadis, culverts, and highway underpasses, were designed to thwart aerial reconnaissance.

Soviet R-17 crews typically took as long as 90 minutes to set up and fire their missiles, but the Iraqis had managed to reduce the preparation and launch time to under half an hour [5 minutes for a S400]. The Iraqis were also careful to avoid emitting telemetry that could help an adversary locate the missile before it was launched.

The Iraqis' use of decoys and other deception techniques, the quick-fire "shoot and scoot" capabilities of the Scud crews.

Poor weather conditions and Iraqi deception techniques made it extremely difficult for coalition forces to detect and attack the dispersed TELs before they launched their missiles. Instead, air commanders focused on destroying the vehicles after they had launched their Scuds. Toward this end, the coalition mounted combat air controls over so-called "kill boxes" where TELs were suspected.

Air commanders hoped that keeping aircraft on station over the kill boxes would allow F-15E and F-16L strike aircraft to hit the TELs after they had launched their weapons but before they had time to flee to safety.

However, sensors aboard orbiting coalition aircraft, including LANTIRN and a synthetic aperture radar, were unable to identify and acquire the TELs, whose infrared and radar signatures were virtually indistinguishable from trucks and other electromagnetic "clutter" in the Iraqi desert and were relatively easy to mask. The elusive nature of the Iraqi targets is illustrated dramatically by the fact that on the 42 occasions during the war when orbiting strikers visually sighted mobile TELs, in only eight instances were they able to acquire the targets sufficiently well to release ordnance.

It became increasingly apparent to the coalition's senior military commanders that finding and destroying the elusive mobile TELs demanded a new approach. Cheney approved a plan to send SOF personnel across the Saudi Arabian border to hunt for Scud launchers.

After the SAS teams found a target, their messages were relayed to the TACC, which would transmit the information to orbiting AWACS aircraft. The AWACS, in turn, would communicate with strike aircraft on combat air control—typically, A-10s during the day and F-15Es at night. Despite these improved command and control measures, however, the time between target identification by the ground teams and the delivery of ordnance by the strike aircraft was 50 minutes or more.

Frustrated with the relatively long delays involved in calling in air strikes, SAS troopers also attacked Iraqi vehicles and other targets directly, usually at night.

Satellite and other overhead reconnaissance was unable to locate the mobile launchers with any precision, so the U.S. and British ground SOF were forced to conduct wide-area surveillance for the TELs.

That said, however, a number of major hurdles are likely to continue to hamper operations against elusive ground targets. In a hostile or denied country, finding and identifying mobile objects that have been obscured by foliage or by deception, or are simply dispersed in vast areas like western Iraq, remain beyond the capability of even the most sophisticated reconnaissance sensors.

Nevertheless, it is possible to imagine a future role for SOF in finding elusive enemy ground targets.

Advances in technology could make it safer and easier for SOF to carry out such operations in the future. For example, mini- and micro-unmanned aerial vehicles could allow ground reconnaissance to search far larger areas than they could from vehicles or on foot, and with far less risk of discovery by adversary forces.

Two other potential SOF roles could enhance the ability of the United States to find and destroy elusive targets on the ground. Although BDA was never more than a collateral mission for SOF during the Vietnam and Persian Gulf conflicts, it could play a larger role in the future in operations involving strategically important targets, such as ballistic missiles and their supporting infrastructure.

Extracts from: *The National interest, October 6, 2017 by Sebastien Roblin, What the Great Scud Hunt Tells about a War with North Korea, We might not be able to take out those missiles, after all.*

When a Scud launch was detected—often when a satellite spotted its launch flash—the information was relayed first to the Air Force command centre in Riyadh, then to an orbiting E-8 JSTAR command plane, and finally to a strike plane orbiting the area. This process typically took at least thirty minutes.

Thirty minutes was in theory the amount of time it took for a Scud crew to start moving after launch—but Iraqi crews had streamlined the firing process to just *six* minutes. Likewise, they had reduced setup time for the missiles from two hours to a half hour. Unable to catch Scuds before *or* after firing, Coalition warplanes were forced to scan so-called “Scud Boxes” where planners *thought* the Scuds might be hiding.

Lessons identified:

If our opponents use shoot-and-scoot tactics, emission control procedures, decoys and concealment, it will be difficult to target their A2/AD mobile systems. A positive identification of a real system is easier from a close distance; an infiltrated SOF team can do that. . An identification within a safe distance (by a fighter jet for instance) is easier when the A2/AD system starts emitting, moving or shooting.

There are then many different challenges, according to which of our assets finds the mobile system. If a satellite finds it, it will send coordinates to a shooter – assuming there is no GPS jamming. As a S400 TEL can move 5 minutes after a shot, either the shooter finds the system and is immediately at risk (efficient stealth mitigates this), or it shoots a stand-off weapon. This weapon needs to hit the target before it moves or need to have a seeker with scan and identification capabilities. In a certain way, standoff weapons with scan and identification capabilities are nothing else but drones or loitering munitions. The comparison between a stealth fighter and drones is discussed in annex 5. For the other kind of weapons, the delay between the location and the time of impact must be short (less than five minutes against a S400). Hypersonic and laser weapons can provide solutions to this speed challenge.

Annex 5: Key technologies

Carrier-based versus land-based aircraft

Long-range anti-ship missiles, as part of A2/AD systems, represent a major threat to aircraft carriers, forcing them to patrol out of range in the event of a high-intensity war. The relevance of aircraft carriers in such conflicts are strongly debated. Advocates claim that they are less vulnerable than land-based aircraft with their operating bases and runways. Opponents reply that it is now too risky to use carriers, especially given their cost. The answer is far more complex.

Consider our key ideas: recovery of the sense of “dialectic of wills” and costs/benefits and risks/stakes ratios, as a way to balance the advantages or disadvantages of aircraft carriers and land-based aircraft. Land-based jets could possess resilience with “flexible take-off and landing”. Enabling fighter jets to take off from motorways, and spreading this concept through the entire West, would cause any potential adversary to reconsider the effort needed to weaken our air capabilities. This “highway strip” concept was used during the Second World War; highway take-off exercises happened in Estonia in 2018, in Germany in 2019.

Another argument related to the “dialectic of wills” – the play of chance and probability, costs and benefits, risks and stakes – is the nuclear umbrella and conventional deterrence. Would a potential adversary take the risk to strike a patrolling aircraft carrier, or a runway located in the homeland of a power, especially if it is a nuclear power? We think that as long as it is “a limited war” about peripheral interests, an adversary with a rational policy will avoid this situation. Thus, the US did not strike any target in China, neither during the Vietnam War nor the Korean War; the United Kingdom and France went out of Egypt (despite a tactical success during the Suez campaign in 1956) when two nuclear powers, the United-States and the USSR, told them to retreat.

The below table tends to show that land-based aircraft could be more appropriate in a direct approach against an adversary equipped with A2/AD systems.

Aircraft-carrier		Land-based aircraft
Independent of the good will of a hosting nation	Dialectic of wills	Can benefit from nuclear deterrence
Operational consequences for all the aircraft in case of a single hit	Robustness, resilience, costs/risks ratio	Aircraft can be distributed on an airfield. “Flexible” take-off and landing
Mobile, not threaten by land forces	Vulnerability	Not threaten by torpedoes and anti-ship missiles
Complex, return to port	Reparation and building time	faster
Expansive to achieve	Inventories, redundancy	Easier
Limited	Augmentation capability	Easier
Affordable by few nations but a better diplomatic tool	Impact on alliances	Allies can share the burden
Technology	Return on investment, dual-use	Runways can be dual-use
Reactiveness in naval battle	Miscellaneous	/

Navigation and guidance: satellites versus alternatives⁴⁰

In the military, satellites are key assets in at least four different domains: communications, ISR, time, navigation and guidance.

In addition to disruption of satellite communications, jammers can also disrupt or deny the use of GPS, which means the navigation, guidance and time of much of the weaponry and modern systems. For this reason, anti-satellite-ASAT⁴¹ kinetic weapons are flourishing. Low Earth Orbit satellites are particularly vulnerable. Protecting them will probably imply sending extra weight in space, increasing costs. The CSO program cost \$1,8 billion for 3 satellites at 480 and 800km. In 2007, China destroyed a satellite at around 800km. Even if missiles cost several millions, they are well worth the price when used against expensive satellites. Jammers and lasers are even more cost effective. The costs/benefits ratio seems to be in favour of ASAT weapons.

ASAT kinetic weapons imply also a major risk that will not be overcome with numerous satellites. ASAT kinetic weapons generate debris; at a certain level debris can generate the Kessler syndrome⁴². Debris in orbit could render space activities and the use of satellites in specific orbital ranges difficult for many years to come. SpaceX's STARLINK program raises concern among many experts about significantly increasing the possibility of Kessler Syndrome. ASAT kinetic weapons could then have a huge indirect impact on our economy; it would also have an impact on our potential adversaries' economy, but for some this would be lower. The risks / stakes ratio forces us to think about alternatives, and they exist.

DARPA⁴³ is working on a new generation of precise navigation and timing tools that can work without GPS. The French "Vision" project intends to deliver precise navigation and guidance that does not rely on satellites. The current features use an inertial unit and a stellar viewfinder, usable day and night. Our adversary cannot target them. It is also possible to update any inertial navigation system using ground features, either with optical or RADAR systems. With the computing assistance (or AI), it is possible to do it automatically. Pseudolites are also an alternative.

Whatever the solution, as long as it is cheaper than the missiles that can target them, we could invert the costs/benefits ratio to our advantage. If our military systems can work without satellites, our potential adversaries are less likely to develop weapons to target them, and the stakes/risks ratio become more favourable to us. These concepts can be extended to ISR and timing capabilities.

40 Annex 5 « key technologies » is providing a table which summarize and add some additional elements to the aforementioned ones.

41 ASAT = Anti-Satellite

42 The Kessler syndrome (also called collisional cascading) is a theoretical scenario in which collisions between objects could cause a cascade in which each collision generates space debris that increases the likelihood of further collisions.

43 DARPA = Defence Advanced Research Project Agency

Satellites	Navigation and guidance	Alternatives
Scarce assets, if targeted can lead to paralysis.	Dialectic of wills	Adversaries' will to target them is lower.
Can be jammed cost effectively. ASAT weapons usually cheaper than satellites. Can lead to huge impact on our economy.	costs/benefits and risks/stakes ratio	Some of them cannot be targeted nor jammed.
Expansive to achieve. Scarce assets.	Technological robustness, resilience.	High. Capacities are distributed among numerous assets.
Increasing.	Vulnerability	Some of them cannot be targeted nor jammed. The others are vulnerable but cheap.
Complex, expansive.	Reparation and building time	Faster.
Expansive to achieve.	Inventories, redundancy	Easier.
Limited.	Augmentation capability	Easier.
Affordable by few nations.	Impact on alliances	Allies can share the burden.
Technology economy. and	Return on investment, dual-use	Dual-use already exists but few return on investment so far .

5th-generation jets versus drone swarms⁴⁴

The increasing cost of fighter jets has led to a significant shortfall in the size of military aviation fleets. 5th generation jets gather many high-end technologies to increase their survivability and to optimize their targeting capability. The problem is that A2/AD systems show a technological catch-up from our potential adversaries as their multi-static radar, passive detection, and long wave radar become more efficient. Coupled with a cooperative engagement capability, stealth aircraft may be engaged. A missile with an active seeker will probably not be able to track a stealth jet in its front sector, but if it approaches directly from above or below, the stealth protection is lower. Furthermore, stealth is not efficient against passive seekers. The latest technical enhancements of IADS⁴⁵ call 5th-generation jets survivability into question, which raises the issue of resilience in the case of attrition warfare.

Implementing passive stealth technologies in a jet has many binding effects. This capacity is usually achieved at the expense of manoeuvrability and payload. In other words, for the same price, we can buy more jets with more range and payload if they are not stealth.

From the OODA loop perspective of our potential adversaries, stealth technologies mainly target the observe phase. When stealth works, the effects are tremendous because stealth directly break the OODA loop. The adversaries can be in a kind of paralysis. It is not exactly

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The reader can find some additional elements in the Annex 5 "key technologies"

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IADS = Integrated Air Defence System

true because long-wave radars are old yet some of them (like the *SPOONREST*⁴⁶) are able to detect some stealth fighters. (This is why a US Apache destroyed an Iraqi *SPOONREST* at the beginning of the *Desert Storm* operation.) The problem was that the tracking and engaging radar were totally unable to lock on to stealth fighters. In some ways, the adversaries' OODA loop was not paralysed (until their long-wave radar were down) but their engagement units' OODA loops were.

5th-generation jets carry many sensors and are able to share all the collected data. Their targeting capabilities help to increase the friendly OODA loop. This reduces the Observe phase. As the collected data are merged into a comprehensive and shared tactical situation, it speeds up the Orient and Decide phases. Data links also help to synchronize more easily the Action phase. Unfortunately, the action phase can be slowed down by a lack of carried ammunitions (for the same number of targets, the number of sorties per day will be many more).

If a disruptive technology enables engaging with stealth fighters at long range, 5th-generation jets will lose their major strength. This leaves two alternatives. Continuing to operate inside IADS ranges and accepting a higher attrition rate, which would call our resilience into question; alternatively, using stand-off weapons to stay out of IADS WEZ⁴⁷. With the latter, stealth is almost useless, as will be many of air-to-ground targeting capabilities.

Studies of using drone swarms against A2/AD systems are numerous, e.g.: MALD, Perdix, Gremlins, HAROP etc. The use of drone against IADS is far from being a new idea. They were used in the Beqaa battle in 1982, Desert Storm in 1991. The most recent use was in Nagorno Karabakh in 2020 (against PANTSIR, S200 and S300).

According to their size and radar cross-section, a drone can delay the observation phase, especially if they fly close to the ground⁴⁸. In swarms they can saturate sensors, extending the observation phase. The adversaries will face multiple dilemmas, they would be probably overloaded, the Orient and Decide phases will thus become difficult. If IADS launchers run out of ammunition, the Action phase will stop for a while; the reloading time could be an interesting vulnerability. We could only exploit this weakness with a large number of incoming threats that force our adversaries to shoot (during the Kippur war in 1973, many Syrian surface-to-air battalions ran out of ammunitions). This issue will further slowdown the Orient and Decide process due to a simple quandary: whether to shoot all the incoming mobiles and risk running out of ammunition or to hold fire and risk being hit.

Regarding the "dialectic of wills", drone employment is easier because there is no risk of human losses. The matter of costs/benefits ratio depends on the type of use (consumable or reusable), efficiency and price. A Harop drone is a loitering munition, can act autonomously and loiter 6 to 9 hours with a range estimated at over 1000km, but it costs about \$1 million. MALD are multi-purpose consumable drones that can act as decoys, jammers (stand-off and stand-in), and EW sensors; their speed is about M0,9 with a range of about 500NM, and the cost varies from about 130000\$ up to 330000\$. By comparison, a Storm shadow / Scalp cruise missile cost around 800 000\$, an AGM88 HARM 250 000\$, a SDB 40 000\$, SDB2 250 000\$. A F35 costs approximately between \$30 000 to 45 000 per flying hour. However, efficiency remains a key factor in order to assess the costs/benefits ratio.

46 Spoonrest = NATO reporting name for an elderly but still common Soviet-designed early warning and search radar, actually named P-12 by its developers. It is the long-range radar for the ubiquitous S-75 Dvina surface-to-air missile called the SA-2 GUIDELINE.

47 WEZ = Weapon Engagement Zone

48 L'essaim, une solution alternative pour la suppression des défenses aériennes, LCL John V. Bartoli, mémoire Ecole de guerre, 2017

There is no doubt that the drone is part of the equation to solve or face an A2/AD threat in a theatre of operation. The following table only addresses the topic of striking A2/AD systems.

Fifth generation jets		Drone swarm
Scarce assets, it worth to invest to target them.	Dialectic of wills	Targeting them will not hamper later actions.
Anti-stealth technologies improve. Risk increasing.	costs/benefits and risks/stakes ratio (Current trends)	Low cost. Built to be consumable.
Resilience expansive to achieve. Scarce assets.	Technological robustness, resilience. (current trends)	Capacities are distributed among numerous assets. It is possible to avoid GPS and remote control dependence.
Increasing.	Vulnerability	Built to be consumable and generate weapons shortfalls.
Complex, expansive.	Reparation and building time	Fast.
Expansive to achieve.	Inventories, redundancy	Easy.
Limited.	Augmentation capability	Easy.
Affordable by few nations.	Impact on alliances	Allies can share the burden.
Technology. Air and sea, defence and attack.	Return on investment, dual-use, multiple-use	Dual-use already exists and is increasing. Air-sea-land. Attack-defence