Intelligent Biology. UNIVERSITY OF BIRMINGHAM

Mind Space:

Cognition in Space Operations

Report for the Pentagon Joint Staff Strategic Multilayer Assessment Group

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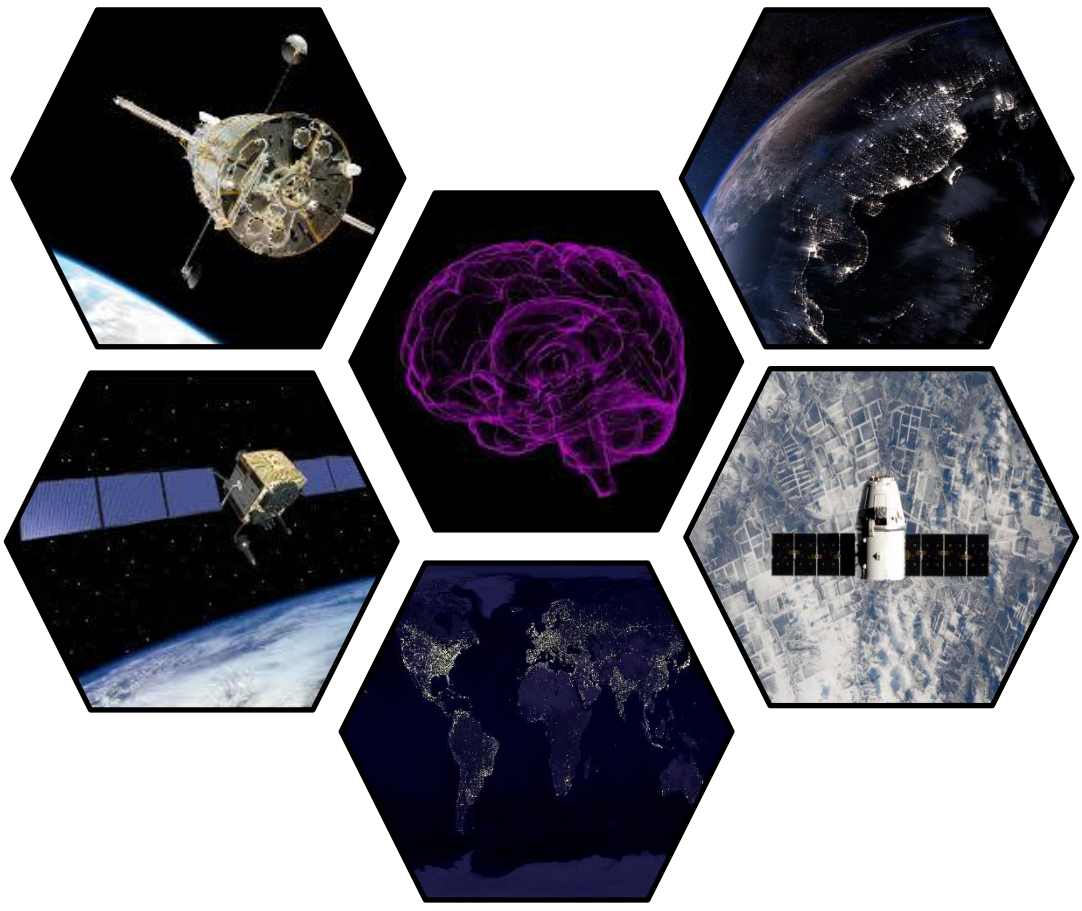

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EXECUTIVE SUMMARY

To conduct deterrence operations, or manage escalation, requires anticipating how others will ***decide*** to respond to our actions. Anticipating your adversary is imperative for offense or defense. Thus, it is crucial to understand audiences' decision-making. But how can you put yourself in the others' shoes in space operations?

- Firstly, operations such as deterrence have a crucial cognitive dimension—acknowledged in U.S., Chinese and Russian thinking—and thus here I apply the latest neuroscience and cognitive work to understand ***how humans really make decisions.***
- Second, I identify ***key features of space operations*** that require distinctive emphases compared to other domains, and I examine their ***cognitive foundations*** to describes implications for space ***policy***.

I apply this understanding of cognitive foundations of space operations to three areas:

- ***Deterrence and escalation management*** are examined in Part I. See table below.
- ***Grey Zone conflict*** is examined in Part II. The current space epoch is the "Grey Zone-Entangled Space Age", and space is an ideal forum for Grey Zone activities in which the U.S. must have the tools to compete.
- ***West Pacific security*** is examined in Part III with a focus on the PRC and Near-term Sino-U.S. scenarios.

FIVE KEY TAKEAWAYS

(1) **Influence**—not just control—is a principal means by which U.S. policymakers cause intended effects on key adversaries in space, across the spectrum of conflict from Grey Zone to limited war upto and including the nuclear level. Focusing only control denies U.S. decision-makers key tools.

Influence is affecting the adversary's decision-making and U.S policymakers must have the doctrine, policies and capabilities to achieve influence in space as well as control.

(2) **Space is ideal for Grey Zone conflict**—more than normal competition and less than war—and Grey Zone strategies require different emphases from peace or war . Grey Zone conflict is characterised by the 'Five multiples', which can be applied to space operations: multiple interpretations (ambiguity is a key feature in space, see below); multiple levels (e.g. state and population levels may view space activities differently as legitimate reasons for war); multiple audiences (allies and significant third parties are key, see extended deterrence below); multiple instruments of power (e.g. systems such as GPS or Beidou can be sources of economic influence); and multiple timescales (e.g. persistent adversary subthreshold actions can over time cumulatively present a serious threat; norms have a fundamental cognitive dimension that U.S. policymakers can manage).

Grey Zone conflict in space is necessarily limited conflict, and thus the central aim is to influence the decision-making of adversaries and other key audiences – success requires policymakers understand and wield influence in space.

(3) **Ambiguity** and difficult **risk** assessment pervade the space environment, due to challenges of attribution, damage assessment, dual use, high classification and reversible actions. Ambiguity makes communicating deterrence much harder, and increases the risk of escalation for instance by muddying mutually understood red lines. *U.S. signals will likely have to be much clearer than U.S. policymakers anticipate, and some communication must be performed ahead of crises.*

(4) Humans pay large costs to reject perceived unfairness, and this complicates the perceived legitimacy of potential U.S. responses to adversary actions in space. An adversary's space actions may have large strategic impacts, but because "satellites have no mothers" in comparison to potential U.S. conventional responses they may rouse little moral impact in key audiences (e.g. allies). Such mixed perceptions may cause inadvertent escalation, which may only be ameliorated by clear communication ahead of time before crises.

(5) Extended deterrence and ally perceptions are central to U.S. success in near-term escalation scenarios involving space with Russia or China. Allies' trust and confidence in the U.S. are the central pillar of extended deterrence – and are inherently psychological. *Increase trust and confidence by: increasing allies' comprehension of space operations during escalation; increase the bandwidth of trust between elites, security apparatuses and populations; and consider how unpredictable behaviour decreases confidence and trust.*

KEY FACTORS FOR DETERRENCE, ESCALATION MANAGEMENT, OFFENSE AND DEFENSE IN SPACE

Key factors for space (compared to conventional and/or nuclear)	Cognitive foundations and policy implications
Uninhabited ("satellites have no mothers") Less destructiveness (nuclear weapons' potentially huge casualties)	Cognitive foundations: There will likely be less moral and emotional responses to destroying/affecting space resources – e.g. in public opinion domestically, in the adversary and key allies. Implications: - Adversaries making actions in space for signalling may anticipate that those actions are less escalatory than is actually perceived by U.S. planners receiving them (e.g. who focus on military impacts). Such mixed perceptions may cause inadvertent escalation. - Potential U.S. cross-domain responses (e.g. conventional strikes) to such space actions may rouse much greater moral impacts in key audiences (e.g. allies) and reduce perceived legitimacy for those U.S. responses.

	- Adversaries' space actions complicate the perceived legitimacy of U.S. responses, which makes them particularly attractive for Grey Zone conflicts.
Attribution (can be difficult in space) Damage assessment (can be difficult in space) Dual use (e.g. manoeuvrable on-orbit repair satellites) Highly classified (all actors capabilities are more opaque) Reversibility (of some non-kinetic actions)	Cognitive foundations: These multiple factors all make the space environment one of Risk and Ambiguity. Risk is uncertainty about potential outcomes. Ambiguity involves an extra layer of uncertainty, so actions are open to multiple interpretations before we even consider their risk. Implications: Risk and ambiguity are both tools. Ambiguity is key to Grey Zone activities (e.g. little green men; little blue men; little manoeuvring satellites) – and adversaries will likely use space for Grey Zone conflict because of this ambiguity. Deterring ambiguous Grey Zone activities is very difficult. Thus, U.S. policymakers must plan ahead of time for responses to important classes of ambiguous space operations, e.g. U.S. responses to persistent ambiguous activities where each instance may not itself cross a "red line". Threats to deter such persistent activities may need to be communicated clearly in advance. Be aware that ambiguity in space enhances *escalation* potential, e.g. by muddying mutually understood red lines. Risk: Managing escalation requires manipulating the adversary's perception of the risks it runs by escalating. But ambiguity greatly complicates the communication of such risks in space. Thus when the U.S. seeks to communicate that an adversary will run significant risks if it conducts space operations, the U.S. signals will likely need to be much clearer than U.S. policymakers anticipate.
Borderless (space is a global commons) Debris from kinetic actions may hobble all of humanity's future space activities	Cognitive foundations: A borderless domain diffuses responsibility for its care and so can help actors rationalize individual self-interested actions that are contrary to the common good (e.g. creating space debris). Implications: Possible debris or other damage to the space environment is unlikely to significantly weigh on adversary decision-makers, especially if muddied by debris-causing U.S. actions.

Fragility / offense dominance (space assets are very hard to defend and may have low resilience).	Cognitive foundations: Space operations may make adversaries' perceive they must make decisions very rapidly – and rapid decisions under stress are inherently more inflexible and problematic. Implications: To help manage escalation in space, introduce deliberate and obvious pauses to slow decision-making.
US specific factors:	
Asymmetric space dependency (U.S. capabilities rely on space more than others do)	Cognitive foundations: U.S. planners may be affected by the "optimism bias" and optimistically hope adversaries will not take advantage of U.S. vulnerability.
Extended deterrence (U.S. allies and partners are under U.S. extended deterrence)	Cognitive foundations: The central foundation of extended deterrence is that the ally trusts and has confidence in the U.S.. Trust is inherently psychological – something one values is at risk, in a situation where what happens to it depends on somebody else's decision. Implications: Policymakers must manage allies' trust. Consider the bandwidth of trust, between elites, security apparatuses and populations. Unpredictable behaviour decreases confidence and trust.
China specific factors:	
More holistic view of space (across the space, terrestrial and information components)	Cognitive foundations: Cross-cultural cognitive science suggests Chinese many concepts and categories more holistically. Implications: Take cross-cultural differences in worldview seriously.

Chapter 1: Introduction

'The realm of strategy is one of bargaining and persuasion as well as threats and pressure, psychological as well as physical effects, and words as well as deeds. This is why strategy is the central political art. It is about getting more out of a situation than the starting balance of power would suggest. It is the art of creating power.' *- Sir Lawrence Freedman, Strategy*[1]

1.1. Strategy is the art of creating power. Power is the ability to influence another's choice to get a desired outcome or also, potentially, to exert control by removing another's capability to choose. Deterrence is just one example of influence. Strategy in space is the art of creating power in space, which involves both influence and control. This does not mean that influence or control in space are identical to these activities in other domains, such as in nuclear or conventional operations. The character of strategy in space compared to other domains will be affected by the:

- physical "terrain" in space (see Box 1.1);
- technology (see Box 1.2);
- international political context in which space operations are conducted (e.g. earthly forms of international competition or norms).

1.2. This introduction discusses three basic ideas:

- Strategy in space requires both *influence* and *control* – neither alone is sufficient for U.S. policymakers to achieve intended effects;
- Space operations, including their crucial cognitive dimensions, differ from other domains in their character but not in their nature[2];
- Since the USSR launched Sputnik in 1957 we have seen different epochs in space strategy – and the current one is the "*Grey Zone - Entangled Space Age".*

STRATEGY IN SPACE REQUIRES INFLUENCE AND CONTROL

1.3. Power consists of the ability to *influence* another's choice or to exert *control* by removing their capability to choose.[3] I define influence as a means to affect an audience's behaviour, perceptions or attitudes. Influence can be achieved by deterrence, persuasion, or the use of hard or soft power. Influence does not only include "soft" means, but also the use or threat of hard power.

1.4. U.S. space doctrine discusses space power and space control, but does not clearly address space influence (Box 1.3). What are examples of influence? Space influence

[1] Sir Lawrence Freedman, *Strategy: A History* (Oxford ; New York: OUP USA, 2013).
[2] I refer here to the character and nature of war. See Ch. 1 in Nicholas D. Wright, "From Control to Influence: Cognition in the Grey Zone" (Birmingham, UK: University of Birmingham, UK, April 2017), www.nicholasdwright.com/publications.
[3] Richard Lee Armitage and Joseph S. Nye, *CSIS Commission on Smart Power: A Smarter, More Secure America* (CSIS, 2007). p. 6 'Power is the ability to influence the behavior of others to get a desired outcome. Historically, power has been measured by such criteria as population size and territory, natural resources, economic strength, military force, and social stability' For discussion of the distinction between influence and control, see e.g. Thomas Crombie Schelling, *Arms and Influence* (Yale University Press, 1966). Ch. 1.

includes space deterrence, such as deterring adversaries from kinetic operations against U.S. or allied space assets. It includes threatening adversaries in order to reduce the frequency of non-kinetic space operations such as jamming, dazzling or spoofing. One may influence the adversary to doubt the reliability of space assets on which they depend in order to conduct activities in other domains – threatening Chinese C4ISR in a Taiwan contingency may affect their planning for a cross-Strait amphibious assault or PRC counterinsurgency on Taiwan (Chapter 6). One may influence an adversary to deescalate through conciliatory gestures or providing "off-ramps". One cannot wholly control allies: the U.S. must often influence allies or significant third parties to support U.S. actions, or indicate their support for U.S. actions. If one wishes to stay in "Grey Zone" conflict short of war, it is impossible to control adversaries who can conduct reversible space operations—i.e. removing their capability—instead adversaries can only be influenced to decrease the frequency or halt such attacks. Offense and defense during war require influence.

1.5. Crucially, to understand the centrality of space influence for U.S. policymakers one must consider influence across the spectrum of conflict, to which I turn next.

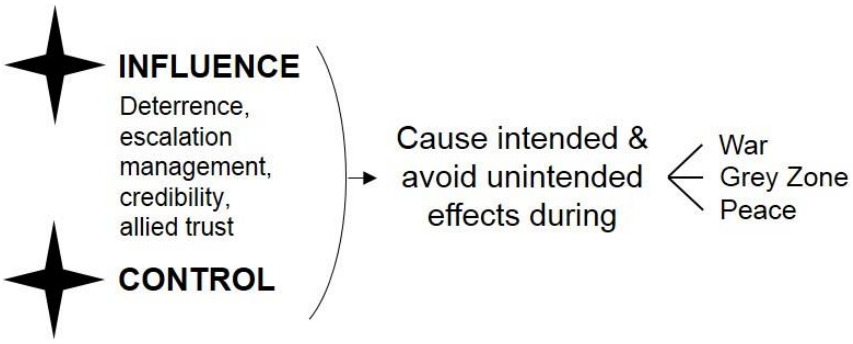


Figure 1.1: Strategy in space requires influence and control

Box 1.1: Space backgrounder

What is space? 'Outer space' begins about 100 km above sea level, at the Karman Line.

Types of orbit (Fig. 1.2): Geostationary Orbit (GEO) satellites are in an orbit with a special property – they appear stationary from the ground. They can cover large parts of the earth's surface. GEO is a small and valuable area in space, thus the possibility of significant debris in GEO is particularly important. Low Earth Orbit (LEO) satellites are closest to the earth. Each LEO satellite covers much less of the earth's surface and moves relative to the earth's surface, so services covering a specific region are often handed over between a succession of LEO satellites within a constellation.

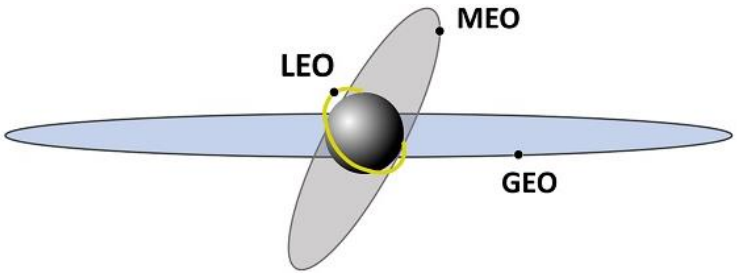


Figure 1.2: OrbitsLow Earth Orbit is (LEO) 100-500 miles, Mid Earth Orbit (MEO) is 6,000-12,000 miles Geostationary Orbit (GEO) is 22,240 miles.

Currently there are an estimated 1,738 operating satellites[4], of which:

United States: 803	Russia: 142	China: 204	Other: 589
LEO: 1,071	MEO: 97	Elliptical: 39	GEO: 531

Of the estimated 803 US satellites, 18 are civil, 476 commercial, 150 Government and 159 military.

Debris in space: Space debris damages space assets and stays for a very long time indeed, particularly in higher orbits like the valuable GEO. "Kessler syndrome" is the possibility of a chain reaction amongst space debris collisions, leading to dangerous belts of shrapnel.

Remarkable change in space: SpaceX and other private companies are now radically reducing the cost of space launches. New small satellites greatly reduce the cost of launching constellations of satellites. Space use will thus likely grow ever more rapidly.

References: For information on the science of space see e.g.[5]

Box 1.2: Space military technology

Space missions[6]: (1) Early warning (e.g. the U.S. Space-Based Infrared System [SBIRS] serving nuclear and conventional roles); (2) Intelligence, Surveillance and Reconnaissance (ISR); (3) Position, Navigation and Timing (PNT); (4) Communications; (5) Command and Control; and (6) Weather.

Counterspace capabilities[7]: We can broadly place these in two groups.

Kinetic: Direct assent anti-satellite (DA-ASAT); Co-Orbital ASAT; ground-station attack; high altitude nuclear detonation.

Non-kinetic: High-powered laser; laser dazzling; high-powered microwave; jamming; spoofing; cyber.

Box 1.3: Space power and space control in U.S. doctrine[8]

The following are all taken from Joint Publication 3-14 "Space Operations"

"**Space power**. The total strength of a nation's capabilities to conduct and influence activities to, in, through, and from space to achieve its objectives." p. GL-8

"**Space control.** Operations to ensure freedom of action in space for the United States and its allies and, when directed, deny an adversary freedom of action in space." p. GL-8

"**Defensive space control.** Operations conducted to preserve the ability to exploit space capabilities via active and passive actions, while protecting friendly space capabilities from attack, interference, or unintentional hazards." p. GL-6

"**Offensive space control.** Those operations to prevent an adversary's hostile use of United States/third-party space capabilities and services or negate (deceive, disrupt, degrade,

[4] Includes launches through 8/31/17. Data from Union of Concerned Scientists, https://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database#.Wt9gCMgvw2w [accessed 25 April 2018].
[5] Ministry of Defence, "U.K. Ministry of Defence (MoD). (2010). The UK Military Space Primer. Shrivenham: Development, Concepts, and Doctrine Centre.," GOV.UK, June 1, 2010, https://www.gov.uk/government/publications/the-uk-military-space-primer.
[6] For a useful broad introduction see Elbridge Colby, "From Sanctuary to Battblefield: A Framework for a U.S. Defense and Deterrence Strategy for Space:," 2016, 44.
[7] Two recent reports: Brian C Weeden and Victoria Samson, "Global Counterspace Capabilities: An Open Source Assessment," 2018, 148; T. Harrison, K. Johnson, and T. G. Roberts, "Space Threat Assessment 2018," April 2018, https://aerospace.csis.org/wp-content/uploads/2018/04/Harrison_SpaceThreatAssessment_FULL_WEB.pdf.
[8] Joint Publication 3-14 29 May 2013

deny, or destroy) an adversary's efforts to interfere with or attack United States/allied space systems." p. GL-7

Space influence/deterrence: No definition of space influence or space deterrence is given, but the idea of space deterrence is linked to Defensive Space Control (DSC). p. II-9 states: "DSC contributes to space deterrence by employing a variety of measures that help assure the use of space".

Influence and control across the range of space conflict

1.6. Influence, not just control, is a principal means for U.S. decision-makers to achieve intended effects and avoid unintended effects in space operations throughout the range of conflict, from Grey Zone, through limited war and total[9] war (Fig. 1.3). This is the case for offense, defense and deterrence.

Figure 1.3: Peace, the Grey Zone and War

1.7. First consider **Grey Zone** conflict.[10] Grey Zone conflict is necessarily *limited* conflict, sitting between "normal" competition between states and what is traditionally thought of as war. Thus, the central aim is to *influence* the decision-making of adversaries and other key audiences, rather than removing their capacity to choose using brute force in itself. Success requires moving the emphasis from control to influence.

1.8. Space is an attractive option for Grey Zone activity. One reason is the ambiguity in space operations that arises from, for instance, difficulties of attribution and the dual use nature of many space capabilities (Chs. 3, 5 and 6).

1.9. Space can already be considered a forum of Grey Zone competition between the U.S., the PRC and Russia, with numerous examples of non-kinetic activities against U.S. assets (Ch. 5).[11] Space will feature prominently in crisis escalation scenarios with such powers that occur in the Grey Zone below the threshold for war (Chs. 3, 5 and 6).

1.10. Second, consider **limited war**. Influence is crucial to keep limited wars limited, for example through intra-war deterrence. In limited war with the PRC or Russia it will be in U.S. interests that war does not escalate to kinetic activity in space and that—if it does—that it does not escalate to "all out" space warfare. The U.S. uses space for

[9] Albeit with the caveat that truly total war between the largest nuclear weapons states, primarily the U.S. and Russia, which essentially involved the end of all humans involved clearly leaves no humans left to influence.
[10] Wright, "From Control to Influence."
[11] Two recent reports: Weeden and Samson, "Global Counterspace Capabilities: An Open Source Assessment"; Harrison, Johnson, and Roberts, "Space Threat Assessment 2018."

many of its conventional capabilities, such as precision strike, that would be central to U.S. success.

1.11. Furthermore, can one influence the adversary to prevent a limited war escalating to the use of nuclear weapons – and indeed from a limited nuclear war becoming all out? Space assets will be crucial here such as the U.S. SBIRs early warning system that identifies launches of both conventional (e.g. PRC anti-ship ballistic missiles) and nuclear missiles. Nuclear entanglement is an important issue for escalation management.[12] Offense and defense in warfighting require influence: consider much of the classic thinking on strategy across the ages from by Sun Tzu to von Clausewitz, B.H. Liddell Hart or J.F.C. Fuller.[13] One seeks to influence the adversary to misplace their forces or collapse, to surprise them, to avoid energizing them, to decrease their information, mislead them and throw them off balance.

1.12. Third, consider **total war** such as the First or Second World Wars. Even in such conflicts one must influence allies and potential allies, as well as influencing the adversary during offense and defense. D-day and its preparations required influence.

THE COGNITIVE CHARACTER OF SPACE OPERATIONS DIFFERS FROM OTHER DOMAINS

1.13. The character of space operations and of their cognitive dimensions differs for space compared to other domains. Thus, to cause intended effects and avoid unintended effects requires understanding the different emphases needed for space strategy. Compared to the nuclear domain, for example, space operations are more ambiguous and much less destructive. Many non-kinetic space operations can be reversible, for example dazzling, jamming or spoofing. Space is offense-dominant with no equivalent of second strike mutually assured destruction. But these different emphases for space operations affect the character, not the nature, of influence.

1.14. This reflects a basic distinction between the changing *character* and unchanging *nature* of conflict between humans. As the scholar Colin Gray[14] writes: '*Many people confuse the nature of war with its character. The former is universal and eternal and does not alter, whereas the latter is always in flux' … 'There is only a single general theory of war, because war—past, present, and future—is but a single species of subject. [For example] Air power has made a huge difference to the conduct of warfare, but in a hundred years it has not altered the nature of warfare or war.'*

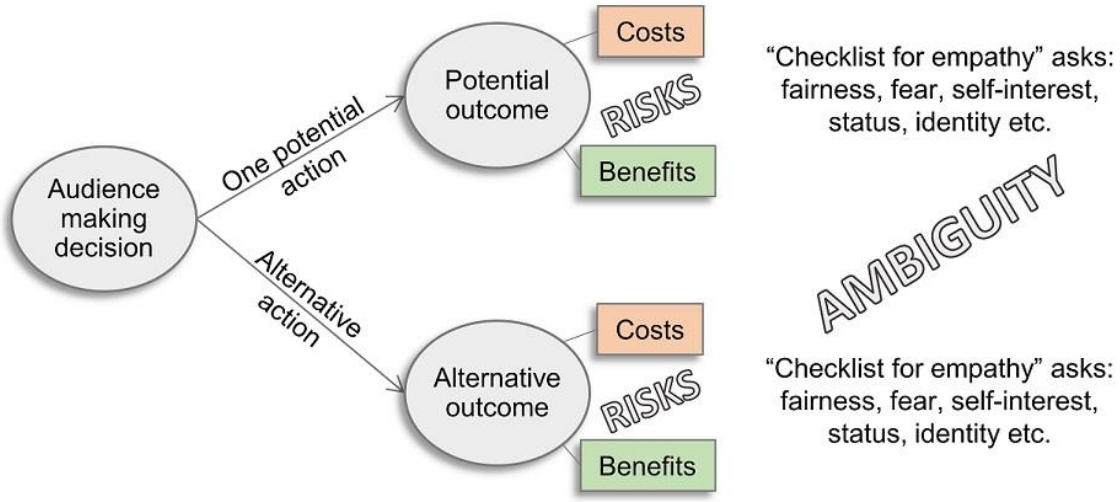
1.15. Human cognition is one fundamental reason why conflict's nature remains unchanged over domains: conflict is a strategic interaction between humans, between human psychologies. As Colin Gray further noted: *'The stage sets, the dress, the civilian and military equipment, and some of the language are always changing, but the human, political, and strategic plots, alas, remain all too familiar.'* Cognition provides a bedrock.

[12] James M. Acton, Escalation through Entanglement: c3i Vulnerability and Inadvertent Nuclear War, International Security (forthcoming)
[13] Freedman, *Strategy*.
[14] Colin S. Gray, "War-Continuity in Change, and Change in Continuity," *Parameters* 40, no. 2 (2010): 5. pp. 6-7

1.16. Similarly we see the fundamental cognitive nature of influence remains across all domains—influence is affecting audiences' decision-making behaviour, attitudes or perceptions—but the character of these cognitive dimensions differs, for instance in space. Deterrence is one form of influence and illustrates the point. The nature of deterrence rests on cognitive foundations. “Deterrence is a *state of mind* brought about by the existence of a credible threat of unacceptable counteraction” [emphasis mine][15] Deterrence in space is the same basic concept, as shown in scholar Michael Krepon’s definition of ““Space deterrence” … as deterring harmful actions by whatever means against national assets in space and assets that support space operations.”[16] Moreover, as Chapter 2 describes, discussions of deterrence in space note the importance of psychological or subjective dimensions: deterrence in space is a fundamentally psychological phenomenon. But, failure to understand how the *character* of space deterrence differs from other domains will lead to operational failure - for example, the ambiguity of many space operations gives them a fundamentally different cognitive character to nuclear deterrence.

1.17. Put simply, there is an unchanging *nature* to the cognitive dimensions of conflict, and there is a changing *character* to the cognitive dimensions of conflict. A core aim of this report is to not only realistically describe the nature, but also the character of the cognitive dimensions of conflict in space now. The nature of the audience’s decision calculus is captured in Fig. 1.4 and described more fully in Chapter 2.[17] The following chapters build on this framework to describe the character of space conflict, which Chapters 3 and 4 tailor for space, Chapter 5 tailors for Grey Zone space operations and finally Chapter 6 tailors to China and space now.

1.18. It is significant to specify that I aim to deal with the character of space strategy *now*, because the character of conflict can change over time. I turn to this next.



[15] Department of Defense Dictionary of Military and Associated Terms, Joint Pub 1-02. The earlier definition is present in the 1994 edition up to 2011, but not by 2016. it now defines deterrence as “The prevention of action by the existence of a credible threat of unacceptable counteraction and/or *belief* that the cost of action outweighs the *perceived* benefits” [emphasis mine].
[16] Michael Krepon, “Space and Nuclear Deterrence,” in *Anti-Satellite Weapons, Deterrence and Sino-American Space Relations*, ed. Michael Krepon and Julia Thompson (Washington, D.C.: Stimson, 2013). p. 15
[17] This is based on an extensive review of empirical evidence in Wright, “From Control to Influence.”

Figure 1.4: The Audience Decision Process. The nature of influence remains the same across domains and epochs but its character changes.

SPACE EPOCHS: FROM SPUTNIK TO THE "GREY ZONE – ENTANGLED SPACE AGE"

1.19. Strategy in space has not remained the same since the USSR launched Sputnik in 1957. Whilst there will always be overlaps, can we divide up the history of strategy in space into discrete epochs that are meaningfully different for policymakers? I argue we can, and that we are now beginning a new space epoch that differs radically from those preceding it. It is the *"Grey Zone – Entangled Space Age"*. It has two distinguishing features, in which space strategic conflict mirrors the *Grey Zone* conflict on earth, and crucial conventional and nuclear space missions are deeply *entangled.*

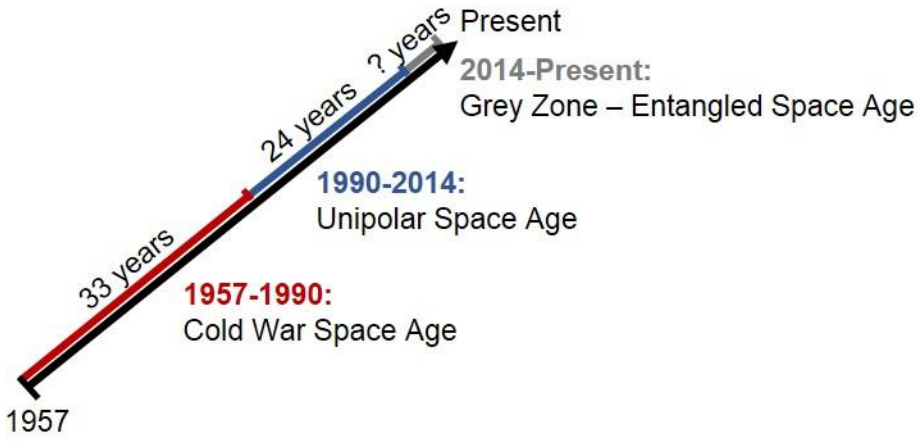


Figure 1.5: Space epochs: *From Sputnik to the "Grey Zone – Entangled Space Age"*

1.20. First came a **"Cold War Space Age"**[18] from Sputnik's launch in 1957 to the end of the Cold War in 1990. It had two key characteristics. First, it was dominated by fierce bipolar US-Soviet military rivalry in space: they launched 93% of the satellites in that period of which the great bulk were military. Second, space was heavily linked to nuclear weapons complexes and operational plans. Thus whilst both sides had ASAT capabilities, space competition was relatively controlled because both sides had much to lose in space and both sides feared deeply that space operations would lead to nuclear war.

1.21. The end of the Cold War brought in a **"Unipolar Space Age"**. This again had two key characteristics. Firstly, the Soviet collapse led to a unipolar US moment in which it faced no serious military competitor, particularly in high-end fields like space. Russian launches dropped precipitously, whilst military satellites formed a much

[18] Another recent suggestion is to call the period from Sputnik to around the end of the Cold War a "first space age" (1957-1990), and to call the essentially post-Cold War epoch from 1991 until now a "second space age". Todd Harrison et al., *Escalation and Deterrence in the Second Space Age* (Rowman & Littlefield, 2017). pp. 1 Tom Cremins, "A New Space Age: Maximizing Global Benefits," Strategic Foresight: Perspectives on Global Shifts (New York: World Economic Forum, 2014).

smaller proportion of those launched globally.[19] A second reason for this inflection point was the demonstration of the conventional Revolution in Military Affairs (RIMA) during the first Gulf War. In that "first space war"[20], space enablement of conventional operations was key. Importantly, the Soviet Union failed to keep up not because it didn't wanted to implement such ideas—indeed the Soviets pioneered ideas on which the RIMA was built[21]—but the Soviet collapse meant they could not keep up with the U.S.. In sum, the condition of great power rivalry on earth largely determined the shift from the first to second space age – and I argue we are again amidst such a change in global strategic competition leading to a new epoch in space strategy.

1.22. I argue we have now entered[22] a third epoch, the *"Grey Zone – Entangled Space Age"*. It has two distinguishing features:

- space strategic conflict mirrors the *Grey Zone* conflict on earth[23];
- crucial conventional and nuclear space missions are deeply *entangled*[24], such that with near-peer adversaries warfighting in space for conventional purposes profoundly threatens the nuclear mission.

1.23. The rise of "Grey Zone" multipolar competition has ended the U.S. "Unipolar moment" on earth. On earth a resurgent Russia and rising China have significant capabilities (e.g. Anti-Access Area Denial; A2AD) and the willingness to use their capabilities (e.g. in East Ukraine, the Baltics or South China Sea) – leading to new earthly intensity of competition that is extending into space (Ch. 5). Shifting balances away from US unipolarity in space itself are also clear, illustrated by a recent Rand report highlighting the marked erosion of U.S. relative advantage in space against the PRC during potential West Pacific scenarios.[25]

1.24. Risks in the Grey Zone-Entangled Space Age are greater and require different management tools from those during either the Cold War or U.S. unipolar moment. Unlike in the Cold War space age, profound nuclear fears no longer limit competition to the same degree, and significant nuclear-conventional space entanglement now exists for precision strike. An example are the PRC's conventional anti-ship ballistic missiles (ASBMs) that would threaten US carriers in West Pacific escalation scenarios (see Ch. 6). U.S. SBIRs early warning satellites that would detect those ASBM launches are also central to detecting nuclear launches. The PRC may attack these U.S. satellites to protect their conventional capabilities—and many who work on Chinese space security believe this to be a real possibility[26]—but to the U.S. this would be an attack on a key nuclear asset. A second difference from the Cold War

[19] Space-track.org
[20] https://www.army.mil/article/161173/SMDC_History__25_years_since_first__Space_War_/?from=RSS
[21] Freedman, *Strategy*. pp. 214-6
[22] I date the start of the new epoch from the 2014 Russian invasion of East Ukraine and seizure of Crimea. The first seizure of territory in Europe since the end of World War Two, this clearly reflected the new intensity of security competition between Great Powers. It also involved Russian Grey Zone space operations (see Ch. 5). Inevitably given the gradual increasing Great Power competition since the mid-2000s, including in space, the choice of 2014 is somewhat arbitrary, but it not only reflects the crystallisation of higher intensity Russia-West competition but also falls midway within the period during which Chinese President Xi Jinping reoriented Chinese foreign policy (2012-2017) policy (Chapter 5).
[23] Wright, "From Control to Influence."
[24] James M. Acton, Escalation through Entanglement: c3i Vulnerability and Inadvertent Nuclear War, International Security (forthcoming)
[25] Eric Heginbotham et al., *The U.S.-China Military Scorecard: Forces, Geography, and the Evolving Balance of Power, 1996–2017* (RAND Corporation, 2015), https://www.rand.org/content/dam/rand/pubs/research_reports/RR300/RR392/RAND_RR392.pdf.
[26] Multiple discussions by the author with U.S. and European experts on China and space raised this possibility.

space age is that the US would be “playing away” against Russia or China whilst they would be “playing at home”, potentially making the asymmetric U.S. dependency on space assets even more pronounced. Thirdly, a greatly enhanced role for the private sector in satellite launches, particularly in the U.S., is driving drive down prices and increasing space congestion. Commercial-military entanglement also raises new challenges in space. Which commercial assets with dual-use military roles or capabilities are legitimate or proportionate to attack or threaten during escalation? How might one might one credibly seek to protect such assets using deterrence or extended deterrence? Finally, there is now no taboo on anti-satellite space operations, with reversible Grey Zone space operations now conducted regularly as Ch. XX describes. What is acceptable now becomes a matter of degree. Eroding norms against space operations will likely further increase the magnitude and likelihood of space operations in the “Grey Zone - Entangled Space Age”.

1.25. We are returning to an era of higher intensity Great Power competition than seen since the end of the Cold War. But we aren’t returning to the Cold War in space even though the Cold War was itself, as its very name suggests, a Grey Zone conflict. Instead, U.S. policymakers must recognize we are entering a new era of Grey Zone competition in space with its own character.

RECOMMENDATIONS

1.26. Influence is a principal means by which U.S. policymakers cause intended effects on potential adversaries in space during peace, grey zone conflict and war. U.S policymakers must have the doctrine, policies and capabilities to achieve influence—not just control—in space.

- Influence should be explicitly added, alongside control, to U.S. space doctrine and practice.
- Space policy should learn from the centrality of influence in Chinese and Russian thinking – and should adapt recent U.S. thinking, such as that on the “7th Joint function”, to the character of cognition in space.[27]

1.27. Influence in space must place the adversary’s decision-making at the heart of strategy.

- This must include a realistic understanding of the *nature* of human decision-making (Ch. 2), as well as its *character* in space (Chs. 3-5).

1.28. Adapt to the new epoch, the *“Grey Zone – Entangled Space Age”:*

- Grey Zone conflict requires influencing adversaries; influence rather than control is key. U.S. decision-makers must have options to respond proportionally to Grey Zone conflict in space, enabling responses without escalation to war.
- Entanglement of the nuclear and conventional space missions is now a fact of life. In the short-term U.S. decision-makers should be prepared for space operations during crises to rapidly escalate to the nuclear level (e.g. involving

[27] Mattis, J., "Information as a joint function," official memorandum, Department of Defense, Washington, DC, USA, 2017 [Online]. Available: https://www.rmda.army.mil/records-management/docs/SECDEFEndorsement_Information_Joint%20Function_Clean.pdf; Alexus G. Grynkewich, “Introducing Information as a Joint Function,” *Joint Force Quarterly*, April 11, 2018, http://ndupress.ndu.edu/Media/News/News-Article-View/Article/1490517/introducing-information-as-a-joint-function/.

SBIRs). This should be mitigated by dialogue, and by U.S. signals that try to deter such actions. In the medium-term the U.S. must reduce dependency on fragile, entangled space assets such as SBIRs – and demonstrate that reduced U.S. dependency.

OVERVIEW OF THIS REPORT

1.29. Part I examines deterrence and escalation management in space.

1.30. Part II examines space in the Grey Zone.

1.31. Part III examines space in West Pacific security.

PART I COGNITIVE FOUNDATIONS OF DETERRENCE AND ESCALATION MANAGEMENT IN SPACE

Part I examines the principles of influence in space. I identify key factors for influence that matter for offense and defense, deterrence, coersive threats more broadly, escalation management and ally assurance. Chapter 2 begins by outlining a practical framework for influence on which later chapters can build. I focus in particular on the examples of deterrence and escalation management. Chapter 3 discusses the cognitive foundations of key features of space operations that apply to all space powers. Chapter 4 examines additional features of space operations, and their cognitive foundations, which are particularly relevant to the U.S. and China.

Chapter 2: Basic framework for influence – the examples of deterrence and escalation management

2.1. This chapter outlines a practical framework for influence, on which later chapters can build. Key points include:

- A realistic account of audience decision-making must lie at the heart of any influence strategy.
- Deterrence and escalation management are intimately related and are both cases of influence.
- Deterrence has a fundamentally cognitive dimension in both U.S. and Chinese doctrine.
- Deterrence in space has a fundamentally cognitive dimension - and the same cognitive failings of deterrence planning in other domains will likely plague planning for space influence operations.
- Space operations in escalation scenarios are highly likely to be cross-domain, but may be "pure" or "supplementary".

2.2. This chapter first describes how deterrence and escalation management relate and then examines both these cases of influence in more detail. I then note the significance of cross-domain influence for space. Finally, I describe two key general challenges in any domain—putting yourself in the shoes of others, and getting to grips with culture—and ways to overcome them.

INFLUENCE

2.3. I define influence as a means to affect an audience's behaviour, perceptions or attitudes. Influence can be achieved by deterrence, persuasion, or the use of hard or soft power. Influence does not only include "soft" means, but also the use or threat of hard power. Influence aims to affect an audience's decision process, which is shown in Fig. 2.1. The account of the audience's decision process used here is

operationalizable for planning, for instance being entirely compatible with U.S. concepts such as the Deterrence Operations Joint Operating Concept (DO JOC).[28] To provide a focus for this chapter, I highlight two important cases of influence: deterrence and escalation management.

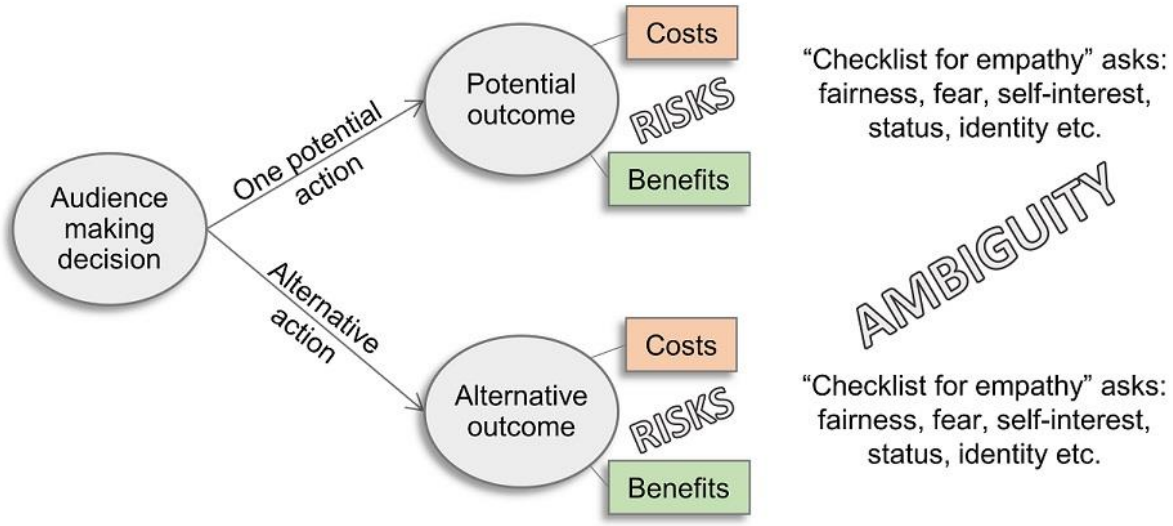


Figure 2.1: The Audience Decision Process. The audience's decision calculus must be at the heart of planning for influence. Practical tools, based in evidence, can help put oneself in the audience's shoes (e.g. the "checklist for empathy" described in Box 2.1 below).

HOW DO DETERRENCE AND ESCALATION MANAGEMENT RELATE?

2.4. Deterrence and escalation management are intimately related and are both cases of influence.

2.5. In U.S. thinking, deterrence is influencing an adversary so that they decide not to act rather than to act (see e.g. Fig. 2.2).

2.6. Escalation can be defined as an increase in the intensity or scope of confrontation considered significant by one or more parties. We can consider three mechanisms of escalation: deliberate, inadvertent and accidental.[29] Escalation may be considered inadvertent when an actor's intentional actions are unintentionally escalatory. In deliberate escalation the degree of escalatory impact on the receiver was intended. In accidental escalation, the action itself was unintended. Management of inadvertent escalation is managing the influence of one's actions on the those receiving them. Management of deliberate escalation by the adversary involves deterrence.

2.7. Deterrence and escalation management can work together and can be antagonistic. Actions taken in order to deter an adversary can contribute to escalation management, or may work against escalation management. How? If an adversary is deliberately escalating, then one can potentially deter further escalation by influencing the adversary's perceived cost/benefit judgement. However, if an adversary is escalating due to inadvertent escalation, then taking actions to deter the

[28] US DoD, "Deterrence Operations Joint Operating Concept," *Version 2*, 2006.
[29] For discussion of such definitions see Forrest E. Morgan et al., "Dangerous Thresholds" (Rand, 2008).

adversary through threatened punishment may make them fear further for their security and thus lead them to escalate further. It can escalate the spiral of tension between them.

2.8. The scholar Robert Jervis neatly captured the tension between spirals and deterrence[30]: are we in the run up to World War I (where more defensively motivated actions led or contributed a spiral of fear driving towards war); or are we in the run up to World War II where we need to deter Hitler?

2.9. Chinese thinking may be highly problematic with respect to such an understanding of escalation.[31] This arises because compared to much U.S. thought, Chinese strategic thinking considers escalation as more deliberate and controllable, and also considers signalling as more effective so that the message intended to be sent is the message that is received. Thus, if the Chinese believe escalation is much more the product of deliberate (rather than inadvertent) mechanisms, they will be much more likely to seek to deter that escalation and so worsen inadvertent escalation.

INFLUENCE: THE CASE OF DETERRENCE

2.10. In U.S. thinking, deterrence is influencing an adversary so that they decide not to act rather than to act (Fig. 2.1). Deterrence may require that the adversary chooses not to act at all (e.g. this is standard in nuclear deterrence thinking) or they may only act at some acceptably low frequency (e.g. in some conventional applications or as seen in Israeli thinking[32]).

A fundamentally cognitive dimension to deterrence

2.11. The cognitive foundation of deterrence is acknowledged by numerous U.S. and other Western official and scholarly documents.[33] One prominent U.S. DoD definition specifies that "Deterrence is a *state of mind* brought about by the existence of a credible threat of unacceptable counteraction" [emphasis mine][34]. The Deterrent Operations Joint Operating Concept also prominently states that "The central idea of the DO JOC is to decisively influence the adversary's decision-making calculus…."[35] Furthermore,

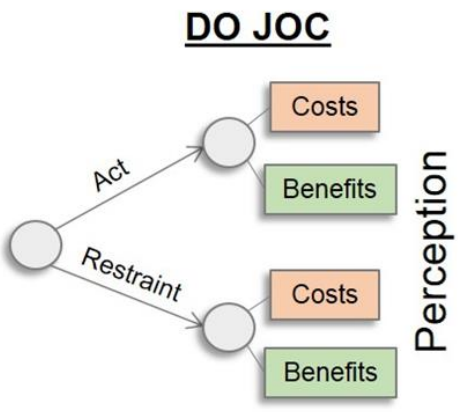


Figure 2.2: The adversary's decision calculus in the US DoD Deterrence Operations Joint Operating Concept (2006).

[30] Robert Jervis, *Perception and Misperception in International Pol* 1976).
[31] See below and Chs. 4 and 6 for further discussion and referenc
[32] Mark Vinson, "An Israeli Approach to Deterring Terrorism," *PRISM Security Studies Journal* 5, no. 3 (2014): 61–75. Thomas Rid, "Deterrence beyond the State: The Israeli Experience," *Contemporary Security Policy* 33, no. 1 (April 1, 2012): 124–47, https://doi.org/10.1080/13523260.2012.659593.
[33] Wright ND (forthcoming) The Neurobiology of Deterrence: Lessons for U.S. and Chinese Doctrine in Eds. Knopf J and Harrington A "Behavioral Economics and Nuclear Weapons", University of Georgia Press
[34] Department of Defense Dictionary of Military and Associated Terms, Joint Pub 1-02. This definition was present in the 1994 edition up to 2011, but not by 2016. it now defines deterrence as "The prevention of action by the existence of a credible threat of unacceptable counteraction and/or *belief* that the cost of action outweighs the *perceived* benefits" [emphasis mine].
[35] DoD, "Deterrence Operations Joint Operating Concept." p. 3

as shown in Figure 2.2 above, which I adapt from the core concept and illustration in the DO JOC, the adversary's decision calculus is clearly shown as a decision between options (each of which has costs and benefits), and in which perception is key. The DO JOC goes on to state that "An adversary's deterrence decision calculus focuses on their perception of three primary elements: The *benefits* of a course of action; The *costs* of a course of action; The *consequences of restraint*" [emphasis in original].

Space deterrence – a fundamental cognitive dimension

2.12. We can make four points about Western thinking on space deterrence.

2.13. Firstly, the definition of space deterrence is not fundamentally special compared to other domains. For instance, as noted in recent leading work discussing deterrence in the context of space:

- Michael Krepon writes: ""Space deterrence" is defined here as deterring harmful actions by whatever means against national assets in space and assets that support space operations."[36]
- Forrest Morgan writes: "Deterrence entails discouraging an opponent from committing an act of aggression by manipulating the expectation of resultant costs and benefits. Deterring attacks on U.S. space systems will require the United States to fashion credible threats of punishment against potential opponents, persuade adversaries that they can be denied the benefits of their aggression, or some combination of both approaches. However, fashioning a space deterrence regime that is sufficiently potent and credible will be difficult given that U.S. warfighting capabilities, much more so than those of any potential adversary, depend on space support."[37]
- UK scholar Bleddyn Bowen writes it is: "how to prevent would-be aggressors from attacking satellites and other parts of space infrastructure on Earth "[38]

2.14. Secondly, deterrence in space has a fundamentally cognitive dimension, which is again seen in leading work discussing deterrence and space:

- "Assessments of cost and benefit are, in fact, subjective—*and it is the enemy's assessment that counts, not the threatener's*."[39] [emphasis in original]
- "deterrence therefore exists in the mind of one's adversary" [40]
- "A key facet of this effort is understanding the psychological and cultural aspects of decision making and how an adversary will evaluate available options."[41]

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[36] Krepon, "Space and Nuclear Deterrence." p. 15

[37] Forrest E. Morgan, "Deterrence and First-Strike Stability in Space: A Preliminary Assessment" (RAND PROJECT AIR FORCE SANTA MONICA CA, 2010), https://www.rand.org/content/dam/rand/pubs/monographs/2010/RAND_MG916.pdf. pp. xii-xiii

[38] https://www.europeanleadershipnetwork.org/commentary/the-art-of-space-deterrence/

[39] Morgan, "Deterrence and First-Strike Stability in Space." p. 25

[40] Harrison et al., *Escalation and Deterrence in the Second Space Age*. p. 21

[41] James P. Finch and Shawn Steene, "Finding Space in Deterrence: Toward a General Framework for 'Space Deterrence,'" *Strategic Studies Quarterly: SSQ; Maxwell Air Force Base* 5, no. 4 (Winter 2011): 10–17.

2.15. Thirdly, given the crucial cognitive dimension of deterrence in space, having a *realistic* understanding of human cognition helps achieve intended effects. Comprehensive treatment is beyond the scope of this report but see e.g. Wright et al (2017)[42], and "outside-in thinking shown in Fig 2.2 and Box 2.1 below.

2.16. Fourth, whilst the *nature* of space deterrence remains the same as in other domains, as discussed in Chapter 1, one must appreciate how the *character* of deterrence (and its cognitive dimensions) in space differs from that in other domains such as nuclear.

INFLUENCE: THE CASE OF ESCALATION MANAGEMENT

2.17. Escalation can be defined as an increase in the intensity or scope of confrontation considered significant by one or more parties. Escalation may be deliberate, inadvertent or accidental.[43] Escalation management has a fundamentally cognitive component for both deliberate and inadvertent escalation.

Managing deliberate escalation – a fundamental cognitive dimension

2.18. Deterrence is the primary means to manage deliberate escalation. The cognitive dimensions of deterrence and space deterrence are discussed above.

Managing inadvertent escalation – a fundamental cognitive dimension

2.19. Escalation may be considered inadvertent when an actor's intentional actions are unintentionally escalatory, that is the degree of escalation was not deliberate and the action was not accidental. I highlight three cognitive aspects below.

2.20. Firstly, fear in action-reaction 'spirals'. 'Spiral' dynamics or the 'security dilemma' are invoked to explain many escalating peacetime action-reaction spirals of political hostility and military preparations[44], as well as inadvertent escalation during limited war.[45] Broadly speaking, such a spiral or security dilemma arises from fear or uncertainty of the other's motivations and capabilities, where precautionary or defensively motivated measures are understood or misperceived as offensive threats that can lead to countermeasures in kind.[46]

2.21. Much scholarship places fear at the heart of action-reaction spirals.[47] As Robert Jervis wrote, 'to determine whether a security dilemma existed … one or both sides should have been deeply fearful that the other side was aggressive or would become

[42] Wright, "From Control to Influence."
[43] For discussion of such definitions see Morgan et al., "Dangerous Thresholds."
[44] Jervis, *Perception and Misperception*. Ch. 3 esp. pp. 62-76. Andrew Kydd, "Game Theory and the Spiral Model," *World Politics* 49, no. 3 (April 1997): 371–400, https://doi.org/10.1353/wp.1997.0012. Charles L. Glaser, "The Security Dilemma Revisited," *World Politics* 50, no. 1 (October 1, 1997): 171–201.
[45] Barry Posen, *Inadvertent Escalation: Conventional War and Nuclear Risks* (Cornell University Press, 1991). Chapter 1. Posen also discusses militaries' offensive bent and accidents, not covered here.
[46] Thomas J. Christensen, "China, the U.S.-Japan Alliance, and the Security Dilemma in East Asia," *International Security* 23, no. 4 (April 1, 1999): 49–80.
[47] Ken Booth and Nicholas Wheeler, *Security Dilemma: Fear, Cooperation, and Trust in World Politics*, First Edition (Basingstoke: Palgrave Macmillan, 2008). Ch. 3 for a review.

so in the future.'[48] Or as Barry Posen concludes an analysis of the security dilemma, to understand the odds of conflict one must ask: "Which groups fear for their physical security and why?'[49] What 'fear' means varies widely: for some scholars being fundamentally biologically or psychologically with culture shaping its expression[50]; whilst for other scholars fear clearly matters but seems to fall out of rational explanations in terms of, for example, uncertainty over another's type.[51] However, at its core fear remains as an unpleasant emotion or apprehension caused by threat or danger.

2.22. Secondly, the thresholds over which an action is considered escalatory are fundamentally subjective – they exist in the minds of observers.[52]

2.23. Thirdly, the legitimacy or proportionality of reactions have a fundamentally subjective in the mind of the observer.[53]

CROSS-DOMAIN INFLUENCE: A KEY COMPLICATION FOR SPACE OPERATIONS

2.24. Space operations in escalation scenarios are highly likely to be cross-domain. Managing the perceived proportionality and legitimacy of cross-domain actions and reactions during escalation is a tough challenge. The section on social motivations in Chapter 3 illustrates these complexities.

2.25. One further point concerns the limitations of the term "cross-domain deterrence", which has been an area of considerable recent scholarly interest (see list in selected bibliography). Given the cross-domain nature of escalation involving space, as well as the interdependence of deterrence with escalation, I suggest instead examining the broader field of "cross-domain influence".

TWO BASIC CHALLENGES: COGNITIVE BIAS AND CULTURE

2.26. Finally in this chapter I highlight two key cognitive failings that plague planning for influence in other domains – and will likely plague planning for space influence operations. These are: how to put yourself in the shoes of other; and how to get to grips with culture.

Cognitive bias - Thinking 'outside-in'

[48] Robert Jervis, "Was the Cold War a Security Dilemma?," *Journal of Cold War Studies* 3, no. 1 (January 1, 2001): 36–60, https://doi.org/10.1162/15203970151032146.
[49] Barry R. Posen, "The Security Dilemma and Ethnic Conflict," *Survival* 35, no. 1 (1993): 27–47, https://doi.org/10.1080/00396339308442672.
[50] Booth and Wheeler, *Security Dilemma*. Ch. 3. Lebow Richard Ned, *A Cultural Theory of International Relations* (Cambridge University Press, 2008). p. 119.
[51] E.g. Andrew H. Kydd, *Trust And Mistrust In International Relations* (Princeton University Press, 2005). Fear is neither indexed nor clearly defined, but figures prominently. Part II is entitled 'Fear and the Origins of the Cold War' in which fear is central to Ch. 3 on 'The Spiral of Fear' and the subsequent historical descriptions. Charles L. Glaser, *Rational Theory of International Politics: The Logic of Competition and Cooperation* (Princeton University Press, 2010). Again fear is not indexed or defined, but for example features in the description of signalling malign intentions pp. 70-1.
[52] Morgan et al., "Dangerous Thresholds."
[53] Schelling, *Arms and Influence*.

2.27. To influence an Afghan farmer not to grow poppy, the influencer must consider that course of action and its alternatives from *the audience's* perspective.[54] If the aim is to deter a hostile State, i.e. influence it not to act, then the influencer must estimate how the hostile State perceives the costs and benefits of acting – and of not acting.[55]

2.28. Embracing an **outside-in** perspective—a mindset that starts with the audience and focuses on creatively delivering something it values—brings benefits relative to an inside-out mindset focused on internal processes that push out products to the audience.[56] In business, this has been a staple of marketing since Harvard Marketing professor Theodore Levitt's 1960 article Marketing Myopia.[57] In a more recent study, customer-driven companies doubled the shareholder returns compared to shareholder-driven ones[58] and the advantages are even more marked in the most challenging and turbulent markets.[59] In international relations, a key recommendation of Joseph Nye's seminal 2004 book on power and influence is, "To put it bluntly, to communicate more effectively, Americans need to listen."[60]

2.29. Influence aims to shape behaviour either immediately or in the future, which requires understanding the audience's decision-making process as shown in Figure 2.1. The decision the audience faces, must be at the heart of planning for influence. Influence is affecting an audience's decision-making process, where that audience can decide between options. The influencer should explicitly estimate that action's perceived costs and benefits and the perceived costs and benefits of alternatives. This includes realistic, conscious and unconscious as well as "irrational" motivations, for example fear, fairness and identity (e.g. Box 2.1, Ch. 3).

2.30. Thinking outside-in seems obvious, yet businesses and governments often fail to do it. One important reason for this is the unavoidable force in any bureaucracy to focus internally on process and known routines.[61] Humans are also predisposed to think egocentrically.[62]

A simple approach to thinking outside-in

2.31. Outside-in thinking is very hard. Box 2.1 shows one simple, practical approach to achieving this. Such practical questions as set out in the checklist below can help to estimate the perceived costs and benefits of an action from an audience's perspective – based on a realistic understanding of human motivation and decision-making, coupled with the specific context.

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[54] This subsection draws on Wright, "From Control to Influence." Please see that report for detailed discussion of the rationale and how to implement such influence.
[55] Lawrence Freedman, *Deterrence* (Cambridge: Polity, 2004).
[56] The evidence is reviewed in Wright, "From Control to Influence."
[57] Levitt, T. 'Marketing Myopia', *Harvard Business Review*, July-August, 1960, p.45
[58] Ellsworth, R. (2002) Leading with Purpose, The New Corporate Realities, Stanford Business Books
[59] Gulati, R. (2009) 'Reorganise for resilience: Putting customers at the centre of your organisation', Harvard Business Press
[60] Nye, JS. (2004) Soft Power: The Means to Success in World Politics, Public Affairs
[61] Graham Allison and Philip Zelikow, *Essence of Decision: Explaining the Cuban Missile Crisis*, 2nd ed. (Pearson, 1999).
[62] M. H. Bazerman et al., "Negotiation," *Annual Review of Psychology* 51 (2000): 279–314, https://doi.org/10.1146/annurev.psych.51.1.279.

Box 2.1: Checklist for Empathy

A set of practical questions can help to estimate the audience's perceived costs and benefits for their potential alternative actions in a given context, i.e. help complete Figure 2.1. These may include:

- **Self-interest**: *"What material benefits may they gain or lose?"*[63] The importance of self-interest was shown by the switching allegiances of Sunni groups during the 2007 Surge in Iraq, which involved U.S. rewards and threats of punishment.[64]
- **Fairness**: *"How fair will it be seen from the audiences' perspectives?"* Humans typically pay costs to reject unfairness and pursue grievances.[65]
- **Fear**: "Do they fear for their security and why?"[66]
- **Identity**: *"What are their key identities?"* Humans are driven to form groups ("us", the "in-group") that are contrasted against other groups ("them", the "out-group"). Individuals also often hold multiple overlapping identities.[67]
- **Status**: *"How may this affect the audience's self-perceived status?"* E.g. For key audiences in Afghanistan, joining the Taliban had high status.[68]
- **Expectations**: "*What are their key expectations, and what may violate them?"*[69] The more unexpected a perceived event is, the bigger its psychological impact.[70]
- **Context, opportunity and capability**: *"What opportunities and capabilities does the audience perceive it has for its potential alternative actions?"* E.g. an intervention to encourage someone to pay taxes who is actively avoiding paying taxes, differs to that for someone who feels unable to use an online system.

Culture – East Asia and the West

[63] Raymond Paternoster, "How Much Do We Really Know about Criminal Deterrence?," *The Journal of Criminal Law and Criminology*, 2010, 765–824; J.H. Kagel and A.E. Roth, "The Handbook of Experimental Economics," *Princeton, NJ*, 1995.
[64] 'Losing Iraq' July 29th 2014, Frontline, PBS
[65] Colin F Camerer, *Behavioral Game Theory: Experiments in Strategic Interaction*, vol. 9 (Princeton University Press Princeton, NJ, 2003).
[66] Posen, "The Security Dilemma and Ethnic Conflict"; Jervis, "Was the Cold War a Security Dilemma?"
[67] Nicholas Sambanis, Jonah Schulhofer-Wohl, and Moses Shayo, "Parochialism as a Central Challenge in Counterinsurgency," *Science* 336, no. 6083 (May 18, 2012): 805–8, https://doi.org/10.1126/science.1222304.
[68] Arturo Munoz, *U.S. Military Information Operations in Afghanistan* (Rand Corp., 2012).
[69] Crombie Schelling, T. (1966) *Arms and Influence*, Yale University Press; Smoke, R. (1977) *War: Controlling Escalation*, Harvard University Press.
[70] Nicholas D. Wright, "The Biology of Cooperative Decision-Making: Neurobiology to International Relations," in *Handbook of International Negotiation*, ed. Mauro Galluccio (Springer International Publishing, 2015), 47–58.

2.32. Does strategic thinking differ between China and the U.S.? Does what is common sense and intuitively plausible really differ between these cultures? Identifying such differences would help tailor influence strategies. Many influential voices argue that strategic thought differs between China and the West, rooted in millennia of cultural difference leading to different worldviews. Henry Kissinger wrote in *'On China'* that 'No other country can claim so long a continuous civilization, or such an intimate link to its ancient past and classical principles of strategy and statesmanship', and argued its cultural tradition shaped leaders such as Mao Zedong, Wen Jiabao and Hu Jintao.[71] The authoritative Chinese military textbook *The Science of Military Strategy* states that 'The cultural tradition of all nations, especially the national cultural psychology has significance on the process of development of strategic theories.'[72]

2.33. But whilst it has been devilishly difficult to determine whether, and how, cultural differences affect behavior, in this report I apply robust findings from cross-cultural cognitive science. This provides an extra, independent source of evidence on cross-cultural differences, which I then explore further using consider cross-cultural analyses from doctrine, interviews and historical cases. I discuss cross-cultural factors further in Chapters 4 and 6.

2.34. Here, however, I first give the example of deterrence, which also highlights the significance of identifying commonalities as well as differences between cultures.

Chinese thinking on deterrence: commonalities and differences compared to the West

2.35. Chinese concepts of deterrence are broader and include both Western concepts of deterrence (influencing an adversary not to act) as well as compellence (influencing an adversary to choose to act rather than not act).[73]

2.36. However, as in the U.S. case above, Chinese doctrine also has cognition at the core of its thinking on deterrence. Chapter 9 in the authoritative PLA textbook *The Science of Military Strategy* is entitled "Strategic Deterrence." The authors write that "[D]eterrence requires turning the strength and the determination of using strength into the information transmitting to the opponent, and to impact directly on his mentality in creating a *psychological pressure* to shock and awe the opponent" [emphasis mine].[74] Elsewhere, this publication states, "There are three basic elements to carry out deterrence: First, appropriate military strength available; second, resolve and will to use force; and third persuading the opponent to perceive such strength and resolve."[75] Note that this was translated into English by the Chinese Academy of Military Sciences themselves--these are their own words and whilst one may argue that the Chinese use the term deterrence slightly differently to

[71] Henry Kissinger, *On China* (Penguin, 2011). Quote from p. 2, see also e.g. pp. 3, 103, 490.
[72] Guangqian Peng and Youzhi Yao, *The Science of Military Strategy* (Beijing: Military Science Publishing House, 2005). p. 128.
[73] Schelling, *Arms and Influence*. Introduced this distinction within Western thinking.
[74] Guangqian Peng and Youzhi Yao, *The Science of Military Strategy* (Beijing: Military Science Publishing House, 2005). See Ch 6 of this report for a discussion of challenges of identifying and interpreting Chinese doctrine.
[75] Peng and Yao. p. 18

the U.S. literature (e.g. to include coercive diplomacy more broadly[76]), the broader point of the cognitive basis of their idea is clear.

2.37. Thus, despite the slightly wider Chinese scope, both Chinese and U.S. accounts consider deterrence as a form of influence, and both Chinese and U.S. accounts of deterrence contain important cognitive dimensions. In this Chinese case, this also accords with other characterizations of such Chinese concepts.[77] Furthermore, these Chinese and U.S. accounts also at least in part consider deterrence in terms of an account of the adversary's decision calculus, which includes the adversary's potential gains and losses from their alternative courses of action.[78]

RECOMMENDATIONS

2.38. Deterrence and escalation management are intimately related, neither alone is sufficient for the U.S. to cause intended and avoid unintended effects in space – and both should be considered together within the framework of *influence*.

2.39. Both deterrence and escalation management have a fundamentally cognitive dimension – and space operations should adopt a realistic account of human decision-making.

- The "checklist for empathy" provides one simple, operationalisable example, based in evidence.

2.40. Space operations should adopt an "outside-in" mindset, which places the adversary's decision-making at the heart of the influence strategy.

2.41. Culture should be taken seriously to understand the adversary in space operations

[76] Li Bin, "China and Global Nuclear Arms Control and Disarmament," in *The War That Must Never Be Fought: Dilemmas of Nuclear Deterrence*, edited by George P. Shultz and James E. Goodby (Stanford, CA: Hoover Institution, 2015), p. 359; Dennis Blasko in Joe McReynolds, ed., *China's Evolving Military Strategy* (Brookings Institution Press, 2016).

[77] For example, Thomas J. Christensen writes that "It is fairly clear that deterrence, coercion, enemy psychology, and morale are key targets of many of the operations discussed in *Zhanyixue*" ("Coercive Contradictions: Zhanyixue, PLA Doctrine, and Taiwan Scenarios," in *China's Revolution in Doctrinal Affairs: Emerging Trends in the Operational Art of the Chinese People's Liberation Army*, ed. James C. Mulvenon and David Finkelstein (Alexandria, VA: CNA Corp,.2005. Henry Kissinger, *On China* (Penguin, 2011). observes (pp. 133-35) that "Mao's actions in the Korean War require an understanding of how he viewed what, in Western strategy, would be called deterrence or even preemption and which, in Chinese thinking, combines the long-range, strategic, and psychological elements." "Mao's approach to preemption differed in the extraordinary attention he paid to psychological elements. His motivating force was less to inflict a decisive military first blow than to change the psychological balance, not so much to defeat the enemy as to alter his calculus of risks." "Having restored the psychological equation, in Chinese eyes, genuine deterrence has been achieved."

[78] See Wright ND (forthcoming) "The Neurobiology of Deterrence" for further discussion.

Chapter 3 Cognition in space operations: key factors for all space powers

3.1. What are the key features that matter particularly for space operations relative to other domains? This chapter examines the cognitive foundations of key features of space operations, which apply to all space powers. These key features are particularly significant in space operations relative to one or more other domains (e.g. nuclear, conventional or cyber). [79] These factors carry important implications for influence operations such as deterrence and escalation management.

3.2. Considering their cognitive foundations places them into four groups (Table 3.1).

Key factors for space	*Cognitive foundations*
Uninhabited; destructiveness	Less social motivations
Attribution; Damage assessment; Dual use; Highly classified; Reversibility	Uncertainty, risk, ambiguity
Borderless; Debris	Tragedy of the commons
Fragility; Offense dominance	Rapid decision-making

Table 3.1: Cognition in Space Deterrence and Escalation: Universal Factors

3.3. In this chapter, for each group in turn I discuss the cognitive foundations relevant for strategy, their implications for space operations, and make policy recommendations. Together, this helps adapt the general account of audience decision-making (e.g. Fig. 2.1) to emphasise factors significant for deterrence and escalation management in space.

UNINHABITED AND LESS DESTRUCTIVE – A CAUSE OF MIXED PERCEPTIONS

3.4. *Summary:* Humans pay large costs to reject perceived unfairness, and this complicates the perceived legitimacy of potential U.S. responses to adversary actions in space. An adversary's space actions may have large strategic impacts, but because "satellites have no mothers" in comparison to potential U.S. conventional responses they may rouse little moral impact in key audiences (e.g. allies). Such mixed perceptions may cause inadvertent escalation, which may only be ameliorated by clear communication ahead of time before crises.

Features of space

3.5. Two key features of space are:

- *Uninhabited:* Space is uninhabited, limiting the emotionally impactful human dimension observed in conventional or nuclear domains. Classically, "satellites have no mothers", unlike airmen, sailors or civilian casualties.

[79] I derived these factors from across authoritative analyses of space operations, including those listed in the selected bibliography, as well as numerous discussions with space experts conducted August 2017-May 2018.

- *Less destructiveness:* Space operations are much less destructive than nuclear weapons' potentially huge casualties or conventional conflict.

3.6. Thus, compared to other domains in which human death features[80], including that of non-combatants, destruction of space assets will have a lower ratio of moral to military significance. This will be particularly emphasized in the cross-domain context of many potential space operations, which inevitably involve cross-domain comparisons of proportionality or legitimacy.

Cognitive foundations

3.7. Social motivations powerfully drive human decision-making within the cross-domain escalation scenarios that will include space. The constellation of powerful, connected human social motivations includes the drive to reject unfair or illegitimate actions. Accepting injustice may go against ideas of "honour" central to the ethos of warriors and statesmen since Ancient Greece as described by Thucydides.

3.8. Historically, moral outrage at human events has often sparked escalation, escalated conflict or even led to war. Alleged rough treatment of an 18th Century English sailor's ear sparked the "War of Jenkins ear" and a decade of war with Spain raging across the globe. In the 2001 Sino-U.S. crisis over the collision of a PRC fighter and U.S. EP-3 reconnaissance plane, the key PRC demand was an apology for their pilot's death. A key feature of U.S. Cold War strategy was the qualitative difference between no casualties and even limited casualties, illustrated by the existence of U.S. tripwire forces in places such as Berlin. Indeed, modern Grey Zone warfare often aims to keep casualties close to zero at least officially.[81]

3.9. Consider the example of fairness. Humans are prepared to reject unfairness at substantial cost, and this is rooted in our biology. In a classic example called the ultimatum game, one individual gets an amount of money (e.g. $10) and proposes a split with a second player (e.g. $9 for herself, $1 for the second person). The other individual then decides whether to accept the offer (in which case both get the split as proposed) or reject the offer (in which case both players get nothing). Despite receiving an offer of free money, the second player rejects offers involving less than 25 percent of the money around half the time.[82] Even non-human primates reject unfairness.

3.10. Understanding fairness can help analysts interpret and forecast others' decisions more accurately. For instance, deterrence analysis that ignores the drive to reject unfairness can't correctly forecast what is needed for actions to be deterred. How this affects deterrence is shown by considering the central concept in the U.S. Deterrence Operations Joint Operating Concept (DO JOC, 2006 v2). The top left panel in Figure 3.1 below shows how in the DO JOC the audience chooses between two options (to act or show restraint) based on the costs and benefits associated with each. The top right panel in Figure 3.1 then shows how in the ultimatum game the audience chooses between two options (to reject or accept) based on the costs and benefits associated with each – but, crucially, correct forecasting of behavior must

[80] Cyber shares this quality, unless a cyber attack causes, for instance, infrastructure failure leading to fatalities. Clearly there can be casualties during attacks on earth-based parts of space systems.
[81] Russian scholar Dmitri Trenin notes this as a feature of hybrid warfare.
[82] Camerer, *Behavioral Game Theory*.

include the value of fairness that drives them to reject. Now consider the DO JOC again, and see that when conducting a deterrence operation the social motivation of fairness may drive them to reject restraint, so deterrence fails.

3.11. Whilst such social motivations will weigh heavily in the impact of many conventional—and certainly nuclear—actions, they will be markedly reduced in space operations despite their military significance (Fig. 3.1 bottom panel). Destroying or affecting space resources will likely cause less moral and emotional responses, for instance in public opinion in the U.S. domestically, in the adversary and key allies. But why does this matter?

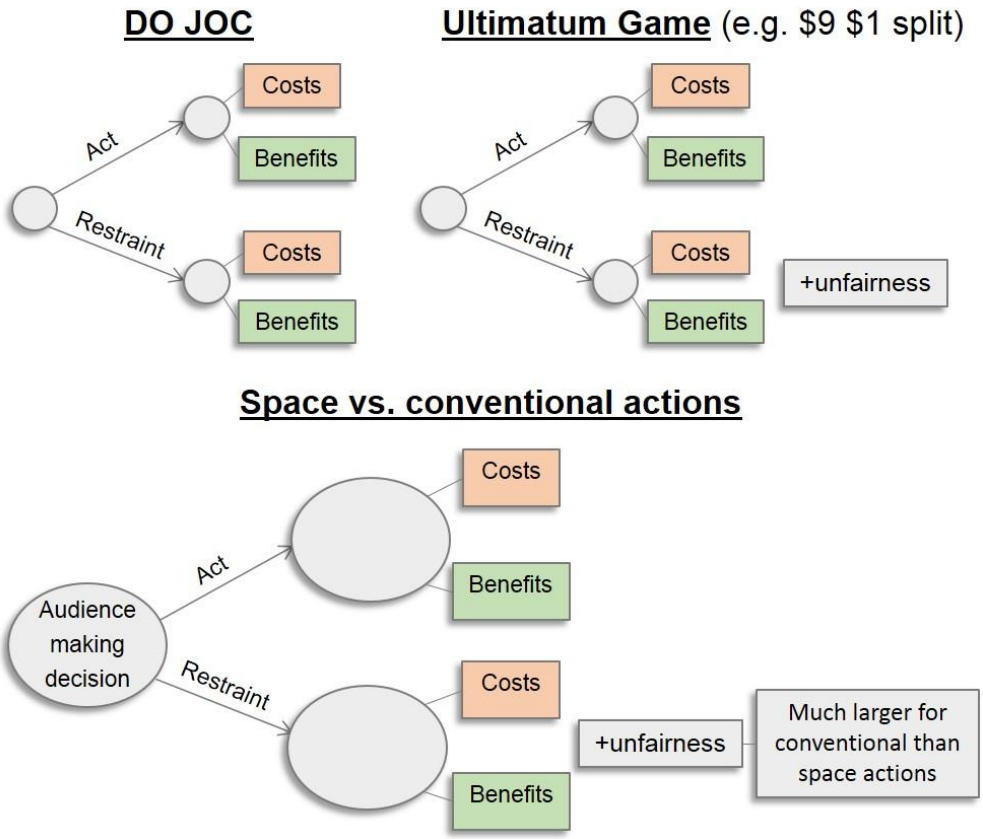

Figure 3.1: Fairness can limit deterrence and cause escalation. The bottom panel shows how this differs for space and conventional actions.

Implications and recommendations for space deterrence and escalation

3.12. *Firstly, credible deterrence will likely be harder than in domains featuring human death.* Making effective deterrent threats or drawing red lines to deter adversary attacks on U.S. space assets will be harder if the adversary anticipates that the threatened U.S. response may not be perceived as legitimate to key U.S. or third-party constituencies (e.g. allies). This arises because the adversary anticipates that their space operations will not have roused the large social motivations required to legitimate a robust U.S. response.

3.13. *Recommendations:*

- Thus, consider that stronger deterrent threats may be necessary in space than those required to deter adversary actions of equivalent military impact outside space.
- Perceived fairness and legitimacy are fundamentally subjective. When anticipating actions and responses to an action, one must ask: "how fair will this be perceived to be by key audiences?" (Box 2.1)

3.14. *Secondly, mismatched perceptions may arise between those viewing space operations through civilian or military lenses.* An adversary's civilian leadership giving authority for actions in space may anticipate that such a bloodless option is less escalatory than is perceived by U.S. military planners receiving them, who focus on military impacts. Differing civilian-military perceptions within *both* sender and receiver provide scope for mismatched perceptions causing inadvertent escalation. Mismatched civilian and military perceptions within European powers posed significant problems in the run up to World War One[83] – and this will likely be exacerbated in the highly technical and opaque world of space operations.

3.15. *Recommendations:*

- Ahead of time clearly communicate the political impacts of space actions to the adversary's political *and* military leadership.
- Ahead of time educate key audiences, for instance domestically and with allies. An example is Air Force Space Command's General John Hyten's appearance on "60 minutes".[84]
- During crises communicate the political as well as military impacts of space actions to the adversary's political *and* military leadership.

3.16. *Third, U.S. cross-domain responses (e.g. conventional strikes) to space actions may rouse much greater moral impacts in key audiences (e.g. allies) and reduce perceived legitimacy for those U.S. responses.* Perceived legitimacy of actions partly determines their impacts on adversaries, allies and other third parties. Legitimacy is a source of influence.

3.17. *Recommendations:*

- Thus, the U.S. will have to work harder than military planners may anticipate to contain the diplomatic and political impacts of such U.S. responses.

3.18. *Fourth, adversaries' space actions complicate the perceived legitimacy of U.S. responses, which makes them particularly attractive for Grey Zone conflicts.*

3.19. *Recommendations:*

- The U.S. must ensure it can respond to space operations in the Grey Zone (see Chapter 5) – with effective capabilities and practices.

3.20. *Fifth, from allies' perspectives can the U.S. plausibly provide extended deterrence against adversary space operations?* In the Cold War allies wondered if the U.S. would really trade Boston for Berlin. One key answer then were human tripwire forces – a strategy revived today on NATO's eastern flank. How much harder would it be to reassure allies such as Japan or Germany about the risks the U.S. would run to respond to militarily significant but bloodless space operations?

3.21. *Recommendations:*

[83] Jack Snyder, "Civil-Military Relations and the Cult of the Offensive, 1914 and 1984," *International Security* 9, no. 1 (1984): 108–46, https://doi.org/10.2307/2538637.
[84] https://www.youtube.com/watch?v=ediem2mn6XM

- The U.S. must actively manage allied perceptions *both* ahead of time and during crises (see Chapter 4) – building trust and confidence in the U.S..

MASTERING UNCERTAINTY: AMBIGUITY AND RISK ASSESSMENT IN SPACE

3.22. *Summary:* Uncertainty pervades the space environment. can be usefully broken down into two distinct components that require different policies: risk and ambiguity. Ambiguity and difficult risk assessment in space arise from challenges of attribution, damage assessment, dual use, high classification and reversible actions. Ambiguity makes communicating deterrence much harder and increases the risk of escalation for instance by muddying mutually understood red lines. U.S. signals will likely have to be much clearer than U.S. policymakers anticipate, and some communication must be performed ahead of crises.

Features of space

3.23. Multiple factors all make the space environment one of uncertainty.

- *Attribution:* Identifying sources of non-kinetic attacks can be difficult in space. Further, evidence of attribution sufficient to convince key audiences may be difficult to provide even for allied elites, let alone declassified for publics.
- *Damage assessment:* This can be difficult for those making actions, for instance consider an attempt at reversible dazzling: did it work as intended, permanently damage the target or fail to work at all? For the receiver, what effect and duration were intended, and is any damage repairable?
- *Dual use:* Technology that serves both civilian and military dual uses are pervasive in space. For instance, manoeuvrable on-orbit repair satellites use technologies can be used against others' satellites; and PNT such as GPS is dual use. Technology can possess dual military uses, for example with ballistic missile defense providing an ASAT capability.
- *Highly classified:* Much in space is highly classified. Capabilities are more opaque, as are policies (e.g. see Box 4.1 on opaque UK policy).
- *Reversibility:* Some non-kinetic actions are intended to be reversible. But are these one-offs, or can and will they be repeated?

3.24. Thus uncertainty pervades space operations for those making actions, those receiving them and observing third parties.

Cognitive foundations

3.25. Fortunately, the human brain contains sophisticated neural machinery for managing uncertainty, in which an important distinction relates to risk and ambiguity.[85] The basic difference is illustrated in Fig. 3.2.

[85] Defining risk and ambiguity are highly contentious because there are multiple overlapping definitions across different disciplines. However, the basic concepts are not that complicated or confusing.Here we use a common perspective in economics, psychology and neuroscience. This makes "a distinction between prospects that involve risk and those that involve ambiguity. Risk refers to a situation in which all of the probabilities are known. Ambiguity refers to a situation in which some of the probabilities are unknown."Antonio Rangel, Colin Camerer, and P.R Montague, "A Framework for Studying the Neurobiology of Value-Based Decision Making," *Nature Reviews Neuroscience* 9, no. 7 (2008): 545–56.

- Risk is uncertainty about which potential outcome will occur, like betting on the toss of a coin.
- Ambiguity involves an extra layer of uncertainty, so actions are open to multiple interpretations before we even consider their risk.

3.26. Risk and ambiguity are central to deterrence and escalation management in space. Policymakers can manipulate risk, and use it as a tool for deterrence or escalation management. They can also manipulate ambiguity. Understanding risk and ambiguity is therefore key to achieve intended and avoid unintended effects.

*Figure 3.2: Uncertainty can be broken down into risk and ambiguity – which undergo distinct processing in the brain, and which require distinct policy recommendations.. **Risk** can be thought of as known uncertainty, for instance betting on the outcome of a coin toss (top left). Risk is shown in the left panel, where you are asked the play a lottery by picking a ball from a bag with 22 balls of which half are black and half white. Thus, the winning chance for each colour is 50%. **Ambiguity** is shown in the right panel. A second bag has the same number of balls, but how many are black and white balls is unknown (shown as grey balls). Adding this extra layer of uncertainty not only leads people to reverse their choices (the famous Ellsberg paradox[86]) but this ambiguity also involves distinct brain processes.[87] Ambiguity is also illustrated by the ambiguous figure on the right panel – is it an old lady or a young lady?*

Implications and recommendations for space operations

Ambiguity in space operations

3.27. Ambiguity in events and actions gives an extra layer of uncertainty, so they are open to *multiple interpretations* before we even consider their risk. Contemporary

[86] Daniel Ellsberg, "Risk, Ambiguity, and the Savage Axioms," *The Quarterly Journal of Economics* 75, no. 4 (November 1, 1961): 643–69, https://doi.org/10.2307/1884324.
[87] Dominik R. Bach and Raymond J. Dolan, "Knowing How Much You Don't Know: A Neural Organization of Uncertainty Estimates," *Nature Reviews Neuroscience* 13, no. 8 (August 1, 2012): 572–86, https://doi.org/10.1038/nrn3289.

examples outside space include “little green men” in East Ukraine or island building in the South China Sea. Implications for space operations include the following.[88]

3.28. *First, one can use ambiguity as a tool:*

- Using reversible, hard to attribute space operations can render an offensive action’s magnitude—or even whether or not it occurred—more ambiguous and so more easily deniable. This ambiguity may affect the perceptions of, for instance, important third parties such as German public or elite opinion in a U.S.-Russia scenario.
- Reversible actions could be used to affect the outcome of conflicts in third party states without making a visible commitment.
- Ambiguous thresholds for deterrent threats enable less loss of face if they are crossed, e.g. compared to hard “red lines”.

3.29. *Second, one can reduce the ambiguity of an adversary’s actions.* This has two aims. One is to enhance one’s own understanding of whether an action occurred, what occurred or who to attribute it to. Another is to generate evidence to convince third parties of one’s interpretation.

3.30. *Recommendations:*

- Invest in attribution. Long term investment can be made in capabilities to attribute attacks. This reduces ambiguity in *one’s own assessment*. It may also provide evidence with which to convince others, such as domestic U.S. public opinion, allied elites and allied publics.
- Ahead of time have public discussions of adversary actions or capabilities to build awareness. Then Chief of Air Force Space Command General John Hyten’s 2015 interview on “60 minutes” provides an example of public engagement.
- Use trust and communicate effectively to successfully convince target audiences (e.g. allies) of one’s own interpretation of events. Wright (2017) discusses in detail how to communicate effectively, which includes finding and building trusted messengers.

3.31. *Third, deterring ambiguous space activities is very difficult.*

3.32. Recommendations:

- Thus, U.S. policymakers must plan ahead of time for responses to important classes of ambiguous space operations, e.g. U.S. responses to persistent ambiguous activities where each instance may not itself cross a “red line”.
- Threats to deter such persistent activities may need to be communicated clearly in advance.

3.33. *Fourth, ambiguity in space enhances escalation potential, e.g. by muddying mutually understood red lines.*

3.34. *Fifth, ambiguity makes sending deescalatory signals via space difficult.* Controlling escalation involves not just minimising escalatory factors, but also positive accommodative and conciliatory gestures.[89] The success of social animals such as

[88] Although not involving space, an excellent general chapter on ambiguity in international politics is in Robert Jervis, *The Logic of Images in International Relations* (Princeton University Press, 1970). Ambiguity in cyber is covered in Wright, “From Control to Influence.” Ch. 9; Martin C. Libicki, “The Strategic Uses of Ambiguity in Cyberspace,” *Military and Strategic Affairs* 3, no. 3 (2011): 3–10.; Antonia Chayes, “Rethinking Warfare: The Ambiguity of Cyber Attacks,” *Harv. Nat’l Sec. J.* 6 (2015): 474.

[89] Wright, “The Biology of Cooperative Decision-Making.”

humans crucially depends on their ability to dynamically manage the balance between cooperation and competition over time. A critical aspect of this is unilateral conciliatory or accommodative signals, which are often needed to control escalation and enable de-escalation.

3.35. *Recommendation:*

- The U.S. cannot understand crisis dynamics and how to control escalation without understanding conciliatory and accommodative gestures – and given the ambiguity in many space operations these may need to occur in other domains.

3.36. *Sixth, ambiguity is key to Grey Zone activities (e.g. little green men; little blue men; little manoeuvring satellites) – and adversaries will likely use space for Grey Zone conflict because of this ambiguity.* Chapter 5 discusses Grey Zone conflict.

Risk and risk assessment in space operations

3.37. Risk arises when there is uncertainty about which of the potential outcomes in a situation will occur. Risk pervades all human decision-making. Consider US, UK and German troops currently deploying to NATO's east, such as the Baltic Republics. Their placement is unambiguous, and provides a tripwire so that there is the risk of escalation if there were serious aggression. This is a classic use of the risk of escalation. Implications for space operations include the following.[90]

3.38. *First, extensive evidence of deterrent threats on crime*[91] *examined three features of deterrent threats: increasing probability of punishment increases deterrence (likelihood); while increased severity does not seem to increase deterrence (magnitude); and evidence is equivocal on the timeliness of punishment (celerity).*

- To deter, consider communicating increased "likelihood" of a U.S. response rather than its "magnitude" or "timeliness". This may be particularly important to deter adversaries' recurring reversible space activites.

3.39. *Second, humans typically overweight small probabilities, so that there is a big difference between "certain" and "quite certain".* Use of reversible counter-space operations during crises may lead the receiver to downgrade their estimate of the satellite's reliability more than intended by the sender – and thus be more escalatory than anticipated. A recent space tabletop exercise reported such effects.[92]

3.40. *Third, a key distinction from ambiguity is that probabilities are better understood with risk.*

3.41. *Recommendation:*

- Thus, good baseline data can help turn events from ambiguous to risky.

3.42. *Fourth, making deterrent threats or managing escalation requires manipulating the adversary's perception of the risks it runs by escalating – but ambiguity greatly complicates the communication of such risks in space.*

[90] While not involving space, for a classic chapter on manipulating risk see Schelling, *Arms and Influence*. Ch. 3.
[91] Paternoster, "How Much Do We Really Know about Criminal Deterrence?"
[92] Harrison et al., *Escalation and Deterrence in the Second Space Age*.

- Thus, when the U.S. seeks to communicate that an adversary will run significant risks if it conducts space operations, the U.S. signals will likely need to be much clearer than U.S. policymakers anticipate.

BORDERLESS SPACE – INFLUENCE TO AVOID A TRAGEDY OF THE COMMONS

3.43. *Summary:* A borderless domain diffuses responsibility for its care, which helps actors rationalize individual self-interested actions that make themselves and everyone else worse off in the longer run (e.g. creating space debris). Possible debris or other damage to the space environment is unlikely to significantly weigh on adversary decision-makers, especially if debris-causing U.S. actions muddy the issue. However, a realistic account of human decision-making suggests three features that can help *influence* actors to show restraint related to: (a) reputation; (b) threats to punish; and (c) using norms, institutions and legitimacy.

Features of space

3.44. Two significant features of space are:

- *Borderless:* Space is a "commons." It is a resource that cannot be owned in whole or part and is accessible to all – just like the commons of "Olde Englande" on which the local community could all herd their sheep (Fig. 3.3). Space may be termed a "global commons", which like the oceans is large-scale and inherently international.
- *Debris:* Space debris from kinetic actions may hobble all of humanity's future space activities. Large-scale kinetic conflict, particularly in relatively small but valuable areas such as GEO, would significantly complicate future use for everyone well into the next century. As an example, by destroying only one LEO satellite in 2007, a Chinese ASAT test left 3000 trackable pieces of debris in orbit to this day.

Figure 3.3: Tragedy of the commons. We all lose if we aren't influenced to collectively show restraint.

3.45. How can we manage this common resource that benefits everyone, without our actions leading to its destruction? Such a problem might be framed as a *Tragedy of the Commons*.[93] This echoes the challenge in Olde Englande of managing the common so individuals could feed their families, which they wouldn't be able to do if cooperation broke down and the common was overgrazed.

3.46. Everyone is better off if the community is restrained—and *influencing* the community to be restrained is the *only* way to manage a potential Tragedy of the Commons[94]—but unfortunately the best outcome for each individual is for them to be selfish and

[93] For insightful analysis on a Tragedy of the Commons in space see Brian C. Weeden and Tiffany Chow, "Taking a Common-Pool Resources Approach to Space Sustainability: A Framework and Potential Policies," *Space Policy* 28, no. 3 (August 2012): 166–72, https://doi.org/10.1016/j.spacepol.2012.06.004.
[94] The only alternative is a successful first strike by one power to prevent the creation of space debris.

"free-ride" whilst the community is restrained, a path that leads to tragedy. This raises three points:

- *Control* isn't enough. It is impossible to guarantee a solution to the prevent a Tragedy of the Commons, as long as members of the community have the ability to free-ride. In space, one cannot remove great powers' capabilities to create space debris short of incredibly escalatory strikes on their ASAT capabilities.
- *Influencing* the community to be restrained is the *only* way to manage a potential Tragedy of the Commons.
- Luckily for humanity we have faced this challenge for millennia and, whilst we often fail, human societies also often do avoid tragedy using successful influence.

Cognitive foundations

3.47. Human cognition balances cooperation and immediate self-interest – any account of decision-making that ignores *either* of these realities is hopelessly lopsided. Thus,

- Unfortunately, one key takeaway is that there will always be a strong drive towards the temptation to "free-ride" and take immediately self-interested actions that lead to a tragedy of the commons. Further, a borderless domain *diffuses responsibility* for its care, an important cognitive feature that can help actors rationalize individual self-interested actions that are contrary to the common good (e.g. creating space debris).
- But a second key takeaway is that there will always be countervailing drives towards cooperation and repairing ruptures in cooperation.

3.48. Further, a realistic account of human decision-making suggests three features that can help *influence* actors to show restraint and so help prevent a Tragedy:

- Reputation: Actors should know that they have a reputation at stake if they abuse the common resource.
- Threats to punish abuse of the common resource helps to maintain cooperation, as does increasing rewards from cooperation. Influence actors' cost-benefit decision-making process (Fig. 2.2).
- Norms, institutions and concerns over legitimacy can also shape actors' cost-benefit analysis in the direction of cooperation.

Implications and recommendations for space deterrence and escalation

3.49. Implications for space operations include the following.[95]

3.50. *Firstly, possible debris or other damage to the space environment is unlikely to significantly weigh on adversary decision-makers, especially if muddied by debris-causing U.S. actions.*

3.51. *Secondly, however, this emphatically does not mean we cannot influence actors to show restraint and so help prevent a Tragedy as described immediately below.* Such activities will just be no panacaea.

[95] See also Weeden and Chow, "Taking a Common-Pool Resources Approach to Space Sustainability."

3.52. *Third, harness the power of reputation.* Actors to know that they have a reputation at stake if they abuse the common resource.

3.53. *Recommendations:* Reputation is in the eyes of others, thus:

- Increase the reputational costs of debris-causing space actions in key audiences by effective communication of attribution.
- Build key audiences' understanding that space can be meaningfully damaged. Build understanding amongst elites in allies, as well as in publics domestically and in allies.
- Do so ahead of time, as well as during crises

3.54. *Fourth, use threats to punish abuse of the common resource.*

3.55. *Recommendations:*

- Convey that causing space debris, without very good reason, is in itself punishable.[96] Such punishment would occur in other domains, e.g. through international diplomatic censure or punishment of commercial space activities. One might argue that if a power abused the common resource of space, then if given the chance how might they abuse a common resource like the South China Sea?

3.56. *Fifth, use norms, institutions and legitimacy:* The U.S. and its allies must build norms and institutions (formal and informal) ahead of time. This cannot be controlled, it requires influence to shape behavior.

3.57. *Recommendations:*

- Norms are impossible for the U.S. to impose on its own – building relevant extended influence with allies and third parties is *necessary*.
- Reduce the costs of cooperation from the audiences' perspective, e.g. provide low cost dispute resolution mechanisms.
- Increase the benefits of cooperation from the audiences' perspective e.g. via commercial incentives.
- Reduce the benefits of creating debris from the audiences' perspective, e.g. increase resilience and allied cooperation with some assets.
- Increase the cost of creating debris from the audiences' perspective, e.g. through international censure. In a conflict international support will often be key.

3.58. *Sixth, the U.S. is the biggest actor in space, so its actions will critically determine international norms and expectations.*

3.59. *Recommendation:*

- The U.S. must take an outside-in perspective and understand its actions and rhetoric (e.g. space "control") from the perspective of key audiences.

FRAGILITY AND OFFENSE-DOMINANCE – LIVING WITH OFFENSE-DOMINANCE

3.60. *Summary:* Space is an offense-dominant environment as defending assets in space is very hard. The currently low resilience of space missions exacerbates this challenge. Space operations can also be extremely rapid, so both the U.S. and adversaries' may perceive they must make decisions very rapidly – and rapid decisions under stress can be more inflexible and problematic. These features matter

[96] Weasel words perhaps, but recommendations must be plausible for great powers.

more because space is highly likely to feature in cross-domain escalation – and space may be the most offense-dominant or unstable domain, it may be the domain the leads to serious escalation overall.

Features of space

3.61. Two final key features of space operations common to all space powers are:

- They are *offense-dominant*.[97] Space assets are very hard to defend and may have low resilience.[98] In contrast, for instance a fundamental feature of the nuclear domain for half a century has been the reality of a secure second strike. It is not clear that a cyber first strike would preclude a meaningful retaliatory second strike. Publicly available information suggests that whoever strikes first in space has a meaningful advantage, because space assets (e.g. for space situational awareness; SSA) are themselves needed to successfully strike the adversary's space assets.
- Decisions about actions in space may also have to be taken very *rapidly*, in minutes or hours, when considering potential disabling enemy first strikes.

Cognitive foundations

3.62. Fears that the benefits of offense outweigh those of defense, particularly fears of disabling first strikes, can lead to escalating spirals of tension and war.[99] Such fears arise from the *perceived* balance between offense and defense, and the fundamentally cognitive dimension of these perceptions should be managed.

3.63. Furthermore, space operations may make decision-makers on all sides perceive they must make decisions very rapidly, which is one cause of stress. Stress affects human decision-making, although the exact nature of its effects requires further research. Indeed, contrary to popular opinion, judgment is not always compromised under stress but rather is different. Stress may reduce the amount of information individuals process, narrow the focus of their attention and lead to a simpler mode of information processing. This may help individuals focus on critical issues, but may lead to dangerously inflexible decision-making as crises evolve.

Implications and recommendations for space deterrence and escalation

3.64. *Firstly, attend to the perceived offense-defense balance.* Some space capabilities plausibly not offensive, for example due to dual use concerns,

3.65. *Recommendations:*

- *Increase perceived and actual resilience.* This should be a key medium term U.S. aim. Denying an adversary the advantages of first strike reduces their incentives to strike first. Resilience should also be demonstrated, for example by conducting conventional exercises without space support.

[97] Consideration offense-defense balance and differentiation is beyond the scope of this report. Although not dealing with space, key reading is listed in the bibliography.
[98] For insightful treatments of crisis stability in space see e.g. "Crisis Stability in Space: China and Other Challenges" (Johns Hopkins University, 2016). and Morgan, "Deterrence and First-Strike Stability in Space."
[99] Key work on spirals is referenced in Ch. 2.

- *Later on, manage the destabilising effects of increased perceived resilience.* Note that the stabilising effect of this increased space resilience may come with an unavoidable destabilising side-effect, whereby more resilient space assets can be attacked as part of signalling during a crisis or limited war. Moreover, at some future point the U.S. may need to consider restraining threats to the adversary's resilience, as was the case with Soviet nuclear forces in the late Cold War.[100]
- *Consider how offensive doctrine, rhetoric and posture will be perceived from the competitors' perspectives:* This matters during crises and also ahead of time. Remember that it isn't only what you do but also how you do it – try to buttress norms and restrain messaging to mitigate arms racing and crises, as failed during the Anglo-German Naval Rivalry in the decade before World War One.

3.66. *Second, manage effects of time pressure during crises:*

3.67. *Recommendations:*

- Consider introducing *deliberate and obvious pauses* to slow decision-making and help manage escalation in space.
- Increase information available to both sides' decision-makers during crises by increasing the *bandwidth of communication* (e.g. military-to-military, intelligence-to-intelligence and leader-to-leader).

3.68. *Third, manage effects of stress during crises.* The evidence does not provide a simple list, and although some recommendations may be seen as common sense it is notable that they are often not done.

3.69. *Recommendations:*

- Ahead of time employ *training and simulations* for top civilian as well as military decision-makers.
- Procedures should ensure alternative points of view are heard to avoid *group think.*
- *Enhance allied decision-making.* U.S. decision-makers may not appreciate the unfamiliarity of allies and key third parties with space operations – thus encourage allies to conduct their own simulations and also conduct joint simulations.
- Decision support systems and simulations should be tested under conditions of stress (time pressure is one option) to evaluate their effectiveness.

RECOMMENDATIONS

3.70. These are contained in each individual section.

[100] For a discussion of the need for U.S. awareness of the threats it posed to the resilience of Soviet nuclear forces in the late Cold War see Posen, *Indadvertent Escalation*.

Chapter 4: Cognition in space operations: Additional Sino-U.S. relevant factors

4.1. This chapter considers additional features of space operations particularly relevant to the U.S. and China, and examines their cognitive dimensions. I examine the following three factors:

Key factors for space	*Cognitive foundations*
Additional U.S. factors:	
Asymmetric space dependency	"Optimism bias" and pruning.
Extended influence (including deterrence)	Ally trust and confidence.
Additional China factors:	
More holistic view of space and space strategy	Cross-cultural cognitive science suggests Chinese view many concepts more holistically.

Table 4.1: Cognition in Space Deterrence and Escalation: Additional Country-relevant Factors

U.S.-RELEVANT FACTOR: ASYMMETRIC SPACE DEPENDENCY – IMPRUDENT PLANNING

4.2. *Summary*: The U.S. has an asymmetric space dependency, whereby U.S. capabilities rely on space more than others' do. The way the humans think ahead may limit the ways U.S. policy-makers think ahead about this challenge—for instance "pruning" of key potential outcomes beyond unpalatable intermediate outcomes, or the "optimism bias"—and I provide recommendations to mitigate these problems.

Features of space

4.3. U.S. conventional capabilities rely on space more than do those of potential adversaries. Thus, if a conventional conflict spreads to space the U.S. stands to lose more than the adversary.[101] Considering "all out" space warfighting, the U.S. cannot simply rely on mutually assured destruction of space assets to deter an adversary, because in such a scenario the adversary will lose considerably less than the U.S.. Considering slower escalation during space warfighting, "tit-for-tat" in space is not a viable strategy for the U.S. as the U.S. will run out of adversary space assets to target first. The asymmetric space dependency will likely continue for at least the near future for both Sino-U.S. (see also Ch. 6) and U.S.-Russia scenarios.

[101] For a discussion of this point see Stephen Biddle and Ivan Oelrich, "Future Warfare in the Western Pacific: Chinese Antiaccess/Area Denial, U.S. AirSea Battle, and Command of the Commons in East Asia," *International Security* 41, no. 1 (July 2016): 7–48, https://doi.org/10.1162/ISEC_a_00249.

4.4. Asymmetric dependency matters not only because it may incentivize U.S. adversaries to extend conflict into space, but also because key vulnerable U.S. space assets have entangled nuclear-conventional missions (e.g. SBIRs) – and this raises significant nuclear escalation risks.[102] Further, because U.S. decision-makers know of their asymmetric dependency, this heightens their fear of adversary first strikes in space, heightening crisis instability. Whether the U.S. is creating the redundancy for these space systems necessary to alleviate such risks is unclear at the unclassified level.

Cognitive foundations

4.5. What cognitive factors might affect U.S. planners or policymakers who are considering this challenge by thinking ahead through sequences of possible actions and reactions? The human brain contains neural circuits for thinking ahead, which perform computations similar to thinking forwards through a decision tree. Considerable evidence exists for this "goal-directed" neural system's impact on choice behavior, and its localization in brain regions such as orbitofrontal cortex (a region above the eyes)[103].

4.6. However, most planning problems faced by humans cannot be solved by evaluating all potential sequences of choices explicitly, because the number of possible sequences from which to choose grows exponentially with the sequence length. Thus, the goal-directed brain system works in very particular ways. It doesn't simply perform a merely "incomplete" job of modelling the world, it employs effective ways of thinking forward – albeit ones with side effects. Here I describe two aspects of the way the brain thinks ahead that may affect planning: "pruning" and "optimism".

Implications and recommendations for space deterrence and escalation

Pruning: "Bonsai trees in the mind and imprudent planning":

4.7. One way the brain makes thinking ahead more manageable is by "pruning" the decision tree. Pruning the decision tree means excising poor decision sub-trees from consideration, and spending limited cognitive resources evaluating the remaining options. Specifically, decision-makers prune those parts of a decision tree beyond large negative events, even when this ultimately results in choosing worse outcomes.[104] Humans tend to be averse to looking beyond a big negative event, even if that is required to win bigger rewards.

4.8. Pruning matters in the real world. It can be seen in historical cases. It figured in the disastrous British decision to occupy the Suez Canal in 1956: key decision-makers totally ignored what would happen if the U.S. did not back them as turned out to be

[102] Such risks are elaborated in James M. Acton, Escalation through Entanglement: c3i Vulnerability and Inadvertent Nuclear War, International Security (forthcoming)
[103] Nathaniel D Daw et al., "Model-Based Influences on Humans' Choices and Striatal Prediction Errors," *Neuron* 69, no. 6 (March 24, 2011): 1204–15. Add review paper.
[104] Quentin J. M. Huys et al., "Bonsai Trees in Your Head: How the Pavlovian System Sculpts Goal-Directed Choices by Pruning Decision Trees," *PLoS Comput Biol* 8, no. 3 (March 8, 2012): e1002410, https://doi.org/10.1371/journal.pcbi.1002410.

the case. More recently, in the 2003 U.S. invasion of Iraq key U.S. decision-makers totally failed to plan for what would happen if there was significant unrest. In both cases these were experienced decision-makers, supported by plenty of time and plenty of planning resources, but the decision-makers failed to look beyond a large negative outcome to plan for potential outcomes that were entirely foreseeable and were foreseen by many.

4.9. Why does pruning matter for near-term China-U.S. escalation scenarios involving space? For instance, in a Taiwan contingency if the PRC uses a direct ascent ASAT weapon whilst a U.S. carrier fleet is moving towards Taiwan in the western pacific – what does the U.S. do next? What are the likely potential outcomes following that point?

4.10. *Recommendations:*

- Integrated space, nuclear, conventional wargames and scenario planning are required, which include the very highest-level decision-makers.[105]
- Preparation at the highest level must ask: *"What happens on the day after?"*

Optimism: The "Optimism bias"

4.11. Humans tend to make optimistic assessments across many aspects of life, including of their own abilities, the risks they run with diseases, and their planning for projects,[106] Indeed, the UK Government introduced a correction for this "optimism bias" into their official Whitehall guidelines for project planning.[107] Optimistic assessments are suggested as a cause of war.[108] U.S. planners may be affected by this "optimism bias" and optimistically hope adversaries will not take advantage of U.S. vulnerability.

4.12. *Recommendations:* One useful finding is that people are much more realistic (i.e. less overly optimistic) when providing advice on exactly the same task for someone else.

- Thus, ask the question: *"If I were planning this for another state, how would my plans differ?"* Given the U.S.'s unique global position, planners may need to consider hypothetical worlds or what advice one would give to an ally.

U.S.-RELEVANT FACTOR: EXTENDED INFLUENCE – DETERRENCE, TRUST AND CONFIDENCE

[105] Note bureaucratic aspect to why this is pruned away as nuclear separate. China uses a tactical nuclear weapon to destroy a U.S. carrier fleet in the western pacific – what does the U.S. do next?. So need integrated nuclear and conventional wargames and planning including with the highest level decision-makers

[106] Tali Sharot, Christoph W. Korn, and Raymond J. Dolan, "How Unrealistic Optimism Is Maintained in the Face of Reality," *Nature Neuroscience* 14, no. 11 (2011): 1475–1479.

[107] HM Treasury, *The Green Book: Central Government Guidance on Appraisal and Evaluation*, 2018.https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

[108] Dominic DP Johnson and Dominic Tierney, "The Rubicon Theory of War: How the Path to Conflict Reaches the Point of No Return," *International Security* 36, no. 1 (2011): 7–40.

'it takes only five per cent credibility of American retaliation to deter the Russians, but ninety-five per cent credibility to reassure the Europeans."

- Denis Healey UK Defence Minister in the 1960s[109]

4.13. *Summary*: U.S. success in any likely escalation scenario—for instance with the PRC in the West Pacific or Russia in the Baltics—critically depends on U.S. influence over key allied perceptions. An example is extended deterrence. The central foundation of extended deterrence is that the ally *trusts* and has *confidence* in the U.S.. Trust is inherently psychological – something one values is at risk, in a situation where what happens to it depends on somebody else's decision. Policymakers must manage allies' trust., e.g. though increasing the bandwidth of communication and managing unpredictability.

Features of space

4.14. Allies will be central to U.S. success in likely escalation scenarios, for instance with the PRC in the West Pacific or Russia in the Baltics. Consider "extended deterrence"[110] involving space. Extended deterrence requires both assuring an ally that the U.S. will support them, and also deterring the ally's potential aggressors – a dual aim pithily captured in Denis Healey's famous formulation above. Thus, a central foundation of extended deterrence is the ally's trust or confidence in the U.S.. Further, extended deterrence is inherently harder than deterring attacks on the U.S. itself because, as it was put in Cold War terms, would the U.S. *really* trade Boston for Berlin?

4.15. Escalation management with allies also critically involves allied perceptions. Do the allies have sufficient confidence and trust in the U.S. to provide the relevant basing, diplomatic and other necessary support? For instance, how would U.S. space operations affect allied perceptions in a Baltic escalation scenario, where alliiance escalation management is central?

[109] Denis Healey, The time of my life (London: Michael Joseph, 1989), 243, quoted in David Yost, "Assurance and US Extended Deterrence in NATO," International Affairs, 85: 4 (2009), 768

[110] Freedman, *Deterrence*. pp. 34-6, 45, 118 Bruno Tertrais notes the fundamental psychological nature of extended deterrence [ref]. Very little appears to have been written on extended deterrence and space, with a notable exception being Dean Cheng, "Prospects for Extended Deterrence in Space and Cyber: The Case of the PRC" (The Heritage Foundation, January 21, 2016), https://www.heritage.org/defense/report/prospects-extended-deterrence-space-and-cyber-the-case-the-prc.

4.16. Trust and confidence is also particularly challenging with some types of space operations, which have a high degree of ambiguity. Where attribution is difficult to prove then allies' trust is even more important. The UK, for instance, relied on allied trust in attributing to Russia a recent "novichok" chemical weapons incident, despite Russian obfuscation.[111] Further, even if one can convince ally leaders and key military or intelligence figures, what about the allied public who will put pressure on the allied leadership (Fig. 4.1)?

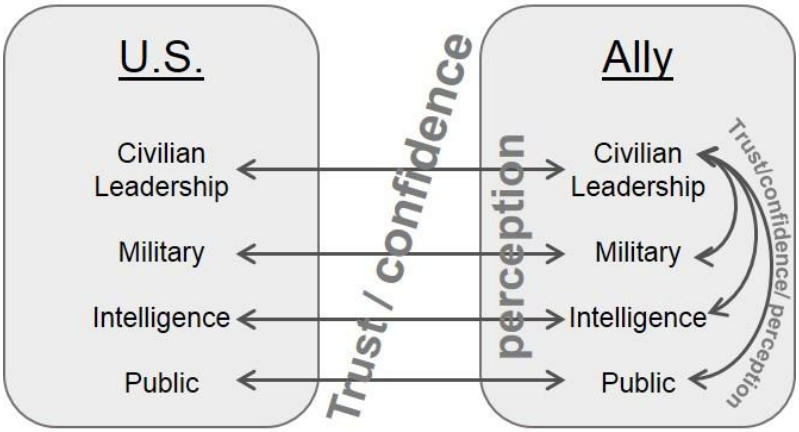

Figure 4.1: Bandwidth of trust between ally and U.S..Trust within the ally also matters.

Cognitive foundations

4.17. Trust is inherently psychological – something one values is at risk, in a situation where what happens to it depends on somebody else's decision. Considerable work has examined trust's cognitive bases and how to enhance trust[112], which I apply below.

Implications and recommendations for space deterrence and escalation

4.18. *Firstly, the concept of "extended influence" should be explicitly added to U.S. space doctrine and planning.* Extended influence encompasses, for example, extended deterrence and escalation management including allies, as well as offence and defence involving allies.

4.19. *Second, to build trust consider the bandwidth of trust-building: between elites, security apparatuses and populations (Fig. 4.1).* Trust between elites is not enough when publics' distrust each other, as shown in the flowering of Anglo-German antagonism 1898-1906 before World War One.[113]

4.20. *Third, manage predictability in U.S. actions to help manage trust and confidence.* Unpredictable behaviour tends to decrease confidence and trust.

4.21. *Recommendations:* Thus, help reduce prediction error (i.e. unexpectedness of one's actions) in the ally from space operations:

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[111] Ryan Henrici, "Syria and Salisbury: The Continuing Battle to Maintain Trust in Evidence of Illegal Use of Chemical Weapons," RUSI, April 16, 2018, https://rusi.org/commentary/syria-and-salisbury-continuing-battle-maintain-trust-evidence-illegal-use-chemical.
[112] Wright, "From Control to Influence."
[113] Paul M. Kennedy, *The Rise of Anglo-German Antagonism 1860-1914* (Amherst, N.Y.: Prometheus Books, 1980).

- When the U.S. makes actions in space, warn allies beforehand, preferably in a meaningful way. Trust within countries will be critical, and hence warnings will not leave allied publics losing confidence in their own decision-makers.
- Unpredictability may contribute to deterrence of the adversary, but will likely decrease confidence of allies. An example is current U.S.-Japan relations, where they are still very strong at many levels (e.g. military-military) but unpredictability at the very highest U.S. levels decreases trust.

4.22. *Fourth, encourage change within the allies so that U.S. space operations are less unexpected to them.* Allies ability to predict U.S. actions is partly a function of their much reduced space capabilities, so they may not fully understand U.S. thinking. Further, even if allied military space experts understand U.S. thinking then other key actors within the ally will likely not.

4.23. *Recommendations:*

- *Training and doctrine within key allies* needs to enable them to understand U.S. space operations, even though the allies will not be capable of conducting them (space will be part of cross-domain influence). The UK has moved down this path with the military (Box. 4.1).
- The U.S. should encourage allies such as Japan and the UK to hold simulations involving space operations involving their own top leadership and stakeholders.
- The U.S.. should encourage such allies to engage more with their publics on space.

4.24. *Fifth, liking and similarity help increase trust.*

4.25. *Recommendation:*

- U.S. soft power is important. U.S. public diplomacy is important.

4.26. *Sixth, manage expectations because trust-building can backfire if it leads to overly optimistic expectations, which cause a backlash when they are violated.* Regarding Grey Zone space activities, for example, will the U.S help counter non-kinetic PRC activities against Japanese satellites?

Box 4.1: Allied perceptions: UK space

The UK will be a crucial U.S. ally in any likely European escalation scenario. The UK has a sophisticated and rapidly growing commercial space base. The UK's military space capabilities and policies are also currently evolving.

UK military space capabilities: The UK possesses the Skynet military communication constellation of seven satellites in GEO. The UK MoD has indicated that the next generation of these satellites will be developed inhouse rather than being operated by private contactors, illustrating their increased interest and seriousness about space. With respect to PNT, UK-based companies were critical to the European Galileo project, although given Brexit the UK is now considering building its own PNT network for military use perhaps in collaboration with Australia and Japan. The UK MoD invested in a recently launched commercial live full-motion colour video capture capability, the Carbonite-2. The UK has numerous overseas territories and partners for groundstations.

UK counterspace capabilities are highly classified, but likely include only non-kinetic options that are UK strengths more generally, including electronic warfare and offensive cyber.

Close collaboration with the U.S. is illustrated by the Five Eyes network. RAF Fylingdales forms part of the U.S. space defense network, and may have capabilities as a space tracking station. The RAF space operations centre at RAF High Wycombe brings space data brought back into UK.[114] The UK has participated for a number of years in the Schriever space war game series.

UK space policy: The UK updated its space doctrine in Dec 2017, which is now broadly in line with U.S. doctrine, including such concepts as space control. The UK has now published its first UK National Space Security Policy and National Space Strategy. The UK Space Agency was formed in 2010. However, whilst policy and doctrine have evolved, there has been no obvious change in the level of personnel.

Significantly, there is considerable opacity about how the UK views space operations by the U.S. or potential adversaries during escalation scenarios. Little information is released on how the UK would consider reversible Grey Zone activities in space.

Commercial sector: The UK has a robust commercial space community as a talent pool on which to draw. The sector has registered growth of some 8-9% per year for past 15 years and comprises about 6% of the world's space industries. It has strength in small satellites. The UK also headquarters international actors such as Inmarsat.

References: See list in bibliography, in particular recent papers by Bleddyn Bowen.

CHINA-RELEVANT FACTOR: MORE CONTEXT-DEPENDENT VIEWS OF SPACE AND SPACE STRATEGY

4.27. *Summary*: PRC thinking considers space (e.g. space, terrestrial and information components) and strategy in space (e.g. deterrence, defense and offense) in a more holistic and context-dependent way than predominates in the U.S. strategic community. Greater Chinese context-dependence in strategic thinking reflects robust differences identified in cross-cultural cognitive science. Take cross-cultural differences in worldview seriously

Features of space

4.28. Space operations must be considered in terms of a number of potentially distinct components, such as assets in space, information flowing through space or links to other related domains (e.g. cyber). In addition, strategy in space may be understood as comprised of more separable components (e.g. deterrence, defense and offense) or in a more holistic and context-dependent.

Cognitive foundations

4.29. Westerners *tend to engage in more <u>context-independent</u> cognitive processes by focusing on a salient object independently of its context, whereas East Asians tend to engage in more <u>context-dependent</u> or holistic cognitive processes by attending to the relationship between the object and the context in which it is located.*[115] This is also

[114] https://www.gov.uk/government/news/lift-off-satellite-launched-into-space-on-raf-mission

[115] Richard E. Nisbett and Yuri Miyamoto, "The Influence of Culture: Holistic versus Analytic Perception," *Trends in Cognitive Sciences* 9, no. 10 (2005): 467–473.

referred to as holistic versus analytic or field-dependent versus field-independent cognition. Context is the setting or background of events or objects within which the focal object is located.

4.30. Greater East Asian context-dependence is seen across diverse cognitive domains, such as perception, attention, memory and action.[116] For instance, in a perceptual task participants view a rod in the context of a surrounding frame and must judge when the rod is vertical – when the frame is tilted, that context more greatly influences Chinese than Western perceptions. Another example tested memory for videos, with East Asians more likely to remember contextual background and the relationships between objects, and furthermore later on East Asians' (but not Americans') accuracy at recalling objects was affected by providing context. Other work showed related effects in, for instance, cross-cultural differences in newspaper coverage of crime.[117]

Implications and recommendations for space deterrence and escalation

Chinese strategic thinking on offense, defense and deterrence.

4.31. This empirical finding from cross-cultural psychology cognition provides specific hypotheses for differences in U.S. and Chinese thinking on a key dimension of doctrine[118]: namely deterrence, defense and offense. Broadly, in Chinese accounts, perceptions of events and actions will be more dependent on their deterrent, defensive or offensive context, and such categories will themselves be understood more holistically together.

4.32. *Implication 1. Chinese accounts of deterrence are more context-dependent, whereby events and actions are viewed more within the context of surrounding events and actions than in U.S. accounts.* This provides a new perspective for how strategic culture may affect deterrence. It parsimoniously explains cultural differences across three core features of deterrence.

4.33. Firstly, it sheds new light on the potential for different Chinese and U.S. perceptions about the intention and meaning of first strikes or preemptive actions. In more context-dependent Chinese accounts, even preemptive actions may be perceived as part of deterrence against an adversary when seen in the context of deterrence operations against that adversary. This may cause significant misperception: a preemptive act understood from within a context-dependent perspective as being heavily influenced by its context to comprise part of a deterrent strategy, would instead be perceived very differently by a context-independent culture that views the act shorn of context.

4.34. Secondly, while a more context-independent U.S. view of coersive episodes renders a meaningful distinction[119] between deterrence (that aims to dissuade an adversary

[116] Richard Nisbett, *The Geography of Thought: How Asians and Westerners Think Differently...and Why*, 1St Edition edition (New York: Free Press, 2003).
[117] Although outside the scope of this systematic review, four studies comparing newspaper coverage were found. See e.g. Ibid.
[118] Posen, The Sources of Military Doctrine.
[119] Thomas Crombie Schelling, *Arms and Influence* (Yale University Press, 1966).

from acting) and compellence (that aims to coerce them to act), in contrast a more context-dependent Chinese view would find little meaningful distinction. In the context of repeated interactions, what constitutes a status quo from which to judge each actor's actions as compellent or deterrent? For example in the 1950s the U.S. issued what they understood to be deterrent threats to the Chinese over Taiwan, but in the context of ongoing Chinese activities and claims towards unification these may be considered compellent.[120] This cultural difference may cause misperception. When making actions, the Chinese 'deterrent' toolkit will include the more 'compellent' tools (e.g. more forceful naval and paramilitary activities in the South China and East China seas, or blockade in a Taiwan contingency) that to U.S. observers would fall outside their narrower understanding of deterrence. U.S. deterrent threats framed in U.S. terms as a deterrent action may instead be more readily perceived from within the broader Chinese concept as little different to more offensive compellent activities, particularly when coupled with worst case interpretations of others' actions.

4.35. Thirdly, a more context-dependent and holistic Chinese worldview also makes new predictions for cultural differences in the relationship between deterrence and warfighting. Whilst during the Cold War considerable thought was given to the relative balance of warfighting and deterrent components of Soviet policy[121], instead here the hypothesis from cross-cultural psychology is that Chinese accounts view deterrence and warfighting together more holistically than U.S. accounts. It is not just that planning or thinking about strategy in general may involve warfighting and deterrence, it is that in more holistic Chinese accounts they are more intimately connected and can be understood only by reference to the whole strategy of which they are both a part. Chinese accounts, which conceive of warfighting in the context of deterrence and deterrence in the context of warfighting, may be interpreted with alarm in the West as a predilection for warfighting as opposed to deterrence.

4.36. *Implication 2. Chinese views of offense and defense are more context-dependent.*

4.37. The concepts of offense (that aims to disarm an adversary) and defense (that aims to deny them their objective) are core military concepts. Previous work examined offensive doctrines and defensive doctrines, which revealed for example how the former may lead to war[122], or how institutional or balance of power factors affect adoption of offensive or defensive doctrines.[123] Instead, here the cross-cultural microfoundations suggest two new aspects to examine. Firstly, with respect to the degree that representations of offense and defense differ, more context-dependent Chinese accounts will view them as more intimately connected parts of a whole and understood only with reference to the whole. If offense and defense are in themselves less distinct, this is significant for Western debates about how far offensive and defensive capabilities may be distinguished.[124] Secondly, in more context-dependent Chinese accounts, perceptions of actions as offensive or defensive will be more strongly influenced by the context of offense or defense with

[120] Richard Ned Lebow and Janice Gross Stein, "Deterrence: The Elusive Dependent Variable," *World Politics* 42, no. 3 (1990): 336–69. p. 354
[121] Lawrence Freedman, *The Evolution of Nuclear Strategy*, 3rd edition (Palgrave Macmillan, 2003). pp. 254-7
[122] Stephen Van Evera, "Offense, Defense, and the Causes of War," *International Security* 22, no. 4 (1998): 5–43.
[123] Posen, The Sources of Military Doctrine.
[124] Michael E. Brown et al., *Offense, Defense and War* (Cambridge, Mass: MIT Press, 2004).

that adversary in which they occur. If major Chinese operations, even extending to the 1962 action against Indian forces or 1979 incursion into Vietnam, may be rendered defensive by occurring within a context of defense, this may be perceived very differently by the U.S..

4.38. Such Chinese thinking on the concepts of offense and defense is illustrated by a key principle of Chinese doctrine: 'active defense', whose essence is the holistic integration of offense and defense.

More holistic view in general

4.39. In fact, high context-dependence appears to be pervasive in Chinese strategic thought, in keeping with its reflecting a general principle that parsimoniously simplifies and unifies across multiple phenomena. I outline further broad examples below.

4.40. Firstly, as one Central Military Commission officer described to the author[125] deterrence, offense and defense are together seen holistically, as intimately interconnected and understood as part of a whole. Context-dependence as a general principle is also seen more broadly at the level of guidance for commanders in the Science of Second Artillery Campaigns:[126]

> 'When carrying out campaign guiding ideologies, commanders should grasp the following few questions. First question is correctly handling the Relationship between Deterrence and Actual Warfare. Deterrence and actual warfare are interconnected, coexistent, similarly conditioned and closely integrated organic wholes. … Second question is correctly handling the relationship between the initiative and passivity. Our military's strategic concept of active defense is clear. … Third question is correctly handling the relationship between the overall situation and the local situation. … That which is "local" is part of the "overall." … Fourth question is correctly handling the relationship between strong and weak. Strong and weak are united by contradiction. Within strength there is weakness, and within weakness there is strength.'

4.41. Secondly, Chinese writing also stresses looking to the broader context of the 'overall situation' (*Da Ju*) to which actions or narrower interests subordinate. This has been identified across ancient Chinese, Mao Zedong's and modern PLA thinking[127], as well as that in contemporary crisis management.[128]

4.42. A third example is seen at the broadest strategic level. As the prominent Chinese scholar Li Bin notes, Chinese understanding of the threats actors face in international system relates more to general contexts than specific agents.[129]

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[125] Beijing, June 2017

[126] Second Artillery, Science of Second Artillery Campaigns. pp. 126-7

[127] Ron Christman, "How Beijing Evaluates Military Campaigns: An Initial Assessment", in The Lessons of History: The Chinese People's Liberation Army at 75, ed. Laurie Burkitt, Andrew Scobell, and Larry M. Wortzel (Pa.: Strategic Studies Institute, 2003).

[128] Alastair Iain Johnston, "The Evolution of Interstate Security Crisis-Management Theory and Practice in China," *Naval War College Review* 69, no. 1 (2016): 28.p. 46

[129] Li Bin, "China and Global Nuclear Arms Control and Disarmament" in The War That Must Never Be Fought: Dilemmas of Nuclear Deterrence, ed. George P. Shultz and James E. Goodby pp. 357-8. See also pp. 364-5

> ‘The core concept in the American security paradigm is “national security threat.” … usually defined as a rival who has the capability and intention to hurt the United States. … In China, there is an indigenous security paradigm in which “national security challenge” is a core concept. Unlike “national security threat” in the American paradigm, a “national security challenge” in the Chinese paradigm is a situation in which China is vulnerable. … For example, it is a belief in China that lagging behind technologically leaves China vulnerable to attacks. “Lagging behind” is a situation … The Chinese security paradigm is sometimes called a “comprehensive security concept” or “comprehensive security theory.’

4.43. One can also note ‘integrated deterrence’ in Chinese strategic thinking, in which one must consider together multiple military and non-military levers to affect an adversary’s decision-making.[130] Other examples include Chinese approaches to ‘information warfare’ and cyber security that critically view such topics more within their wider context than in the Western security community.[131] This is not to state that all Chinese thinking or thinkers are more context-dependent than in the U.S., but rather this provides a useful perspective to parsimoniously capture diverse and significant aspects of the Chinese strategic worldview or ‘cultural thoughtway’.

4.44. But, so what: even if cross-cultural differences exist, does that matter much for policy? Consider the challenge of managing inadvertent escalation in near-term Sino-U.S. contingencies. Pathways for inadvertent escalation during confrontations involve series of steps perceived to reflect increased intensity or scope of actions, which are inherently subjective for both sides.[132] This paper details specific ways these steps will be understood as more discrete in context-independent U.S. accounts but more integrated in context-dependent Chinese accounts, where the differing perceptions can lead to inadvertent escalation.[133] Firstly, U.S. deterrent threats, framed in U.S. terms as a deterrent action, may instead be more readily perceived as little different to more offensive compellent activities from within the broader Chinese concept in which compellence and deterrence do not meaningfully differ. In turn, when making actions, the Chinese ‘deterrent’ toolkit will include the more ‘compellent’ tools (e.g. more forceful naval and paramilitary activities in the South China and East China seas, or blockade in a Taiwan contingency) that to U.S. observers would fall outside their narrower understanding of deterrence. Second, one can consider Chinese thinking where acts—even striking first or preemptive actions—occurring in the context of a deterrent strategy can be rendered part of deterrence. Chinese acts such as firing shots at ships during a blockade, or even a missile attack, may be anticipated as less escalatory than will be perceived from a U.S. perspective viewing the act shorn of context. Third, a Chinese perspective in which deterrence and warfighting are ‘dialectically unified’ may view U.S. deterrent actions as more warfighting-related. Fourth, Chinese may sincerely percieve that offense within a context of defense renders even major actions defensive, but if others do not

[130] Michael S. Chase and Arthur Chan, *China’s Evolving Approach to “Integrated Strategic Deterrence”* (Rand Corporation, 2016).
[131] Keir Giles and William Hagestad, “Divided by a Common Language: Cyber Definitions in Chinese, Russian and English,” in *Cyber Conflict (CyCon), 2013 5th International Conference On* (IEEE, 2013), 1–17.
[132] Forrest E. Morgan et al., “Dangerous Thresholds” (Rand, 2008).
[133] Other applications include ‘tailoring’ deterrence.

perceive such context then others will respond to their own perception rather than what was intended.

Recommendation

4.45. Policymakers are often beseeched to put themselves in others' shoes, but practically doing this requires specific questions. Taken together, a context dependent-independent framework provides analysts with specific questions to help put themselves in the others' shoes, in order to anticipate effects of potential actions on others and to interpret actions. To militate against their cultural prisms, U.S. analysis can specifically ask *'what is the broader context of this action'*; and Chinese analysts can ask *'how would an action look if shorn of context'*?

RECOMMENDATIONS

4.46. These are contained in each individual section.

PART II SPACE IN GREY ZONE CONFLICT

Chapter 5: Space in Grey Zone Conflict

5.1. Key points from this chapter include:

- Space is an ideal forum for Grey Zone conflict, which is more than normal competition and less than war.
- Russia and China are using Grey Zone actions in space, e.g. in Crimea.
- Strategy in the Grey Zone requires different emphases than either peace or war. Grey Zone conflict in space is necessarily limited conflict, and thus the central aim is to influence the decision-making of adversaries and other key audiences – success requires policymakers understand and wield influence in space.
- Technology changes, but the humans on the receiving end of influence remain human. The aim is to influence human psychology, so cognitive factors provide a solid bedrock for anticipating space effects.
- New technologies provide opportunities for potential adversaries to pursue highly asymmetric strategies.
- 'Five multiples' characterise Grey Zone conflict: multiple levels, timescales, domains, interpretations and audiences. The U.S. should develop the capabilities and policies to conduct space operations in Grey Zone conflicts, centred around operational requirements arising from the five multiples of the Grey Zone.

5.2. This chapter first looks notes the centrality of influence in the Grey Zone, puts the current Grey Zone epoch in historical context and describes current Grey Zone space operations by Russia and China. I then explore space operations in the Grey Zone using the five multiples.

THE CENTRALITY OF INFLUENCE IN THE GREY ZONE

5.3. Grey Zone conflict is necessarily *limited* conflict, sitting between "normal" competition between states and what is traditionally thought of as war. Thus, the central aim is to *influence* the decision-making of adversaries and other key audiences, rather than removing their capacity to choose using brute force in itself. Success requires moving the emphasis from control to influence.

5.4. What, if anything, differentiates the Grey Zone from other types of conflict? The fundamental nature of conflict is unchanged, but the Grey Zone requires different *emphases*. I summarise these key challenges as the ***"Five Multiples"*** of the Grey Zone (Box 5.1) and discuss each in turn below.

Figure 5.1: Peace, the Grey Zone and War

Box 5.1: What is the Grey Zone? The Five Multiples of the Grey Zone

***(1) Multiple levels*:** The U.S. must successfully influence multiple societal levels, namely at the *state level* (e.g. adversarial, allied or neutral states); at the *population level* (e.g. mass communication within states and communities). State and population levels may, for example, view space activities differently as legitimate reasons for war (see also Ch. 3).

***(2) Multiple instruments of power*:** Multiple classes of instruments—e.g. military, information, economic and cyber—cut across these multiple societal levels. Systems such as GPS or Beidou, for example, can be sources of economic influence.

***(3) Multiple timeframes*:** One must consider multiple separate timeframes, e.g. managing an ongoing process evolving over years; and managing short-term crises in light of that ongoing process. Persistent adversary subthreshold actions in space, for instance, can over time cumulatively present a serious threat. On longer timescales one must manage norms, arms races and extended influence.

(4) Multiple audiences: Ally and third party perceptions are critical in the Grey Zone – and U.S. actions will inevitably reach multiple audiences. For instance, if it lost allied support in the South China Sea, the U.S could suffer deterrence by ally denial. See also the discussion of extended influence in Ch. 4.

(5) Multiple interpretations: Ambiguity is a key feature of the Grey Zone and of space operations more broadly. Ambiguity's essence is that events or actions are open to multiple interpretations (see also Ch. 3).

THE LATEST HISTORICAL EPISODE OF GREY ZONE CONFLICT

5.5. We are not entering a "new Cold War", we are merely entering the latest epoch of Grey Zone conflict between great powers[134] of which many have occurred historically. Consider just the twentieth century.

- *The decade before the First World War (1904-1914)* saw repeated crises between the great powers and alliance construction, as well as competition

[134] Grey Zone competition between great powers characterizes overarching historical epochs, but clearly such conflict may also occur between regional powers such as Saudi Arabia versus Iran. The DPRK, for instance, conducted Grey Zone competition during the Cold War and that continued during the unipolar post-Cold War U.S. moment.

for influence using multiple instruments of power and over multiple timescales (e.g. within crises and over longer periods[135]).

- *The interwar period.* EH Carr's classic work on the Grey Zone competition between the two world wars—*The 20 Years Crisis 1919-1939*[136]—describes how power contains multiple elements. *'Power is always an essential element of politics.'* He describes three sources of power in international politics: *'(a) Military Power (b) Economic Power (c) Power over Opinion'.* Nazi Germany used subversion, stoked ethnic tensions in neighbouring states and fait accomplis[137]. Ambiguity was key for the German military build-up before and after Hitler gained power.[138] The USSR, Germany and other great powers engaged in proxy conflict during the brutal Spanish Civil War.[139]
- *The Cold War*, as the name itself attests, was more than peaceful competition but was not a hot war between the West and the USSR. Space featured in this Grey Zone conflict, but was limited by nuclear fears.
- *Now:* During its unipolar moment after 1990 the U.S. faced no great power rivals. This gradually changed in the early 2000s with a resurgent Russia under Vladimir Putin and a rising China. Whilst choosing a precise tipping point is somewhat arbitrary, 2014 provides a natural juncture. Regarding Russia, 2014 saw Russia seize part of Ukraine, a country of some 50 million people for whom the U.S. had not long before been arguing for NATO membership.[140] Regarding China, Deng Xioping's reported dictum that China should "hide its light and bide its time" appeared to guide foreign policy from the 1980s. However, after Xi Jinping assumed power in 2012 China began to turn towards authoritarianism at home and a more assertive foreign policy abroad.[141] Intensity of competition has increased in specific military flashpoints, notably in the East China sea with Japan[142] and the China South China Sea with numerous actors. This new foreign policy trajectory became increasingly apparent to outside observers between coming to office 2012 and Xi's 2017 speech confirming China's new course [143] – precisely when to draw a line is difficult but 2014 provides a nice midway point in this period.

5.6. This latest epoch of earthly Grey Zone conflict has extended into space. As Chapter 1 discusses, it has done so in ways unlike the last Grey Zone epoch (the Cold War) or the intervening Unipolar U.S. moment. Both Russia and China have extensive reversible capabilities for engaging in Grey Zone conflict with the U.S., but that does

[135] Arthur A. Stein, *Respites or Resolutions? Recurring crises and the origins of war.* In Richard N. Rosecrance and Steven E. Miller, *The Next Great War?: The Roots of World War I and the Risk of U.S.-China Conflict*, 1 edition (Cambridge, MA: MIT Press, 2015).
[136] EH Carr the 20 years crisis 1919-1939. p. 97
[137] Michael I. Handel, *The Diplomacy of Surprise, Hitler, Nixon, Sadat* (Center for International Affairs, Harvard University, 1981).
[138] Martin Gilbert, *History of the Twentieth Century / Martin Gilbert.* (London: HarperCollins, 2001).
[139] Smoke, *War*.
[140] https://www.nytimes.com/2008/11/30/world/europe/30iht-nato.4.18268641.html
[141] Elizabeth C. Economy, *The Third Revolution: Xi Jingping and the New Chinese State* (Oxford, New York: Oxford University Press, 2018).
[142] Nicholas D Wright and James L. Schoff, "China and Japan's Real Problem: Enter the Fairness Dilemma," *The National Interest*, November 2, 2014.
[143] https://www.washingtonpost.com/news/monkey-cage/wp/2017/10/25/xi-jinping-just-made-it-clear-where-chinas-foreign-policy-is-headed/?utm_term=.fbed0092201d

not mean they intend to do so. Next I describe Russian and Chinese actions—all described in open source reports—that illustrate the transition to the Grey Zone in space over the past decade.

CONTEMPORARY GREY ZONE ACTIONS IN SPACE– RUSSIA AND CHINA

5.7. Both the Russians and Chinese have conducted space operations that mirror the transition to Grey Zone conflict on earth. One would anticipate further such actions, likely with greater frequency or intensity, during escalation scenarios. Chinese technical work describes, for instance, plans to jam GPS signals used by U.S. drones, such as the RQ-4 Global Hawk, over the Spratly Islands and South China Sea.[144]: Moreover, it may be possible to construe anti-satellite and some ballistic missile defense tests as signals, such as the 2007 Chinese direct assent-ASAT test, although I do not include them in the lists below.

5.8. Below I note examples of Russian and Chinese actions, based on open source information, that illustrate the transition to Grey Zone space operations.[145]

Russian actions

5.9. *Since 2007 cyber actions[146]:* Satellite data used by governments, militaries, and embassies globally has been stolen by a Russian-speaking hacker group with likely Russian government links. The group is believed to use malware called Turla, and attacks unencrypted data links on older communications satellites.

5.10. *2014 electronic warfare actions[147]:*, Russia jammed GPS signals in Ukraine during the Crimean conflict. This grounded some remotely piloted aircraft, and caused GPS loss for radios and phones. Independent Ukrainian analysts report that from 2014 to 2017 Russia used six different jamming and radio monitoring platforms in Ukraine, including the R-330Zh jammer and the R-381T2 ultra-high frequency radio monitoring system.

5.11. *2015 electronic warfare actions*[148]: The Krasukha-4 truck-mounted jamming system was shown deployed to Syria in a video leaked in 2015. Russia also reportedly supplied R-330P jammers to the Assad regime.

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[144] Bill Gertz, "Inside the Ring: China targets Global Hawk drone," The Washington Times, December 11, 2013.

[145] In particular these lists draw on the excellent recent report on counter-space activities by Harrison, Johnson, and Roberts, "Space Threat Assessment 2018."

[146] Ellen Nakashima, "Russian hacker group exploits satellites to steal data, hide tracks," The Washington Post, September 9, 2015;"Turla: Spying tool targets governments and diplomats," Symantec Security Response, August 7, 2014,

[147] Sergey Sukhankin, "Russian Electronic Warfare in Ukraine: Between Real and Imaginable," RealClearDefense, May 26, 2017; "It is official, Russian army deployed R-330Zh jammer in the battle of Debaltseve," InformNapalm.org (English), May 14, 2016; "Russian R-330Zh jammer detected 7 m from the contact line in Donbas," InformNapalm.org (English), November 16, 2017.

[148] Elias Groll, "Spy Planes, Signal Jammers, and Putin's High-Tech War in Syria," Foreign Policy, October 06, 2015; David Stupples, "How Syria is becoming a test bed for space threat assessment 2018 3 2 high-tech weapons of electronic warfare," The Conversation, October 8, 2015

5.12. *2017 electronic warfare actions*[149]*:* GPS spoofing was likely used to provide grossly incorrect location data that affected 20 ships affected in the Black Sea.

5.13. In addition to these cases, from 2013-2017 Russia conducted a number of rendezvous and proximity operations (RPO) that may be consistent with a co-orbital anti-satellite programme.[150] Russia has also tested a dual-use missile defense system that can also DA-ASAT capability to strike LEO satellites.

Chinese actions

5.14. *2006 laser*[151]*:* Reports appear that lasers had illuminated U.S. imagery satellites over China.

5.15. *October 2007 and July 2008 cyber actions*[152]*:* Cyberattacks believed to originate in China targeted the U.S. Geological Survey remote sensing satellite, Landsat-7. These interfered with ground station communications.

5.16. *June and October 2008 cyber action:* Hackers believed to be from China attacked NASA's Terra Earth observation satellite. The hackers "achieved all steps required to command the satellite but did not issue commands."

5.17. *September 2014 cyber action:* Chinese hackers attacked the National Oceanographic and Atmospheric Administration's (NOAA) satellite information and weather systems.[153] Used by the U.S. military and other agencies, the attack forced the NOAA to take down the system and stop transmitting satellite images to the National weather service for two days.

5.18. Finally, one can note potential for Chinese export of counter-space technologies. In 2015, for instance, Chinese researchers presented a guide to build GPS spoofing devices and sold kits for about $300 at the Las Vegas DefCon hacking convention.[154]

MULTIPLE TIMEFRAMES

'There are no endings. If you think so you are deceived as to their nature. They are all beginnings. Here is one.' *- Hilary Mantel*

"You have to produce results in the short term. But you also have to produce results in the long term. And the long term is not simply the adding up of short terms." *- Peter Drucker*

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[149] https://www.newscientist.com/article/2143499-ships-fooled-in-gps-spoofing-attack-suggest-russian-cyberweapon/

[150] Weeden and Samson, "Global Counterspace Capabilities: An Open Source Assessment." p. 2-10

[151] Vago Muradian, "China Tried to Blind U.S. Sats with Laser," Defense News, September 25, 2006; Francis Harris, "Beijing secretly fires lasers to disable US satellites," The Telegraph, September 26, 2006.

[152] David D. Chen, "Opening Statement of Mr. David Chen," Testimony before the U.S.-China Economic and Security Review Commission, February23, 2017.

[153] U.S.-China Economic and Security Review Commission, "2015 Report to Congress of the U.S.-China Economic and Security Review Commission," 296. Mary Pat Flaherty, Jason Samenow and Lisa Rein, "Chinese hack U.S. weather systems, satellite network," The Washington Post, November 12, 2014.

[154] Huang Lin and Yang Qing, "GPS Spoofing: Low-cost GPS Simulator" (Presentation, 23rd Annual DefCon, Las Vegas, NV, August 6-9, 2015).

5.19. One must consider at least three separate timeframes – and U.S. success depends on success at all three. First, managing short-term crises in light of an ongoing process. Second, managing an ongoing process evolving over years. Third, managing cumulative sequences of actions over an intermediate timescale of weeks or months.

Crisis management and recurrent crises in light of an ongoing process

5.20. Crisis management in terms of deterrence and escalation is covered in Part I, but an equally important part of escalation management is understanding what a crisis means after it is over.[155] Consider the series of crises in the decade before the start of the First World War. Each of the numerous series of crises was managed so it did not escalate to war. But the longer-term effect of each crisis was to escalate the Grey Zone conflict between the powers, crystallise alliances, increase arms racing and make each crisis more dangerous such that eventually a crisis did lead to war. We are not in currently at that heightened degree of tension, but if we must deal with recurrent crises then the use of space operations—and responses to space operations—must be viewed not only in light of success in that one crisis but how affects longer-term space norms and the international system in space.

Cumulative sequences of actions over time

5.21. Another crucial Grey Zone timeframe relates to cumulative sequences of actions over time, occurring over weeks, months or perhaps longer. No single example of the action may reach a threshold above "normal" competition between states, but cumulatively they push the activity over the threshold into the Grey Zone (Fig. 5.1).

5.22. *Firstly, persistent adversary subthreshold actions can over time cumulatively present a serious threat.* An example in cyber is the Advanced Persistent Threat (Box 5.2), where each individual action may not be greater than an act of espionage consistent with normal competition – but taken together they pose a significant threat. In space, persistent use of non-kinetic actions against U.S. assets over time, whilst each may not constitute an event serious enough to require a robust response, may form a sequence that requires a robust response – even though such a response may be perceived as disproportionate in response to the single adversary action.

5.23. *Recommendation:*

- Ahead of time communicate that persistent threats will be seen as a cumulative threat and be responded to as such.
- Discuss strategies to counter such threats with allies, e.g. Japan.

5.24. *Secondly, "salami slicing" is a famous cumulative tactic, whereby an adversary aims to achieve a goal through multiple small slices none of which is sufficiently large to provoke a response.* A contemporary case is the PRC's extension of influence in the South China Sea, for example through gradual island building and militarization. In space this may manifest as the gradually increasing use and deployment of counterspace capabilities, no single step of which would provoke a response.

[155] Rosecrance and Miller, *The Next Great War?*

5.25. *Third, humans typically overweight small probabilities, so that there is a big difference between "certain" and "quite certain".* Use of reversible counter-space operations during crises may lead the receiver to downgrade their estimate of the satellite's reliability more than intended by the sender – and thus being more escalatory than anticipated. A recent space tabletop exercise reported such effects.[156]

Box 5.2: Advanced Persistent Threat in cyber

An advanced persistent threat (APT) is a highly covert long-term a set of continuous computer hacking processes targeting a specific entity. APTs are used to target either private organizations, states or both for economic or political motives. Sophisticated and severely complicated malware, such as Stuxnet, DUQU, and Red October have all successfully evaded detection for a significant period of time, in some cases for several years.[157] APTs tend to require significant technical and financial resources which indicates that attackers are generally well organised and likely to be working under a state umbrella.[158] APTs are used to pursue a variety of aims. Whilst Stuxnet's primary aim was sabotage, DUQU's and Red October's objective was espionage[159]. Red October was discovered in 2012, but is believed to have been active since 2007, targeting diplomatic, governmental and scientific institutions by disseminating malicious MS Word and Excel documents which exploited known vulnerabilities[160]. Each institution was targeted with tailor-made malware and email messages designed to increase the probability of the file being opened by the victim.[161]

Managing an ongoing process over years

5.26. International systems go through years of Grey Zone conflicts or even decades: the Cold War lasted some four decades and as its name suggests was less than war but more than peace. I note three areas on this timescale particularly relevant to space.

Norms and norm change – the neural phenomenon of "prediction error"

5.27. Managing change is key to the international system more broadly and in space. Change will always occur, for example through technological or economic drivers. Failure to manage change can lead to war. Norms are the "rules of the road" in the international system and are key to its day-to-day functioning. Space currently still has some aspect of a strategic "sanctuary", which in part stemmed from the tight Cold War linkage of the space and nuclear missions. Managing potential changes in norms is critical in the Grey Zone, and indeed rejecting current Western-based norms is a key aim of both Russian and PRC Grey Zone activities.

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[156] Harrison et al., *Escalation and Deterrence in the Second Space Age*.
[157] Nikos Virvilis and Dimitris Gritzalis, "The Big Four - What We Did Wrong in Advanced Persistent Threat Detection" (IEEE International Conference on Availability, Reliability and Security, CPS, 2013), 248–54.
[158] Virvilis and Gritzalis.
[159] B. Bencsath et al., "The Cousins of Stuxnet: Duqu, Flame, and Gauss.," *Future Internet* 4, no. 4 (2012): 971–1003.
[160] Kapersky Labs, "'Red October' Diplomatic Cyber Attacks Investigation - Securelist," accessed March 31, 2017, https://securelist.com/analysis/publications/36740/red-october-diplomatic-cyber-attacks-investigation/.
[161] Virvilis and Gritzalis, "The Big Four - What We Did Wrong in Advanced Persistent Threat Detection."

5.28. *Firstly, cognitive science gives one source of insight into how norms change. The neural phenomenon of "prediction error" is critical to how humans change their expectations about the world – unexpected events that violate norms change those norms.* The U.S. must manage unexpectedness and unpredictability in the Grey Zone.

- Breaking a norm can be deliberate, to shock. Soviet leader Nikita Khrushchev banging his shoe on the table in the UN. Chinese leader Deng Xiaoping hugging the prime minister of Japan. Saddam Hussein's use of chemical weapons. Syrian regime use of chemical weapons.
- Salami slicing and ambiguity can be used to change norms without causing significant prediction error and thus less psychological impact.

5.29. *Secondly, U.S. decision-makers must be aware that each episode in the Grey Zone sets the stage for the next interaction.* Violating norms, even for admirable reasons, can escalate Grey Zone conflict on a longer timeframe.

5.30. *Third, norms inherently stem from the perceptions of multiple actors, which makes U.S. coordination with allies over the evolution of space norms critical.* Notably even close U.S. allies such as the UK and Japan have been reluctant to actively support U.S. positions on space security diplomatically, let alone more distant allies. If the U.S. wishes to shape norms in its preferred direction, it needs allied support. One model is the Tallinn manual process (Box 5.3).

Arms races and dual uses

5.31. Arms races such as the Anglo-German naval rivalry before World War One critically involve cognitive factors. This includes fear, for example of surprise attack. It also involves "prediction error" or unexpectedness, for example where an action taken for self-defensive purposes is less well understood by the competitor and so exerts a larger impact on the recipient than intended.[162] Managing arms races in space is crucial, although beyond the scope of the current report.

5.32. It is noteworthy, however, that the ambiguity at the heart of space operations deeply complicates space arms races. In the example of the Anglo-German naval rivalry before World War One, strategic arms limitation would have been possible between Britain and Germany as a Dreadnought battleship was pretty unambiguous. However, in the interwar period the German arms industry first under Weimar and then Hitler used dual use technologies to build the basis of the German armed forces so stunningly successful in 1940.[163] The dual use nature of many offensive space technologies is highly problematic for any verifiable arms control.

5.33. *Recommendation:*

- "Trust but verify" is a famous dictum, and space will require greater trust building to compensate for difficulties in verification.

[162] Nicholas D Wright, "Neural Prediction Error Is Central to Diplomatic and Military Signalling DiEuliis D, Casebeer W, Giordano J, Wright ND, Cabayan H (Eds)," in *White Paper on Leveraging Neuroscientific and Neurotechnological (NeuroS&T) Developments with Focus on Influence and Deterrence in a Networked World*, ed. Diane DiEuliis et al. (US DoD Joint Staff, 2014).
[163] Odd Arne Westad, *The Cold War: A World History*, 1 edition (New York: Basic Books, 2017).

Extended deterrence and influence over time

5.34. Convincing allied elites and publics of the legitimacy of U.S. responses to space operations—as well as that the U.S. will fulfil extended deterrence guarantees—critically involves messengers that are trusted and credible to the target audience. Trust is fundamentally psychological, and trusted messengers can often only be created with over longer timeframes (e.g. military-to-military relationships, the BBC). Chapter 4 discusses this further.

Box 5.3:[164] The Tallinn Manual (2013)[165] and Tallinn 2.0 (2017)[166]

Written between 2009 and 2012 at the invitation of the NATO Cooperative Cyber Defence Centre of Excellence and originally entitled the 'Tallinn Manual on the International Law Applicable to Cyber Warfare', the Tallinn Manual is an academic and non-binding study on how international law (international humanitarian law and jus ad bellum) applies to cyber warfare and cyber conflict. Key norms addressed by the Tallinn Manual include:

- States may not knowingly allow cyber infrastructure located in their territory to be used for acts that adversely affect other States.

- States may be responsible for cyber operations directed against other States, even though those operations were not conducted by the security agencies. In particular, the state itself will be responsible under international law for any actions of individuals or groups who act under its direction. For instance, a State that calls on hacktivists to conduct cyber operations against other States will be responsible for those actions as if it had conducted them itself.

- The prohibition on the use of force in international law applies fully to cyber operations. Although international law has no well-defined threshold for determining when a cyber operation is a use of force, the Tallinn Manual states that any cyber operation that caused harm to individuals or damage to objects is qualified as a use of force.

Cyber operations that merely cause inconvenience or irritation do not qualify as uses of force.

'Tallinn 2.0', the second edition of the Tallinn Manual was released in March 2017. Whilst the focus of the original Tallinn Manual rested on highly disruptive and destructive cyber-attacks and those taking place during armed conflict, which allowed for states to respond in self-defence, Tallinn 2.0 addresses malevolent cyber operations below this level, examining the international legal framework that applies to the grey areas of hostile cyber operations.[167]

MULTIPLE AUDIENCES

5.35. Ally and third-party perceptions are critical in the Grey Zone – and U.S. actions will inevitably reach multiple audiences. If the U.S. lost allied support in the South China Sea, for instance, it could suffer deterrence by ally denial.

5.36. *Recommendation:*

- Chapter 4 discusses the importance of *"Extended influence"* in space.

5.37. Audience analysis is critical across these multiple audiences.

[164] From Wright, "From Control to Influence."
[165] Michael N. Schmitt, ed., *Tallinn Manual on the International Law Applicable to Cyber Warfare* (Cambridge: Cambridge University Press, 2013), http://csef.ru/media/articles/3990/3990.pdf.
[166] Michael N. Schmitt and NATO Cooperative Cyber Defence Centre of Excellence, eds., *Tallinn Manual 2.0 on the International Law Applicable to Cyber Operations* (New York, NY: Cambridge University Press, 2016).
[167] Schmitt and NATO Cooperative Cyber Defence Centre of Excellence.

5.38. *Recommendation:*

- Audience analysis requires both local knowledge within key local audiences, and also the ability of the U.S. analysts to put themselves in the shoes of their audiences – the type of 'outside-in' thinking enabled by our *Checklist for Empathy* (Box 2.1).

MULTIPLE INTERPRETATIONS: AMBIGUITY

5.39. The difficulty of attributing space actions magnifies the challenge of ambiguity in space. Ambiguity and problems of attribution are central to space activities – not only difficulties in Governments establishing unambiguous versions of events (e.g. a PRC or Russian source of a non-kinetic space action that may justify retaliation) but also in communicating that unambiguously to key local and allied audiences.

5.40. In the short term ambiguity is a tool, and when wielded by the adversary can be countered. However, in the long-term ambiguity can damage credibility and even lead to unwanted escalation. For instance, in the run up to World War One, the ambiguous British commitment to France (an "entente cordiale" not an alliance) incorrectly left some key German decision-makers optimistic that Britain may not support France in war.

5.41. *Recommendation:*

- Chapter 3 discusses means to manage ambiguity, particularly in the short term.

MULTIPLE LEVELS

5.42. The U.S. must successfully influence multiple societal levels, most notably in space at the *state level* (e.g. adversarial, allied or neutral states) and at the *population level* (e.g. mass communication within states and communities). For example, the public may not see space activities as legitimate reason for war, constraining decision-makers.

5.43. The '*Checklist for empathy'* in Chapter 2 provides a realistic analysis of an adversary, ally and other's decision calculus, which includes key human motivations such as fairness, legitimacy, surprise and self-interest.

MULTIPLE DOMAINS OR INSTRUMENTS OF POWER

5.44. Multiple domains are important in the Grey Zone, which includes space amongst others such as diplomatic, information, economic and cyber. Key cognitive factors can be common or differ between domains. For instance, managing surprise and predictability (concepts incorporated in a simple *'prediction error' framework* grounded in neuroscience) is critical across domains and levels to cause intended effects and avoid unintended effects.

5.45. Space is not just important in itself, but plays a role across domains. The PRC's Beidou satellite navigation system, for instance, plays a role in spreading PRC influence through the "One Belt One Road" economic programme across Asia and beyond.[168]

[168] https://www.forbes.com/sites/saadiampekkanen/2017/05/26/chinas-ambitions-fly-high-one-belt-one-road-to-extend-into-space/#16c09dfc4c0c

RECOMMENDATIONS

5.46. The U.S. should develop the capabilities and policies to conduct space operations in Grey Zone conflicts, centred around operational requirements arising from the five multiples of the Grey Zone.

5.47. Further recommendations specific to each of the five multiples are noted in the text.

PART III SPACE IN WEST PACIFIC SECURITY

Chapter 6: The PRC and space

6.1. Key points from this chapter include:

- PRC ideas on deterrence in space differ from U.S. ideas, and this largely derives from differences in overall Chinese thinking on deterrence – it is more context-dependent.
- PRC thinking on escalation in space raises dangers: because inadvertent escalation is insufficiently considered; and because space is seen as a less escalatory domain (see also Chapter 1 on entanglement).
- PRC thinking includes elements grey zone competition such as "quasi-war", which are concerning for escalation management as they may involve military action.
- PRC dependency on space is increasing and there are some PRC dependencies in a Sino-U.S. Taiwan escalation scenario that give the PRC "something to lose" in space.

6.2. The first part of this chapter examines PRC domestic foundations for space, capabilities and organization. Then I examine PRC thinking, particularly focusing on doctrine. Finally I briefly examine PRC space dependency in a Taiwan scenario.

DOMESTIC FOUNDATIONS, CAPABILITIES AND ORGANISATION

The PRC's domestic foundations for space operations

6.3. China has independently placed humans into space and successfully landed a probe on the moon – one of only three countries achieve both feats. China has a sizeable domestic space industrial and scientific complex on which to base its strategic aims. However, China still lags far behind America and does not appear bent on a cold-war-style race, spending far less on its civil space programme than the NASA's $19.7bn allocation last year.[169] Whilst in 2017 China's estimated $11 billion spending on space activities was in second place globally, the U.S. spent some $48 billion.[170]

6.4. The number of Chinese launches has been increasing and was second to the U.S. in 2017, but it is not outpacing the U.S.. In particular, in the commercial launch market SpaceX alone accounted for around 40% globally, with 40% European and under

[169] "China's Ambitions in Space Are Growing," *The Economist*, January 20, 2018, https://www.economist.com/news/china/21735074-america-keeping-its-distance-chinas-ambitions-space-are-growing.
[170] "Global Space Industry Dynamics" (Alexandria, VA: Bryce Space and Technology, 2017), 3, https://brycetech.com/downloads/Global_Space_Industry_Dynamics_2017.pdf.

20% Russian. With the rise of SpaceX, it alone is predicted to account for over half the commercial launch market in 2018.[171]

6.5. Domestic politics is also a factor in Chinese space activities. Aiming to boost national pride at home, in 2016 President Xi Jinping declared that April 24th would henceforth be celebrated as "space day", reflecting the anniversary of China's first satellite launch in 1970.[172] Chinese measure their progress not only against the U.S., but for example against India that plans a first soft-landing on the moon following China's similar achievement earlier in the decade.

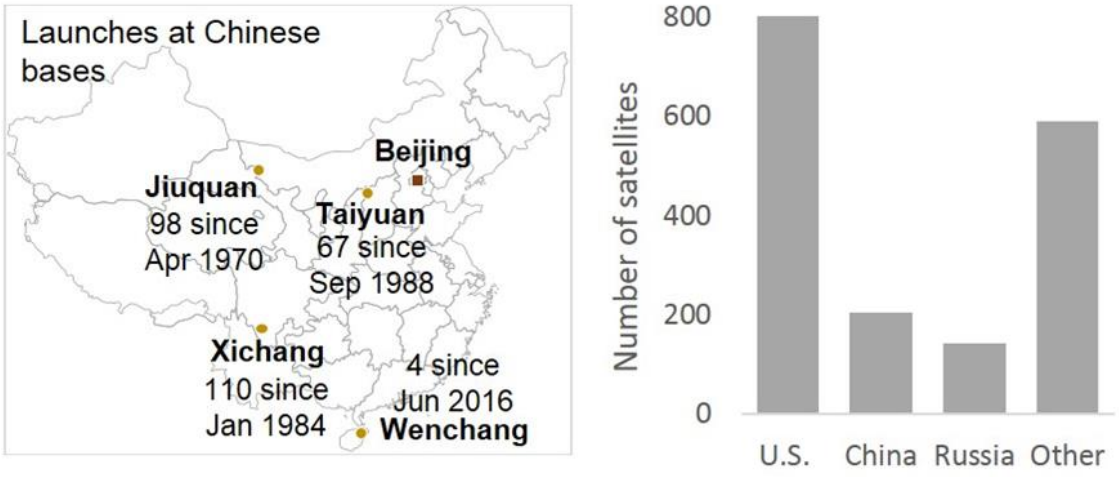

Figure 6.1: Chinese domestic space industry[173]

PRC counter-space capabilities

6.6. Chinese kinetic ASAT capabilities are advanced.[174] Direct-ascent ASAT weapons have been tested since 2005. Operational capabilities against LEO likely are fielded now, or will be very soon, whilst those against MEO and GEO may still be in the developmental stage.[175] With respect to co-orbital ASAT, there have been multiple tests of technologies for close approach and rendezvous in both low-earth orbit LEO and GEO. However, public evidence is argued to indicate they have not conducted a co-orbital kinetic intercept.[176]

[171] [Economist ref]
[172] "China's Ambitions in Space Are Growing."
[173] Left panel adapted from "China's Ambitions in Space Are Growing." Right panel from Data from Union of Concerned Scientists, https://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database#.Wt9gCMgvw2w [accessed 25 April 2018].
[174] Weeden and Samson, "Global Counterspace Capabilities: An Open Source Assessment." Harrison, Johnson, and Roberts, "Space Threat Assessment 2018."
[175] Weeden and Samson, "Global Counterspace Capabilities: An Open Source Assessment."
[176] Weeden and Samson.

6.7. Chinese non-kinetic capabilities are believed include laser, microwave, electronic and cyber.[177] Chapter 5 describes Chinese recent use of such space operations.

PRC organisation for space security

6.8. In 2015 the People's Liberation Army created a new organization dedicated to space and cyberspace, called the Strategic Support Force (SSF). The SSF coordinates space and counterspace activities. The SSF does not appear to have full authority over direct-ascent ASAT weapons, but does control other counterspace activities.[178]

THE PRC THOUGHT AND DOCTRINE ON SPACE

Basic principles of Chinese strategic thinking

6.9. China has not fought a significant external military campaign for almost four decades since the 1979 Sino-Vietnam conflict. Even the 1995-6 Taiwan crisis involving PRC missile tests was now over 20 years ago. Anticipating how the PRC will act in future confrontations and conflict thus depends heavily on interpretation of authoritative Chinese strategic writing, alongside analysis of capabilities and organization described above. Such dependence on these sources is even more the case for space, with the PRC only emerging as a serious space power with the huge growth of its space capabilities since the turn of the millennium.

6.10. Key principles of People's Liberation Army (PLA) thinking are:

- "Active defense": As Chapter 4 describes this influential idea, whereby within a context of strategic defense there should be active offensive actions.
- "Local war under conditions of informatization": This principle describe the importance of preparing for limited conflicts on or near China's periphery against a highly technologically sophisticated adversary. Space played a big part stimulating the precursor to this thinking, "local war under modern high technology conditions", in this through Chinese observation of the U.S. in the first Gulf War.[179]
- "People's War": In its current interpretation this involves bringing the whole of society's effort to the struggle.

6.11. Western observers also argue for additional core features of Chinese thinking:

- The primary priority is regime security.
- Internal and external security concerns are blurred.[180]

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[177] Harrison, Johnson, and Roberts, "Space Threat Assessment 2018."
[178] Kevin L. Pollpeter, Michael S. Chase, and Eric Heginbotham, "The Creation of the PLA Strategic Support Force and Its Implications for Chinese Military Space Operations," 2017, https://www.rand.org/content/dam/rand/pubs/research_reports/RR2000/RR2058/RAND_RR2058.pdf.
[179] Kevin L. Pollpeter and Jonathan Ray, "The Conceptual Evolution of China's Military Space Operations and Strategy," in *China's Evolving Military Strategy*, ed. Joe McReynolds (Brookings Institution Press, 2016). p. 243
[180] Alastair Iain Johnston, "The Evolution of Interstate Security Crisis-Management Theory and Practice in China," *Naval War College Review* 69, no. 1 (2016): 28. p. 43. Andrew Scobell, *China's Use of Military Force: Beyond the Great Wall and the Long March* (Cambridge, UK: Cambridge University Press, 2003).

- Anti-access area denial (A2AD): Whilst some argue this concept is not articulated in authoritative Chinese thinking, the idea of a Chinese "counter-intervention" strategy to deter, delay and deny US intervention in future regional conflict and crises has figured prominently in U.S. thinking.[181]
- Seizing the initiative is a key priority in conflict.
- Strategic and political, not military, objectives should be paramount.

Chinese views of space

6.12. Chinese views of where space begins are essentially consistent with those in the West. Chinese views of the relation of space to other domains has evolved over the past two decades. Space is now viewed as an independent domain, as shown in its treatment by the authoritative Chinese military textbook *The Science of Military Strategy*, which is an evolution compared to earlier versions of the book.[182]

6.13. Space is considered critical for modern warfare. Outer space is now a "commanding height" in modern warfare.[183] A recent PRC whitepaper confirms this importance, which also extend to other aspects of Chinese influence such as the contribution of space to the "One Belt One Road" programme.[184]

6.14. Space missions are envisioned to take place in asymmetric system-of-systems warfare,[185] as described below.

Deterrence: in general and for space

6.15. Chinese views of deterrence in general are more context-dependent than in the West, as Chapter 2 describes. Deterrence includes both deterrence and compellence, and can include making first strikes or pre-emptive actions within the context of a deterrent strategy. However, there are also commonalties with Western thinking, notably that deterrence involves manipulating costs and benefits from the adversary's perspective and that there are crucial cognitive dimensions to deterrence. These basic features, both commonalities and differences, carry over into space deterrence.

6.16. Chinese definitions of space deterrence carry over the broader Chinese understanding of deterrence into space operations.

- A U.S. scholarly analysis[186] of the authoritative Chinese textbook the Science of Military Strategy (2013) notes: "Space deterrence is the use of space forces to carry out deterrent activities and is one of five delineated military

[181] James Johnson, "Washington's Perceptions and Misperceptions of Beijing's Anti-Access Area-Denial (A2-AD) 'Strategy': Implications for Military Escalation Control and Strategic Stability," *The Pacific Review* 30, no. 3 (May 4, 2017): 271–88, https://doi.org/10.1080/09512748.2016.1239129; M. Taylor Fravel and Christopher P. Twomey, "Projecting Strategy: The Myth of Chinese Counter-Intervention," *The Washington Quarterly* 37, no. 4 (2014): 171–187.
[182] Pollpeter and Ray, "The Conceptual Evolution of China's Military Space Operations and Strategy." p. 241.
[183] Pollpeter and Ray. p. 242.
[184] Dean Cheng, "Responding to the Chinese Space Challenge," *The Heritage Foundation*, no. 4645 (January 6, 2017): 3.
[185] Pollpeter and Ray, "The Conceptual Evolution of China's Military Space Operations and Strategy." p. 258
[186] Pollpeter and Ray. pp 259-62

deterrent activities alongside nuclear deterrence, conventional deterrence, cyber deterrence, and nuclear-conventional deterrence.

- Another U.S. scholar who has published extensively on Chinese space notes that: "Chinese writings define space deterrence as the use of space forces and capabilities to deter or coerce an opponent, preventing the outbreak of conflict, or limiting its extent should conflict occur."[187]

6.17. Chinese writing also discusses how space deterrence may differ from deterrence in other domains.

- One U.S. analysis notes[188]: "Space deterrence is compared to nuclear deterrence, which is likewise identified as being strategic in nature. However, space deterrence is considered more flexible and more believable. [Yuan Zelu, Space warfare of the joint campaign (Beijing: National Defense University Press, 2005) p. 43] Nuclear threats will most likely not be used and threats to use them lose some of their credibility because of their immense destructive power."
- Another U.S. analysis draws on the 2007 PLA Military Encyclopaedia[189] to describe how: "In the Chinese view, space deterrence has several unique characteristics. One is "its broad impact" (*quan fangwei xing*). Effective space deterrence will affect not only space forces but terrestrial forces and operations as well. … "space deterrence" is not about deterring adversaries from acting in space, but exploiting space-related systems to achieve certain political and military aims (largely on Earth). (2) "space deterrence is unified" or "integrated" (*yiti xing*) across [(a) military, civilian commercial; (b) orbiting, terrestrial and data links; (c) include both offensive and defensive operations.]; (3) Finally, implementing space deterrence must take into account "its comprehensive nature" (*zong-he xing*). [space strength and deterrence reflects in part a nation's economic, financial and scientific as well as military capabilities]."

Escalation management: in general and for space

6.18. Chinese thinking on escalation management in general is held to differ from the West in that much less emphasis is placed on inadvertent or accidental escalation.[190] That is, escalation is seen a more deliberate process. As one recent Western review concludes:[191] "It is not clear whether these PLA authors think that accidental or inadvertent escalation could result from the PLA's own actions." Chinese views of escalation are also more context-dependent, with less distinction between deterrence, warfighting, offense and defense. Whilst Western ideas may in the past

[187] Dean Cheng, "Evolving Chinese Thinking About Deterrence: What the United States Must Understand About China and Space," The Heritage Foundation, March 2018, /global-politics/report/evolving-chinese-thinking-about-deterrence-what-the-united-states-must.
[188] Pollpeter in Andew Erickson, *Chinese Aerospace Power: Evolving Maritime Roles* (Naval Institute Press, 2012).
[189] Cheng, "Evolving Chinese Thinking About Deterrence." Cheng draws on the Chinese Military Encyclopedia 2nd ed. Editorial Committee, *PLA Encyclopedia, 2nd ed., Military Strategy* (Beijing,PRC: China Encyclopedia Publishing House, 2007), pp. 280 and 281.
[190] See list in selected biography for key references.
[191] Alison A. Kaufman and Daniel M. Hartnett, *Managing Conflict: Examining Recent PLA Writings on Escalation Control* (VA: Center for Naval Analyses, 2016). p. vi

decade have influenced at least some scholarship to recognize inadvertent escalation, it is unclear how far that has or will percolate to key military and political decision-makers.[192]

6.19. Escalation involving space has also been discussed. Concerningly, some writings argue space warfare represents a less escalatory methods of warfare than traditional combat activities.[193]

6.20. Escalation in space has also been considered in relation to deterrence. U.S. scholar Dean Cheng[194] argues that "actual use of space weapons is the highest rung of what seems to be an "escalation ladder" of deterrent actions." He goes on to describe four rungs on that ladder. First are "displays of space forces and weapons (*kongjian liliang xianshi*) occur in peacetime or at the onset of a crisis." Second, "military space exercises (*kongjian junshi yanxi*) are undertaken as a crisis escalates if displays of space forces and weapons are insufficient to compel an opponent to alter course." Third, "Space force deployments (*kongjian liliang bushu*) are seen as a significant escalation of space deterrent efforts. Fourth, "The Chinese term the final step of space deterrence as "space shock and awe strikes" (*kongjian zhenshe daji*). … Employing a combination of hard-kill and soft-kill methods, one would attack an opponent's physical space infrastructure and data links. If this succeeds, opposing decision-makers will be psychologically shaken and cease their activities. If it fails, an opponent's forces will nonetheless have suffered some damage and losses, which will help ensure victory in the course of open conflict."

PRC relative space dependency

6.21. Chinese analyses perceive a deep U.S. dependence on space for their conventional warfighting capabilities.[195] It is unclear how far the Chinese believe they would rely on space, and therefore how far they would perceive an asymmetric space dependency.

6.22. I discuss a potential asymmetric space dependency in a Taiwan scenario below. For discussions of Chinese use of space in ISR see [196].

The PRC and Space in Grey Zone Conflict

6.23. Chinese strategic writing acknowledges a space between peace and war. One recent review[197] found a fairly consistent continuum of conflict described in the progression of crisis and conflict. These stages proceeded as follows:

- crisis → military crisis → armed conflict → local war → total war.

[192] Johnston, "The Evolution of Interstate Security Crisis-Management Theory and Practice in China."
[193] Kaufman and Hartnett, *Managing Conflict*. p. v
[194] Cheng, "Prospects for Extended Deterrence in Space and Cyber: The Case of the PRC." pp. 2-3, 5-6.
[195] Cheng, "Evolving Chinese Thinking About Deterrence"; Pollpeter and Ray, "The Conceptual Evolution of China's Military Space Operations and Strategy." See also Pollpeter, Chase, and Heginbotham, "The Creation of the PLA Strategic Support Force and Its Implications for Chinese Military Space Operations." Biddle and Oelrich, "Future Warfare in the Western Pacific."
[196] A. S. Erickson, "Chinese Air- and Space-Based ISR: Integrating Aerospace Combat Capabilities over the Near Seas," 2014, http://www.andrewerickson.com/wp-content/uploads/2014/02/China-Air-Space-Based-ISR_Chinas-Near-Seas-Combat-Capabilities_CMS11_201402.pdf.
[197] Kaufman and Hartnett, *Managing Conflict*.

6.24. Of particular note here are those stages in the middle of the continuum of conflict in which militaries are involved but war has not yet broken out. The review notes that some PLA writings identify these stages as constituting a state of "quasi-war," and state that they have characteristics of both peace and war. PLA writings indicate military activities in this stage may resemble combat operations, even if the countries involved do not consider themselves to be at war. However, PLA writings do not provide any clear indications of how an outside observer would discern the intentions of these military operations.[198]

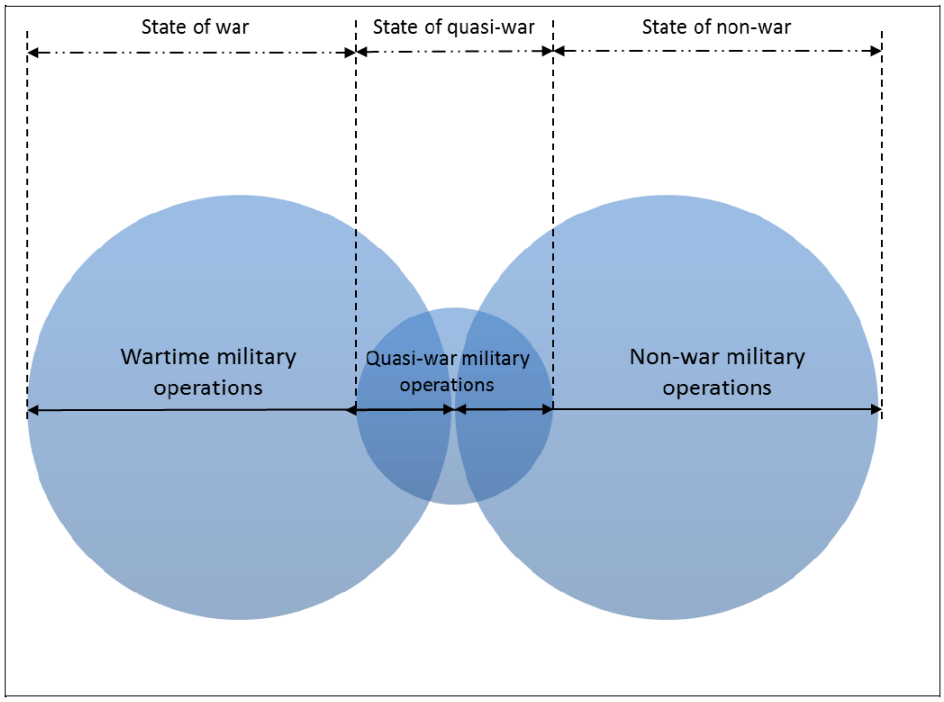

Figure 6.2 Quasi-war military operations. Taken from[199]

6.25. A further potential Grey Zone activity that might be employed by PRC strategists are "Space Blockade Operations", which are intended to intimidate or coerce an adversary.[200] The definition of space blockade is:

- "a space power independently or in support of other services within a certain period of time preventing the enemy from entering space or a special place area as well as severing the enemy's information chain. Space blockade operations ordinarily involve space power offensive operations to achieve space superiority. Their purpose is not to destroy enemy space power, rather they involve special enemy and space relationships."[201]

6.26. U.S. scholar Dean Cheng describes different varieties of space blockade activities[202]:

- ""blockade terrestrial space facilities" (*hangtian jidi fengsuo*)";

[198] This paragraph is based on Kaufman and Hartnett. Please see that text for further details.
[199] Kaufman and Hartnett. These authors base this diagram on the Chinese text: Liu Xiaoli, Military Response to Significant Sudden Incidents and Crises: Research on Military Operations Other than War
[200] Cheng, "Evolving Chinese Thinking About Deterrence."
[201] Kevin Pollpeter, PLA space doctrine in Erickson, *Chinese Aerospace Power*. Pollpeter cites the quote from: Chang Xianqi, Military Astronautics, Beijing: National Defense Industry Press, 2002), p. 292
[202] Cheng, "Evolving Chinese Thinking About Deterrence."

- ""blockade orbits" (guidao fengsuo; 轨道封锁). This can include actually destroying satellites [potentially one's own] that are in orbit, or else creating clouds of space debris or deploying space mines. The purpose [is to] demonstrate a capability … threatening the destruction of adversary satellites … [to] one might limit the function;"
- ""blockade of launch windows" (*fashe tongdao fengsuo*)"
- "Finally, one can impose an "information blockade" (*xinxi fengsuo*; 信息封锁). By interfering with and disrupting an opponent's data links… tampering with the satellite's controls, one can contaminate or block the data that is passing through the satellite. A third form of information blockade involves "dazzling" a satellite, using low-powered directed energy weapons against sensors or other systems. In each case, the intent is to effect a "mission kill,""

SPACE AND ESCALATION IN A TAIWAN CONTINGENCY

6.27. When considering Sino-U.S. escalation scenarios involving space, one must first place that in the context of plausible cross-domain escalation scenarios. Four potential earthly locations for escalation are shown in Figure 6.3 below. Grey Zone confrontations may occur in any of these four areas. However, of these, a Taiwan contingency is most likely to drive Chinese decision-makers to the level of high-intensity kinetic operations in the conventional and thus space domains. I discuss this scenario and implications for asymmetric Sino-U.S. space dependency below.

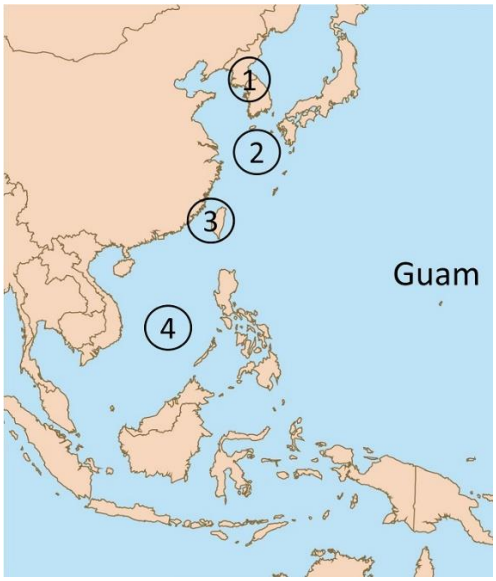

Figure 6.3: Four potential locations for Sino-U.S. escalation to war. From north to south these are: (1) Korean peninsula; (2) East China Sea; (3) Taiwan; and (4) South China Sea.

ESCALATION IN A TAIWAN CONTINGENCY: PRC SPACE DEPENDENCY?

6.28. In a Taiwan contingency, if one considers realistic Chinese use of a high intensity kinetic anti-satellite operation this would occur following very significant escalation more broadly. An important question then becomes whether the PRC has anything to lose by a high intensity kinetic anti-satellite operation, if the U.S. were to retaliate in space. That is, do any current Chinese capabilities rely on space-based assets that

cannot be replaced by non-space-based assets? Figure 6.4 illustrates possible Chinese use for space.

6.29. Firstly, Chinese anti-ship ballistic missiles (ASBMs) that target US carriers will require Chinese space-based assets east of Guam. But would Chinese ASBMs require space assets to target US carriers at about 200-300 mile range from which US planes from those carriers would be useful? Alternatives to space would be e.g. UAVs, other radar or naval assets such as submarines, or sensors based on maritime militia (not likely useful as US could exclude such fishermen in tense scenario). Within the 200-300 mile range discussions the Chinese would likely not need space assets.[203]

6.30. Second, would the PRC need space based assets to send a flotilla to Taiwan across the Taiwan Straits and then on PRC capture Taiwan? They would for GPS etc. at least in the early stages, but even if they did capture Taiwan how would they then hold Taiwan? This might be a use case for PRC space assets.

6.31. Third, would such a PRC marine force be resupplied etc. when one assumes they would need GPS etc. to do that? Again, this might be a use case for PRC space assets.

6.32. Fourth, to blockade Taiwan, would the PRC need space assets? This seems unlikely.

6.33. Thus, overall, it seems that there may be some PRC space dependency in the early stages of a Taiwan contingency that could give them something to lose – but not if they were prepared to forego an amphibious assault on Taiwan.

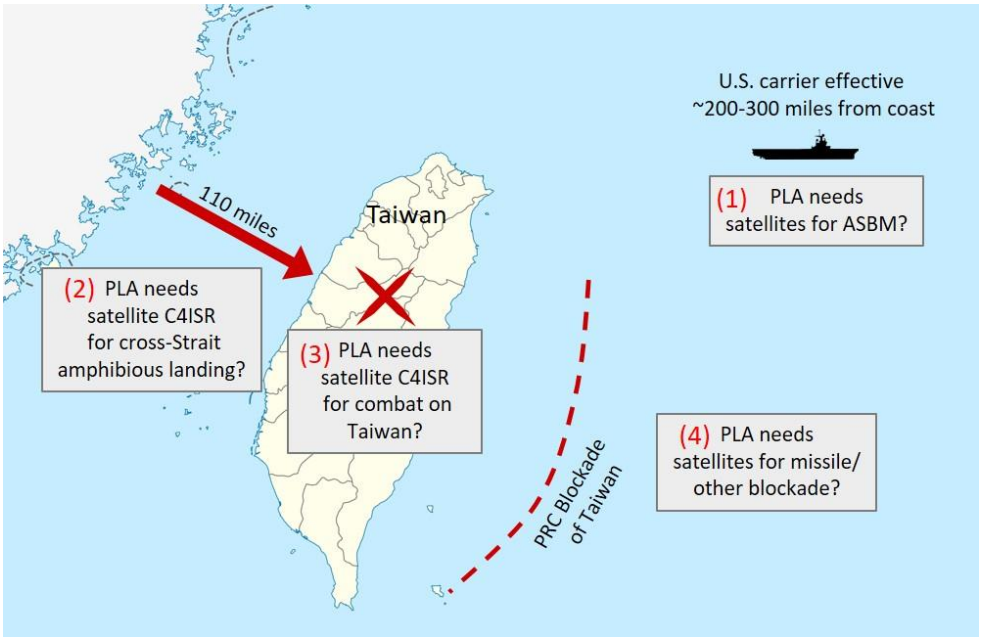

Figure 6.4: PRC space dependency in Taiwan contingencies.

[203] Author's unclassified discussions with experts, March/April 2018 Washington DC, which was the source of the four estimates here.

Appendix 1 Questions from Air Force Space Command

From a foundational standpoint, the SMA effort needs to address the advantages and disadvantages (rewards and risks) to the US adopting a policy of space as a joint warfighting domain. With an understanding the space domain is already contested and that US space assets are at risk, this SMA should focus on these key questions:

Space Defense, Deterrence, and Warfighting

a. What are the Offensive Space Control and Defensive Space Control requirements for today and in the future?

b. What are the critical nuances for attempting to achieve domain control for the inherently global (and not severable into smaller operational functions) space domain? How can the DoD best account for these factors?

c. What can be done in the near- and mid-term to address the shortfalls in foundational intelligence needed to contest the space domain?

d. What are the requisites for defense and deterrence of attacks on space assets? Are these the same as for defense and deterrence of attacks from space? Are there nuances to space deterrence which are different from nuclear deterrence; and if so, what are they and how should they be accounted for? What are the nuances of deterrence across domains (e.g. ground to space, space to cyber)? What should be the primary target for developing and communicating an effective deterrence strategy (e.g., domain specific and separate; domain agnostic focused on disruption of information flows; entire input-to-user space systems, etc.)?

e. What are the implications of the growing and increasingly global commercialization of space for deterrence and warfighting in and/or through space? What are the implications of DoD use of commercial space services?

f. What roles can DoD, AFSPC, and USSTRATCOM play in helping to develop international norms around space operations and space defense (e.g., as for space junk)?

Organisation of the US Space Enterprise

g. Is the space enterprise organized effectively to support the organizing, training and equipping of space capabilities required to operate in a contested space domain; why or why not?

h. What specific changes to policy, law, federal acquisition regulations and space enterprise organization are required to ensure acquisition and technology refresh rates support operations in a contested space domain?

i. What are the US domestic political considerations, pitfalls and opportunities for moving the space enterprise in the directions required for defensive and offensive actions?

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