Outer Space; Earthly Escalation? Chinese Perspectives on Space Operations and Escalation

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Acronyms

A2AD	Anti-Access Area Denial
ASAT	anti-satellite
ASBM	anti-ship ballistic missiles
CAS	Chinese Academy of Sciences
CASC	China Aerospace Science and Technology Corp
CAST	China Academy of Space Technology
CPC	Communist Party of China
DSP	Defense Support Program
ICOC	International Code of Conduct for Outer Space Activities
ISR	Intelligence, Surveillance, and Reconnaissance
EU	European Union
GGE	[UN] Group of Governmental Experts
IHL	International Humanitarian Law
LTS	Long-Term Sustainability [of Outer Space Activities]
MoU	Memorandum of Understanding
NSS	National Security Strategy
OBOR	One Belt One Road
OODA	observe-orient-decide-act
PLA	People's Liberation Army
PRC	People's Republic of China
RMA	Revolution in Military Affairs
RPO	rendezvous and proximity operations
SBIRS	space-based infrared system
SBSP	space-based solar power

SCS	South China Sea
SEIS	space-enabled information services
SSA	space situational awareness
SSF	Strategic Support Force
TCBM	transparency and confidence building measures
THAAD	Theatre High Altitude Area Defense
TT&C	tracking, telemetry, and control
UNOOSA	United Nations Office for Outer Space Affairs
USSR	Union of Soviet Socialist Republics

PREFACE

Brig Gen Robert Spalding
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Conflict has come to space despite past US efforts at prevention. Therefore, space operations are an increasing focus of attention for strategists and policymakers. Given the growing Chinese capabilities and ambitions, it is critical to understand strategic perspectives and anticipate future actions across the range of confrontations in which space is but one of many operational domains. This extends from the repeated use of reversible Chinese counter-space capabilities; to the part space plays in the "One Belt One Road" initiative to spread Chinese influence in Eurasia; through to the central role planned for space in the People's Liberation Army's (PLA) key objective of winning "local wars under conditions of informatization." Escalation is best controlled when anticipated, and this white paper aims to help this process by providing a glimpse into the cognitive world of Chinese planners.

This white paper thus comes at an important time. Its contributors highlight key areas that have clear implications for operational planning and US requirements to achieve intended outcomes:

- A new era of great power competition in space has begun over the past decade, and the US must adapt to these new strategic realities. This may mean returning to some Cold War strategies. However, old strategies alone will not be sufficient to meet new challenges from China and other competitors in all domains, to include space. Bold thinking that challenges past notions of war and peace are called for.
- Gray Zone conflict—a war of ones and zeros and dollars and cents designed to subdue adversaries without bloodshed—was never confined to earth, and the US must determine the conditions it seeks to make manifest in space. This requires forward looking programmatic and industrial strategy to provide the means for setting those conditions.
- Entanglement between nuclear and conventional missions in space, as well as between commercial and military space systems, makes escalation in space more likely.
- Chinese thinking on conflict in space, as well as deterrence and escalation management more broadly, differs from US thinking. Mirror imaging will ensure surprise. Space may well offer the first warning of movement from Gray Zone to kinetic warfare.
- Gray Zone warfare and Chinese military art operates on a continuous timescale which defies Western notions of beginning and end. The US Government (USG), including agencies outside the Department of Defense, must think beyond programmatic budgeting schedules towards persistent advantage in power and control.
- US allies and commercial players will play an increasingly significant role as space power becomes more distributed than before. The US must forge a new consensus on space with allies such as Japan.
- Whilst centuries of confrontations on land or sea have helped evolve mutually beneficial norms of behavior, space is still a comparatively new arena. These "rules of the road" cannot be influenced from a position of weakness.

In sum, we have entered a new era in space that requires new thinking, new partners, and new capabilities. To succeed across the range of conflicts the United States now faces in space, including kinetic, the US must both influence and control the space domain. To that end, a recognition of Chinese views on space is a first step.

EXECUTIVE SUMMARY

United States policymakers must prepare to manage escalation in West Pacific confrontations that involve space operations. How can they put themselves in the shoes of Chinese planners and manage escalation in the current strategic environment in space? We raise three key points.

(1) Managing space operations now is not the same as in the Cold War Space Age (1957-1990) or the Unipolar US Space Age (1990-2014) – we recently entered a new space epoch, the *"Gray Zone-Entangled Space Age."* It has two distinguishing features:

(a) ***Gray Zone conflict*** is more than normal competition and less than war. Space strategic conflict mirrors the Gray Zone conflict on earth, with a rising China and resurgent Russia. Space is ideal for Gray Zone conflict, particularly using diverse reversible technologies (Chs. 1 and 8). As James Lewis puts it (Ch. 3): "If America is waiting for the onset of armed conflict, it will miss the game."

Recommendations: Gray 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. Both influence ***and*** control are necessary for US success. **US space policy and practice must explicitly place influence and control at the heart of space operations.**

US decision-makers must have options to respond proportionally to Gray Zone conflict in space, enabling responses without escalation to war. Allies are critical (e.g. Ch. 7 on Japan), as is long-term competition to shape norms (Ch. 8).

(b) ***Entanglement*:** Crucial conventional and nuclear space missions are now deeply entangled, so warfighting with near-peers in space for conventional purposes profoundly threatens the nuclear mission. Commercial and military space systems are also increasingly entangled.

Recommendations: In the short-term, US decision-makers must now prepare for space operations during crises to rapidly escalate to the nuclear level (e.g. involving the space-based infrared system; SBIRs). This should be mitigated by dialogue and US deterrent signals. In the medium-term, the US must reduce dependency on fragile, entangled space assets such as SBIRs – and demonstrate that reduced US dependency.

(2) Managing escalation in space operations is not the same as in other domains. The nature of conflict is the same across domains, but the character differs.

Recommendations: Chs. 1, 2 and 7 outline the particular emphases required for space operations, e.g. dealing with ambiguity and offense-dominance.

(3) Chinese strategic thinking on space, escalation, and space escalation differs from US thinking.

Recommendations: To avoid misperception, planners must take seriously different Chinese thinking on space conflict, e.g. related to deterrence or space blockade (Ch. 4). Beyond conflict, the US Government (USG) more broadly must compete for position over longer-term space industrialization (Chs. 5 and 6).

Report Overview

We examine space operations and the management of escalation with China in the West Pacific. We bring together leading experts who have all worked on both space and Chinese strategy. After an Introductory chapter, the report has three parts. Part I considers space and escalation management in strategic context. Part II examines Chinese perspectives on space conflict and longer-term space strategy. Part III examines additional core dimensions in West Pacific escalation, namely the Japanese perspective that will be critical in West Pacific escalation scenarios, and the longer-term competition to shape norms.

Introduction

In Chapter 1, Nicholas Wright provides a grounding for the chapters that follow. First, he describes current strategic environment in space. The current *Gray Zone-Entangled Space Age* (2014-present) differs from either the Cold War Space Age (1957-1990) or Unipolar US Space Age (1990-2014). It is more dangerous, both because China and Russia are pursuing Gray Zone strategies in space and already undertake Gray Zone space operations.

Second, he discusses Gray Zone conflict in more detail, including specific examples of Chinese and Russian space operations that mirror the transition to Gray Zone competition on earth. Understanding Gray Zone competition also provides a framework for thinking of Chinese goals, such as the longer-term strategy or shaping of norms in space that later chapters examine.

Third, he provides a short primer on current Western thinking on escalation; Western thinking on space; PRC thinking on escalation; and PRC thinking on space escalation.

Part I considers space and escalation in strategic context.

In Chapter 2, Bruce MacDonald discusses key features of escalation and its management in space operations. These include: (1) Escalation incentives in space will be high especially for China once conflict has broken out. (2) Uncertainty over scale of space effects usage is uncertain, making their usage in a crisis potentially escalatory if effects are greater than planned. (3) Inexperience of countries in space gives rise to a "sorcerer's apprentice" problem, placing leaders at risk of making unwise decisions.

MacDonald outlines five phases of escalating conflict involving space—from pre-conflict thought to nuclear war—each one with more risk than the previous ones. No clear-cut escalation barrier exists in space, and given the short-term tactical benefits of escalating ahead of an adversary, each additional escalation could create incentives for further escalation that an adversary would not always anticipate. Escalation in space is a slippery slope with few off-ramps.

He recommends: (1) dialogue, including peacetime discussions; (2) given the crisis instability in space and the US dependence on space, the US should emphasize deterrence with warfighting in a supporting role; and (3) expand wargaming.

In Chapter 3, James Lewis places space escalation within the context of China's broader strategy: *The "bottom line" for China is to make progress towards its regional objectives without provoking a fight.*

Escalation now is not the same as it was during the Cold War nuclear era, and Chinese thinking on escalation is not the same as US Cold War thinking on nuclear escalation. Instead, China probably sees escalation as a tool to manipulate opponents as part of strategies to advance Chinese interests through non-violent methods. In this Gray Zone conflict: If America is waiting for the onset of armed conflict, it will miss the game.

Fundamental tensions exist in the Chinese strategy, which may make them miscalculate. (1) Gray Zone salami tactics are inherently in tension with core doctrine that stresses rapid escalation to seize the initiative (e.g. the concept of "active defense"). (2) Nationalist sentiment is increasingly used for regime legitimacy and kept in check by social control mechanisms; but in an unexpected crisis, the regime's nationalist rhetoric could force them to escalate.

During crises, kinetic space actions, with their lack of casualties, may appeal to China as an ideal demonstration of nationalist resolve—but may instead lead to a war China is unlikely to win.

Part II examines Chinese perspectives on space

In Chapter 4, Dean Cheng describes Chinese thinking on the role of space during conflict—in which space has become seen as a key battleground for "information dominance." Enabling the flow of information to one's own forces, and preventing the flow of information to one's adversary's forces, has become a central goal for the Chinese military in which space is key.

Cheng describes the evolution of Chinese thinking on the military role of space, from the First Gulf War to "Information Dominance." He describes five styles of military space operations that help achieve information dominance: space deterrence, space blockades, space strike operations, space defense operations, and provision of space information support. Across such space missions, Cheng notes the Chinese adopt a holistic approach that integrates attack, defense, space, and other systems.

Roughly analogous to an "escalation ladder," Cheng describes how space deterrence incorporates a "deterrence ladder" whose rungs include: *displays of space forces and weapons; military space exercises; space force deployments; and space shock and awe strikes.*

Cheng concludes by noting Chinese awareness of greater US than Chinese dependence on space in "local wars."

In Chapter 5, Peter Garretson, a serving US Air Force Officer, argues US observers miss the "real threat" posed by Chinese space strategy. To help understand Chinese strategy he presents "nine distinctions" where he thinks China has it right on space and where China differs from the US.

He argues the real threat is the long-term formation of "one ladder" into space that harnesses the industrial potential of space and enables the Chinese to outflank the US. In contrast, the US has more short-term views of space strategy as a simple extension of earthly strategy, and no US Government body pays attention to the long-term Chinese space threat. *"We're playing chess, they're playing Go. Have they already set up to win?"*

The nine distinctions he describes are: "Status Quo vs Revisionist"; "Functional vs. Geographic"; "Conventional vs Irregular (Insurgent)"; "Chess (Maneuver / Attrition) vs. Go (Additive / Linking / Encircling)"; "Present vs. Future Focus"; "Divided Lanes vs. Comprehensive Spacepower"; "Geocentric vs. Cis-Lunar"; "Prestige & Nuclear vs Industrial & Economic"; and "Strategic Strength vs. Tactical Engagement."

In Chapter 6, Namrata Goswami's provocative contribution argues that China has three long-term goals in space, and goes on to describe their strategy for achieving these goals.

Goswami describes the rising the 'spirit of aerospace' in parts of the Chinese government that is galvanizing their space policy. She argues that China's long-term goals in space fall under three distinctive categories. First, their long-term investment in space-based resources. Second, their utilization of space for diplomacy. This includes leveraging space assets as part of the "One Belt One Road" initiative, which has been described as central to Chinese Gray Zone strategies to extend their influence. Third, their development of space capacity for military advantage.

Goswami then outlines five aspects of the strategy to achieve these goals: (1) Incrementalism; (2) establish perceived legitimacy; (3) lead in specific areas of space technology to gain leadership in the development of norms regarding their use; (4) extend earthly strategic concepts like "area denial" and "active defense" to space; and (5) integrate civilian and military aspects of the Chinese space enterprise.

Part III brings in additional core dimensions

In Chapter 7, Kazuto Suzuki, one of Japan's leading space security scholars, provides a view from Japan. Japan is crucial in many plausible Sino-US escalation scenarios. He identifies three key areas.

(1) Space in *"Gray Zone conflict":* Japan recently placed countering Gray Zone activities at the heart of its official defense strategy. The character of space makes it ideal for Gray Zone actions, and also makes deterring space Gray Zone activities difficult either by denial or punishment.

(2) Sino-US escalation management is tough because calibrating the *proportionality* of reactions is tough. This arises because of the lack of casualties in space, the cross-domain nature of responses, and because one satellite does not have the same value to China as to the United States. Declaratory policy is an important tool for the US.

(3) The Japan-US alliance: This aids the US by (a) patching holes in Space Situational Awareness data sharing; (b) enhancing resilience via complementary allied space systems; and (c) contributing to collective retaliation via economic, cyber, conventional, or other means.

In Chapter 8, Brian Weeden describes the crucial long-term role that norms of behavior for space play in enhancing stability or amplifying instability and escalation. Other domains, such as sea or air, have successfully developed stabilizing norms.

Weeden describes three recent efforts to develop norms for space, and why they were more or less successful. This is an active area of Gray Zone competition between the US, China and Russia, in which the US has not successfully achieved its objectives.

Weeden then provides concrete areas for future efforts to develop norms: (1) Norms of behavior for rendezvous and proximity operations in space; (2) Norms of behavior for how militaries interact with each other in space; (3) Norms of behavior for the testing and development of counterspace weapons; and (4) Extending the Law of Armed Conflict to space.

He concludes by noting the importance of US engagement in this competition for *influence*, which will shape the future of stability, escalation, and conflict in space.

INTRODUCTION

Chapter 1. China and Escalation in the "Gray Zone-Entangled Space Age"

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This introduction provides a grounding for the chapters that follow.[1] I cover three areas:

- First, I describe the current strategic environment in space: we have entered a *Gray Zone-Entangled Space Age*. This provides the backdrop against which to consider Chinese thinking.
- Second, I discuss Gray Zone conflict in more detail, including specific examples of Chinese and Russian space operations that mirror the transition to Gray Zone competition on earth. Understanding Gray Zone competition also provides a framework for thinking of Chinese goals, such as the longer-term shaping of norms in space.
- Third, I provide a short primer on current Western thinking on escalation; Western thinking on space; PRC thinking on escalation; and PRC thinking on space escalation.

Space Epochs: From Sputnik to the "Gray Zone – Entangled Space Age"

Strategy in space has not remained the same since the USSR launched Sputnik in 1957. The history of strategy in space falls into distinct epochs, and we are now beginning a new space epoch that differs radically from those preceding it. It is the *"Gray Zone – Entangled Space Age."* It has two distinguishing features: space strategic conflict mirrors the *Gray Zone* conflict on earth, including increased intensity and repeated reversible space operations; and crucial conventional and nuclear space missions, as well as commercial and military space systems, are deeply *entangled.*

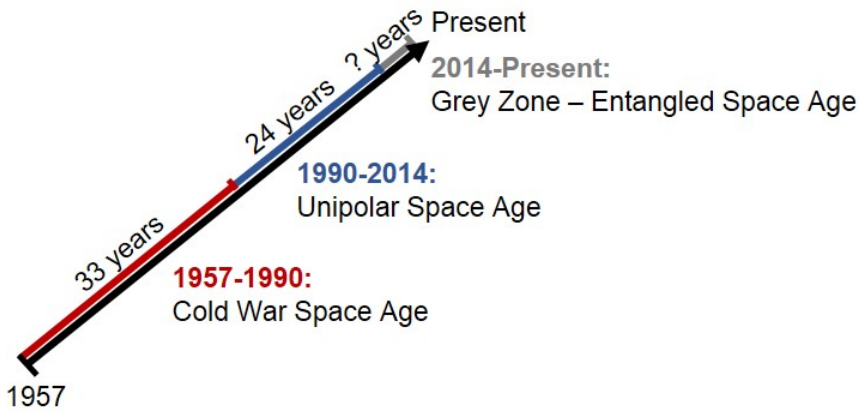

Figure 1.1 Space epochs: From Sputnik to the "Gray Zone – Entangled Space Age" (Wright, 2018)

[1] This Introduction draws on Wright, 2018

First came a **"Cold War Space Age"**[2] from Sputnik's launch in 1957 to the end of the Cold War in 1990. It had two key characteristics (see Harrison et al., 2014, p. 1; Cremins, 2014). 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 anti-satellite (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.

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 smaller proportion of those launched globally.[3] A second reason for this inflection point was the demonstration of the conventional Revolution in Military Affairs (RMA) during the first Gulf War. In that "first space war," space enablement of conventional operations was key (Lang, 2016). 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 RMA was built (Freedman, 2013, p. 214-216)—but the Soviet collapse meant they could not keep up with the US. 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.

I argue we have now entered[4] a third epoch, the *"Gray Zone – Entangled Space Age."* It has two distinguishing features:

- space strategic conflict mirrors the *Gray Zone* conflict on earth (Wright, 2018), including for example higher intensity of competition and repeated reversible space operations; and

- *entanglement* is now deep amongst many core space missions and sectors. Examples include entangled commercial and military space systems. Crucial conventional and nuclear space missions are also now entangled (Acton, 2018), so warfighting in space for conventional purposes with near-peer adversaries profoundly threatens the nuclear mission.

The rise of "Gray Zone" multipolar competition has ended the US "Unipolar moment" on earth. A resurgent Russia and rising China have significant capabilities (e.g. Anti-Access Area Denial; A2AD) and are willing 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. I describe Russian and Chinese space operations below (e.g. during the 2014 Crimean invasion). Shifting balances away from US unipolarity in space itself are also clear, illustrated by a recent RAND report highlighting the marked

[2] 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."
[3] Space-track.org
[4] 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. This also involved Russian Gray Zone space operations (see this chapter). Inevitably given the gradual increasing Great Power competition since the mid-2000s, including in space, the choice of 2014 is somewhat arbitrary. However, 2014 not only reflects the crystallisation of higher intensity Russia-West competition, but also falls midway within the period from 2012-2017 during which Chinese President Xi Jinping's reorientation of his country's foreign policy became evident.

erosion of US relative advantage in space against the PRC during potential West Pacific scenarios (Heginbotham et al., 2015).

Risks in the Gray Zone-Entangled Space Age are greater and require different management tools from those during either the Cold War or US Unipolar Space Ages. Consider the following:

(1) 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. US SBIRs early warning satellites that would detect those ASBM launches are also central to detecting nuclear launches. The PRC may attack these US satellites to protect their conventional capabilities—and many who work on Chinese space security believe this to be a real possibility[5]—but to the US this would be an attack on a key nuclear asset.

(2) A second difference from the Cold War space age is that th*e US would be "playing away" against Russia or China whilst they would be "playing at home,"* potentially making the asymmetric US dependency on space assets even more pronounced.

(3) *Thirdly, commercial-military entanglement also raises new challenges in space*. A greatly enhanced private sector role in satellite launches, particularly in the United States, is driving down prices and increasing space congestion. 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?

(4) *Fourth, escalation management becomes even harder if we also see entanglement of US space systems of those with allies* (e.g. Japan in Chapter 7 here).

(5) *Finally, no taboo now prevents repeated anti-satellite space operations, with reversible Gray Zone space operations now regularly conducted* as described below. 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 "Gray Zone - Entangled Space Age."

We are returning to an era of higher intensity Great Power competition than any seen since 1990. But we aren't returning to the Cold War in space even though the Cold War was itself, as its very name suggests, a Gray Zone conflict. Instead, US policymakers must recognize we are entering a new era of Gray Zone competition in space with its own character.

Gray Zone Conflict in Space

The centrality of influence in the Gray Zone

Gray Zone conflict is necessarily *limited* conflict, sitting between "normal" competition between states and what is traditionally thought of as war (Wright, 2017). 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. I define influence as a means to affect an audience's behavior,

[5] Multiple discussions by the author during 2017-18 with U.S. and European experts on China and space raised this possibility.

perceptions, or attitudes. Influence can be achieved by deterrence, persuasion, or the use of hard or soft power. Success requires moving the emphasis from control to influence.

What, if anything, differentiates the Gray Zone from other types of conflict? The fundamental nature of conflict is unchanged, but the Gray Zone requires different *emphases*. I summarize these key challenges as the ***"Five Multiples"*** of the Gray Zone (Box 1.1). The US should develop the capabilities and policies to conduct space operations in Gray Zone conflicts, centered around operational requirements arising from the five multiples of the Gray Zone.

Next, I describe current Chinese Gray Zone activities in space, and then briefly describe Chinese thinking on the Gray Zone.

Figure 1.2: Peace, the Gray Zone and War (Wright, 2018)

Box 1.1: What is the Gray Zone? The Five Multiples of the Gray Zone

***(1) Multiple levels*:** The US 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 Chs. 3 & 7).

***(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 (see Chs. 5 & 6).

***(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 (see Chs. 5, 6 & 8).

(4) Multiple audiences: Ally and third-party perceptions are critical in the Gray Zone, and US 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 Ch. 7 on Japan.

(5) Multiple interpretations: Ambiguity is a key feature of the Gray Zone and of space operations more broadly. Ambiguity's essence is that events or actions are open to multiple interpretations (see Chs. 2 and 7).

Contemporary Gray Zone actions in space

Both the Russians and Chinese have conducted space operations that mirror the transition to Gray Zone conflict on earth. In 2014, Russia jammed GPS signals in Ukraine during the Crimean conflict (Sukhankin, 2017; InformNapalm.org, 2016, 2017). 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.

A number of Chinese actions, based on open source information, also illustrate the transition to Gray Zone space operations.[6]

- *2006 laser use:* Reports appear that lasers had illuminated US imagery satellites over China (Muradian, 2006; Harris, 2006).

- *October 2007 and July 2008 cyber actions:* Cyberattacks believed to originate in China targeted the US Geological Survey remote sensing satellite, Landsat-7. These interfered with ground station communications (Chen, 2017).

- *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."

- *September 2014 cyber action:* Chinese hackers reportedly attacked the National Oceanographic and Atmospheric Administration's (NOAA) satellite information and weather systems (US-China Economic and Security Review Commission, 2015, p. 296; Flaherty, Samenow, & Reing, 2014). Used by the US 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.

- 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 (Lin & Qinq, 2015).

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 US drones, such as the RQ-4 Global Hawk, over the Spratly Islands and South China Sea (Gertz, 2013). Moreover, it may be possible to construe anti-satellite and some ballistic missile defense tests as signals, such as the 2007 Chinese direct ascent-ASAT test.

Chinese thinking on Gray Zone conflict

Chinese strategic writing acknowledges a region between peace and war. One recent Western review found a fairly consistent continuum of conflict described in the progression of crisis and conflict (Kaufman & Hartnett, 2016). These stages proceeded as follows:

[6] In particular this list draws on the excellent recent report on counter-space activities by Harrison, Johnson, & Roberts (2018).

Crisis → Military Crisis → Armed Conflict → Local War → Total War

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 People's Liberation Army (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 (Kaufman & Hartnett, 2016).

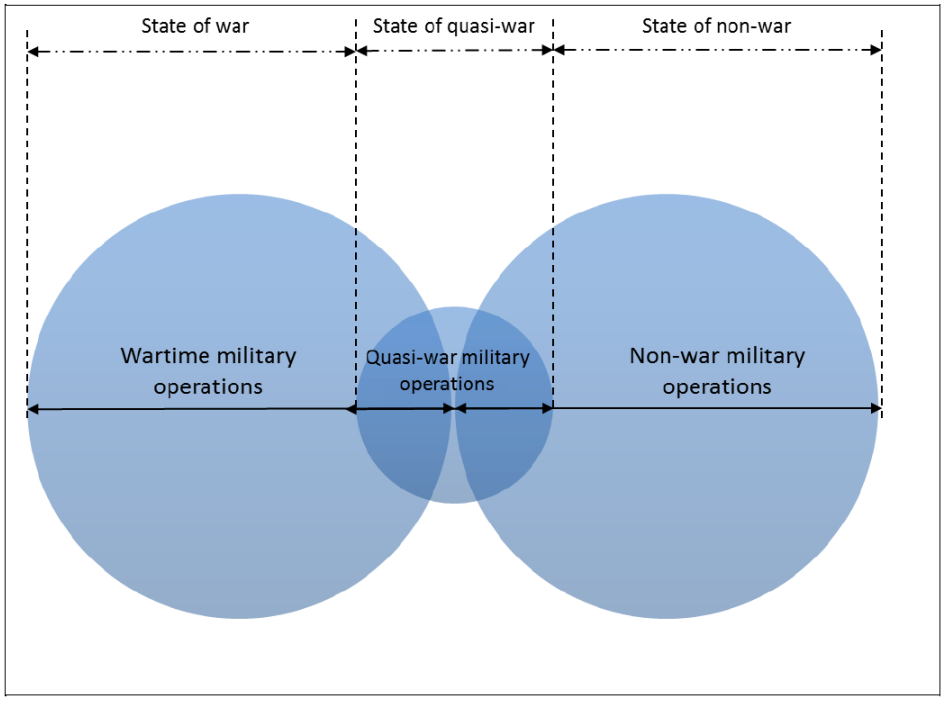

Figure 1.3 Quasi-war military operations[7] (Kaufman & Hartnett, 2016)

Current Western and Chinese Thinking on Escalation – A Primer

Western thinking on escalation

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 (for discussion of such definitions see Morgan et al., 2008). 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.

Escalation management is an example of *influence*. Management of inadvertent escalation is managing the *influence* of one's actions on those receiving them. Deterrence is the primary means to

[7] 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 (Beijing: National Defense University Press, 2009)

manage deliberate escalation, and in US thinking deterrence is *influencing* an adversary so that they decide not to act rather than to act.

Western thinking on escalation and space

A number of key features matter particularly for space operations, relative to other domains. Table 1.1 shows these key factors for space identified in a recent extensive literature search.[8] These factors carry important implications for influence operations such as deterrence and escalation management. The table first shows factors that are important for all space powers, and considering their cognitive foundations places them into four groups. I then note additional factors that are also important for the US and China. Wright (2018) discusses all these factors in detail, and Chapter 2 in this volume discusses a number of them.

KEY FACTORS FOR SPACE	COGNITIVE FOUNDATIONS
Factors for all space powers	
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
Additional US 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 1.1: Key factors for space deterrence and escalation, with their cognitive underpinnings.

Chinese thinking on escalation

Chinese thinking on escalation management in general is held to differ from that in the West in that it places much less emphasis on inadvertent or accidental escalation (key references are Johnston, 2016; Kaufman & Hartnett, 2016; Morgan, et al., 2008; Henley, 2006, 2007). That is, escalation is seen a more deliberate and controllable process. As one recent Western review of People's Liberation Army (PLA) literature concludes: "It is not clear whether these PLA authors think that accidental or inadvertent escalation could result from the PLA's own actions" (Kaufman & Hartnett, 2016, p. vi). Chinese thinking may thus be highly problematic from a Western perspective on escalation. If Chinese decision-makers believe escalation results more from deliberate than inadvertent

[8] I derived these key features for space relative to one or more other domains (e.g. nuclear, conventional or cyber) from across authoritative analyses of space operations, including those listed in the selected bibliography of Wright 2018, *MINDSPACE: Cognition in space operations*, as well as numerous discussions with space experts conducted August 2017-May 2018.

mechanisms, they will more likely to seek to deter that escalation and so worsen inadvertent escalation.

Whilst Western ideas may in the past decade have influenced at least some Chinese scholarship to recognize inadvertent escalation, it is unclear how far that has or will percolate to key military and political decision-makers (Johnston, 2016).

Chinese views of escalation are also more context-dependent, with less distinction between deterrence, warfighting, offense, and defense (Wright, 2018). Greater Chinese context-dependence in strategic thinking reflects robust differences identified in cross-cultural cognitive science. Specifically, Westerners tend to engage in more *context-independent* cognitive processes by focusing on a salient object independently of its context, whereas East Asians tend to engage in more *context-dependent* or holistic cognitive processes by attending to the relationship between the object and the context in which it is located (Nisbett & Miyamoto, 2005).

Chinese thinking on escalation and space

Escalation involving space has also been discussed. Concerningly, some writings argue space warfare represents a less escalatory methods of warfare than traditional combat activities (Kaufman & Hartnett, 2016, p. v).

Escalation in space has also been considered in relation to deterrence. US scholar Dean Cheng argues, "actual use of space weapons is the highest rung of what seems to be an 'escalation ladder' of deterrent actions" (2016, p. 2-6). He goes on to describe four rungs on that ladder. First, "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."

Finally, the greater *context-dependence* in Chinese strategic thinking extends to space. 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 US strategic community. Greater Chinese context-dependence in strategic thinking reflects robust differences identified in cross-cultural cognitive science. US decision-makers should take cross-cultural differences in worldview seriously.

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PART I THE BASICS: SPACE AND ESCALATION IN STRATEGIC CONTEXT

Chapter 2. Space and Escalation

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The Basics

Information is the lifeblood of US military strength, making the space assets that create and/or transmit this information to distant forces extraordinarily appealing targets. The US economy increasingly depends on space-enabled information services (SEIS) as well. China is also becoming more space dependent, but most scenarios for possible military space operations would occur much closer to China (e.g., Taiwan, East/South China Sea) than to the US mainland, allowing China to be less space-asset dependent than the US. The space and cyber domains are closely intertwined, and in their essence deal with information and share a number of similarities. The importance of both the space and cyber domains to strategic planning and crisis management is matched by the lack of much real-world crisis management experience in these domains. These incentives exist for Russia as well. In a crisis, both China and the US would likely face an unstable, high-stakes environment that is neither familiar nor well understood. In this environment, China in particular would likely be tempted to escalate quickly in both space and cyber domains to disrupt US military forces and operations if it could, ideally before they could even arrive (Miller & Fontaine, 2017). Being somewhat less space dependent, China would be less vulnerable to US space offense and might be more emboldened to escalate in space than the US. Both countries seem likely to conduct offensive operations in cyberspace during the early stages of a crisis, though they would want to exercise some caution in the extensiveness of their operations because of escalatory risks.

Understanding space escalation dynamics in the context of crisis stability requires grasping its strategic landscape, including how deterrence functions or fails in a crisis and what factors strengthen or weaken that deterrence. Interdependencies between and among space and other domains are enormously complicated, and their exploration is essential to understanding twenty-first century strategic crisis dynamics. In the late stages of a crisis that threatens to transition into conflict, adversaries would be likely to engage in limited space and cyber actions designed both to send a signal of intention to escalate if conditions are not met (could be either a real threat or a bluff) and to put themselves in a more advantageous position should major conflict break out. Space asset vulnerabilities provide an adversary with dangerously attractive incentives to escalate and pre-emptively attack in a crisis (MacDonald, Blair, Cheng, Mueller, & Samson, 2016). In such a scenario, each side would confront the choice of striking first with all its assets in place, knowing that a conflict is beginning; or ceding the initiative, absorbing a first strike, and making a ragged retaliation against an opponent fully expecting such a response. As a crisis progresses and becomes more intense, each side must wrestle with the prospect that the chances for full-scale conflict are increasing. While neither side may wish for a full-scale war, neither side wishes to receive a major first strike.

The current fundamental challenge to crisis stability in space—and hence the risk of crisis escalation—is the ease and preferability of launching a disabling first strike against an adversary's space assets relative to retaliating against those of an aggressor. This is the essence of crisis

instability, where pre-emption pays far greater benefits than retaliation (Colby & Gerson, 2013). The weaker or more disadvantaged country in a crisis may find this line of thinking irresistible, or at least preferable to the alternatives. Countries sometimes go to war not because they want to, but because doing so appears less risky than not doing so. Any space power would want to avoid being in an unstable use-or-lose situation. In addition, a major feature of the space and particularly cyber domains is that major attacks can be initiated with little advance warning—and in the case of cyber—with almost no warning. In the space and cyber domains, there is nothing comparable to the stabilizing threat of an assured second-strike capability like that represented in the nuclear domain by sea-based ballistic missiles.

For the United States, there are greater risks if conflict escalates into space. Given our greater dependence on space both militarily and economically, the US will want to emphasize deterrence of conflict in space. This can be achieved not just by having space offense, though this would be a necessary component, but also through cross-domain pre-eminence. Conflict is unlikely to be confined to space; cyber and conventional domains will also be involved. Even if the US prevailed in a space-only conflict, the victory would likely be Pyrrhic unless it was overwhelming—China and Russia are unlikely to engage their forces far away from their shores, unlike the US. Thus losing our space capabilities would be more damaging to us than it would be to Russia or China (Morgan, 2010). Until we have a much more survivable and resilient space architecture, we should not want to put our space assets at risk unless absolutely necessary. This 'vulnerability/dependence gap' can be addressed through cross-domain advantages that the US has, particularly in the cyber domain

Another dimension of the problem is the issue of the scale of the attack, both qualitatively and quantitatively. While jamming one or two satellites in isolation appears unlikely to quickly escalate into all-out space war (given the longstanding role of electronic warfare in past conflicts), attacking multiple intelligence-gathering satellites would carry a far higher risk of escalation. Somewhere between these two extremes, however, is an uncertain and unknowable boundary that divides offensive space actions that modestly threaten stability from those that are clearly destabilizing and escalatory. In this unpredictable environment, a country with no desire to spark an all-out space war may still prompt rapid escalation with modest offensive actions that inadvertently cross an unknown threshold. In addition, for technological, commercial, and other reasons the space and cyber domains are evolving far more rapidly than the conventional and nuclear domains, potentially rendering space and cyber strategies ineffective or irrelevant within a few years. In both space and cyberspace, we may learn firsthand how much escalation is too much only after it is too late to stop. Evolving space dynamics could undermine whatever current understanding we may have of crisis and strategic stability in space, and this imperfect grasp of general principles can only add to our uncertainty about the space and cyber offensive capabilities of particular adversaries. Therefore, uncertainty, bluffs, and worst-case thinking are bound to remain prominent forces in the strategic landscape of space. For example, rendezvous and proximity operations on satellites will become more common in the years to come, but they could easily be viewed in a crisis as potentially hostile acts—or in fact be used to commit hostile acts.

One bright spot for the United States is its many treaty-committed allies, which would greatly complicate any planning for substantial space offense by China (which has no comparable state partners). Due to the United States' high level of dependence on non-US commercial space infrastructure, a Chinese attack would necessarily extend to additional countries that may otherwise facilitate a US counterstrike, threatening a much wider conflict than China might want to risk.

Five Escalation Phases and Space

The essence of the space escalation challenge is the perception of the risk-reward trade-off, the uncertainty of space and cyber action effects, how risk averse or risk tolerant each country would be, and the overall misperception and fog of war issues that are part of any crisis or conflict. Below are outlined phases of escalation that can be identified where space—and cyber—would be involved. Escalation into each higher phase is not a given, but certainly incentives for such escalation will exist.

Phase 1: Pre-conflict/signaling

Phase 2: Escalated signaling/transition to conflict

Phase 3: Conflict, prospect of rapid space/cyber operations; significant conventional operations

Phase 4: Major conflict, substantial operations against economic targets

Phase 5: Escalation into the nuclear domain

Phase 1 Pre-conflict/signaling: In the pre-conflict phase, space and cyber usage will mostly serve a signaling/warning role, whose purpose is to tell the adversary that a transition to actual conflict is not far off, the country is considering escalation, and that the adversary should cease or reverse its provocative behavior. The military or economic impact of these signaling actions at this stage should be minimal. This message would mainly support diplomatic crisis dialogue to reinforce points that country is making in that dialogue. The chief problem is that signaling can easily be misinterpreted even if the signal is executed exactly as planned. There would need to be diplomatic dialogue, both back channel and front channel, to minimize misunderstanding; even then there would be suspicion about possible deception. The problem would be magnified if the operational effects were greater than the signaling country anticipated. An unintended cascading consequence from a modest tactical application would almost certainly be interpreted as an intended consequence by the affected country.

Phase 2 Escalated signaling/transition to conflict: If this Phase 1 signaling does not achieve the intended results, China or the US would likely "up its game" and escalate its space operations activity using space and cyber operations that both send a more serious signal about the imminence of conflict unless the other side backs down, and a desire to get a jump on the more likely conflict to come. This phase of escalation would in essence mark the transition from crisis into conflict. The appeal of space and cyber operations at this stage for leaders is that the effects of the space and cyber operations are unlikely to produce any significant casualties. As long as there is a wish to avoid major conflict if at all possible, these domains are a natural for early engagement. However, the chances for cascading unintended consequences leading to conflict are greater in this phase, making this a riskier phase of a crisis. One major class of unintended consequences would be if a space or cyber operation inadvertently spilled over into the civilian sector and caused economic or humanitarian damage. If perceived as intentional, this could easily result in a horizontal escalation into intentional targeting of economic and other civilian activities. I address the cross linkage with the nuclear mission in Phase 3 below.

If these Phase 2 operations do not achieve the desired effects, and the crisis is observed to be transitioning into open conflict, both parties involved in the crisis would be seriously tempted to escalate, and rapidly, with the incentives especially strong in the space domain. The strength of this

temptation will depend on perceptions of how successful the escalation will be. Until the US can deploy a significantly more resilient space architecture, which may not occur until the late 2020s at the earliest, the temptation for China would likely be quite strong.

Phase 3 Conflict: The next phase of operations would be a full range of military operations involving the conventional, cyber, and space domains—conflict will not be confined to just space and cyberspace. In this Phase 3, escalation in the space and cyber domains would likely be rapid and prolonged, both in support of conventional battlefield operations and more strategic space and cyber targets. An important concern here would be the extent to which strategic nuclear targets would be avoided. This becomes a very important issue where certain systems support both conventional operations and strategic operations, e.g., SBIRS/DSP ballistic missile early warning satellites. On top of all the other risks of the previous phases, the combined risks of greatly expanded multi-domain operations and the possibility of strategic "contamination" sending an unintentional signal of possible nuclear escalation make this a dangerous phase.

Both China and the US will have major incentives not to escalate their conflict into the realm of their economies and financial systems, as both nations receive immense benefits from the strength of their economies, and it is possible that diplomacy and negotiations could head off such an escalation. Under specialized circumstances involving, for example, the threatened failure of China's political system, such escalation could be perceived as preferable. Unintended "contamination" of the economic infrastructure with serious economic consequences from military strikes in Phase 3 could usher in a transition to this Phase 4.

Phase 4 Major conflict: This would feature widespread strategic economic attacks, with particular emphasis on space and cyber domains.

Phase 5 Escalation into the nuclear domain: Less likely still but an option that cannot be ruled out would be a further escalation into a Phase 5 where nuclear weapons use is at least threatened if the economic and military effects are seen as threatening the existence of the Chinese regime.

Challenges across all five phases: Another escalation threat is the inexperience that nations share in the space and cyber domains, unlike in conventional domains of conflict and in the nuclear domain to a lesser extent. This inexperience gives rise to a "sorcerer's apprentice" problem, placing leaders at risk of making potentially unwise judgment calls without a full grasp of their implications. The space and cyber domains are sufficiently new and dynamic that such decisions are highly likely. Adding to this uncertainty is the ever-growing interdependence of infrastructures within and among advanced countries, making the impact of major attacks against a country's space and/or cyber infrastructures inherently unknowable.

In considering all these factors, it is important to keep in mind that events in space do not happen in isolation. Any space conflict would likely be part of a multidimensional field of play, with space being important because of the effects it has on the earth. Significant instability in space is unlikely to lead to war if there is stability in other domains and in the larger geopolitical relationship between participants, while conflict could easily spread to a stable space domain if war in other domains appeared preferable to the alternative.

While any use of nuclear weapons would pose a serious threat of escalation to full-scale nuclear war, any use of space or cyber offense would not pose a comparable escalation threat. That said, a series of reciprocal escalations could easily become unstable. No clear-cut escalation barrier exists in the space and cyber domains, and given the short-term tactical benefits of escalating ahead of an

adversary, each additional escalation could create incentives for further escalation that an adversary would not always anticipate. Escalation in space, then, is a slippery slope with few off-ramps.

Recommendations

(1) *The US should emphasize credible deterrence in planning offensive space capability to minimize the possibility of conflict in space*. Great care must be exercised in considering escalation in space offense, with full recognition of the potential for unstable escalation. Escalation in space is a slippery slope with few off-ramps; US military and economic dependence on the space and cyber domains, both of which are vital national interests, suggest that *the primary focus of US space and cyber policy should emphasize deterrence, with war-fighting in a supporting role*.

(2) *Expand wargame training especially at senior levels, with special emphasis on crisis dynamics games.* To address the lack of experience with space conflict and the unique challenges this inexperience poses, the US Department of Defense should consider expanding its space wargaming exercises to include a full suite of space-oriented crisis games with the objective of gaining deeper insights into the behavior of the United States, China, allies, and others in a space crisis context, either apart from war games or as an important adjunct to them. Specific objectives could include the impact of different kinds of signaling in a crisis, the role of uncertainty, interaction between the space and cyber domains, and techniques to de-escalate in a crisis or in the early stages of actual conflict.

(3) *Encourage greater US-China dialogue on space*. The single most important non-military option available in a crisis is to dialogue with the adversary country, and any crisis communication stands to substantially benefit from prior peacetime discussions on these matters. Such exchanges allow participating parties to develop familiarity with each other and with the perspectives of adversaries. While minds are unlikely to be changed, such dialogue can at least help to reduce misunderstanding, especially important in a crisis. In addition, channels of communication, also essential in a crisis, can be established and maintained.

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Chapter 3. "Bottom Line Thinking" about the "Commanding Heights"

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The concept of escalation, which can mean an increase in intensity or scope of conflict, is an inheritance from nuclear strategy. The term came into prominence with the Cuban missile crisis and its use peaked in the mid-1980s, when the threat of global nuclear war seemed greatest. This nuclear heritage should make us careful in using the escalation construct. Conflict and competition will take new forms that emphasis coercion and avoid direct military confrontation as much as possible. Escalation (or the threat of escalation) is not something to avoid, but can be a tool to manipulate opponents. This is probably how China sees escalation, coming from a strategic culture less influenced by Cold War nuclear strategy and inclined to the use of stratagems in its foreign and military policies. The Chinese prefer terms like "war control" and "crisis management" to escalation (Kaufman & Hartnett, 2016).

Mao Zedong, surprised at the collapse of American forces after China's intervention in the Korean War, was tempted to occupy the entire Peninsula,[9] but since that time, China's preference has been for short, intense, and geographically limited conflict when conflict is necessary. The Chinese—although unprepared for the cost of overcoming Vietnamese resistance—could have occupied Hanoi in 1979, but chose not to do so. In the current rivalry with the US, several factors make it unlikely that China will take actions involving the use of force if it can be avoided without political cost. Nuclear weapons create a ceiling for conflict among nuclear powers (and their allies) that limits China as much as the United States. China still does not see itself as able to compete with the US militarily, at least without immense cost, and does not expect this to change for at least another decade.

China's preferred approach is to use coercive measures that stay below the "threshold" of use of force to advance its territorial and maritime goals (noting that Taiwan may be a special case where using armed force is tempting to Beijing). China will seek to maneuver its military forces while avoiding armed clashes. It will build forces whose goal is not just to deter attacks on China, but to deter opposition to China's coercive measures by raising the risk of conflict with China beyond the point that an opponent would be willing to accept. Stability, from this perspective, does not mean an absence of conflict but avoiding armed clashes that China does not think it could win. If America is waiting for the onset of armed conflict with China, it will miss the game.

China's success in the South China Sea, where the US has been incapable of preventing the construction of a number of artificial islands and fortified bases, only encourages China to continue to "slice the salami,"[10] to obtain strategic advantage incrementally and without armed conflict. It will develop capabilities and position forces to constrain opponent responses and make it costly or impossible to prevent China's own actions. China will improve its military capabilities so that if war should occur, its forces would be better positioned to win it. For space, this means demonstrating

[9] Being ultimately dissuaded by the cost of military confrontation with the U.S. David Halberstam, "The Coldest Winter: America and the Korean War"

[10] Salami slicing refers to a series of many small actions, often performed by clandestine means, that as an accumulated whole, produces a much larger action or result that would be difficult or unlawful to perform all at once. The term is typically used pejoratively.

improved anti-space capabilities and signaling that US space assets are at risk and should armed conflict begin, moving rapidly to degrade the US informational advantage from space. There is some discussion in Chinese sources of using limited military actions to shape an incipient conflict in favorable ways, sometimes called "preparation for military struggle." Many of China's military technology programs and organizational reforms are intended to better position the PLA for early action, but the intent is as much to manipulate an opponent's perception of the cost of conflict with China as it is to defeat them in combat. China may miscalculate how much it can get away with, but it plans for limited military action (in duration and geographic extent) rather than larger conflict and its strategies seek coercive effect without violence. In this, China's various border disputes with India, where China a combination of construction, revisions of maps, and the positioning of PLA units, to achieve without firing a shot, may be a good guide to how the PLA would prefer to operate.

Crisis and Miscalculation

The risk to an approach that uses military force for coercive effect while trying to avoid armed conflict comes from the unexpected, from crisis. Chinese writings define crisis as a "state of danger in which there is a possibility of military conflict between nations" (Heath, 2017). This is what China's leaders would prefer to avoid and, if unavoidable, to manage in ways that reduce the risk from confrontation to ensure minimum cost to China's interests. China may be caught in its own narrative of ascendance and American decline. The Party's insularity and relative inexperience in foreign affairs contributes to the risk of miscalculation. Most Chinese, to varying degrees, believe the propaganda they are fed daily. This propaganda shapes their thinking and creates unavoidable tensions between the pragmatic, low risk approach China preferred in the past and the emotional response engendered by appeals to nationalism. Miscalculation by China is as likely to result from domestic politics as form strategic errors.

Many analysts have discussed how the legitimacy of the Party as the sole, unelected ruler of China has come under pressure as the 1949 Revolution grows more distant. Mao and Deng had revolutionary legitimacy; their successors do not, although Xi is striving to reclaim the revolutionary mantle. The Party has adopted other rationales for its continuing, unelected, and unchallenged rule; that is, its essential role in economic growth and in China's return to global power, while playing on the fears of the potential for national fragmentation. The narrative of a China victimized by hostile foreign powers (who have gradually been elided from European imperialists to the United States) during the century of humiliation is a central theme in the Party's rationale for retaining power, as is the themes or China returning to its rightful place at the center of world affairs (and replacing the ailing American hegemon). Nationalism plays an increasing role in the justification for Party rule and creates political dynamics in China that contributes to the risks of unexpected crisis.

So far, China's leaders have been able to balance nationalism with control, using its vast information control effort to turn nationalism on and off as needed. Our concern should be an increasing risk of either aggressive acts by individual People's Liberation Army (PLA) actors or commands (such as flying your fighter into an EP-3), even though Xi has instructed that such incidents be avoided, or a wave of nationalist fervor that threatens the regime's survival. The recent targeting of American aircraft pilots with low-powered lasers from the military base China has established in Djibouti, suggests that as China extends its military presence internationally the risk of unexpected action and miscalculation by the Chinese military will grow. The political risk of nationalism is that it may force Beijing in a crisis to choose between escalation or damage to Party rule. Nationalist fervor may create the political circumstances where China's leaders would need to move to a more aggressive posture, including armed demonstrations or the use of force.

Escalating to the Use of Force

Beijing believes that China is ascendant (and the US in decline). China's leaders believe that the balance of power is shifting in China's favor. In these circumstances, outright armed conflict is best delayed. In only a few circumstances would it make sense for China to use force, and engage in armed conflict with the US. The most likely scenario is that Chinese political requirements could drive escalation more than military strategy, given the Party's need to project continuous ascent to its own population. The gradual encroachment in the South China seas and the positioning of forces in ways the US appeared powerless to prevent may be the model for military conflict China would prefer.

While Beijing believes that the balance of power is shifting in China's favor, China (and Russia) believe that the US has developed or is developing military technologies (including, space, cyber, stealth, precision guided munitions, hypersonic strike) that allow it to achieve strategic effect by crippling command and control and China's strategic forces, without the use of nuclear weapons, effectively undercutting nuclear deterrence. In response, they have developed new weapons to counter (or counterbalance) America's perceived advantages. To the extent it can, it is in China's interest to mask (or exaggerate) these new capabilities for as long as possible.

China's concepts of future warfare calls for operational and tactical offense in the context of strategic defense. Should China decide to engage in armed conflict, it will attempt to use a combination of strike weapons, submarines, anti-satellite, and cyber-attacks to quickly overwhelm opponent forces in the theater of operations. China's military prefers to strike first—preemptively and without warning. The ambiguity and reinterpretation of China's "No First Use" policy reflects this. If the intent is to overwhelm an opponent rapidly, then piecemeal deployment and gradual escalation undercut the chances for success.

In the event of conflict, early attacks on American space assets would be central to China's rapid escalation. China (like our other opponents), believes the US military is dependent on space services and China has developed means to damage or cripple reconnaissance, communications, and navigation using both kinetic and non-kinetic attacks. Having crossed the use-of-force threshold, the next escalatory threshold will be whether to attempt to geographically limit conflict or to strike the American homeland, actions that may produce retaliatory risk that is disproportionate any military benefit such attacks may provide.

Chinese strategists are concerned with "war termination," e.g. ending armed conflict in ways that advance China's interests, but finding a way to terminate a war with the US on favorable terms may present them with unsolvable problems. While the opening phase conflict might see China gain swift local advantage, this would be attractive only if China assumes that any American response will be limited and of short duration, and this assumption makes sense only if there was a collapse of US political resolve. A short, sharp, regional conflict could follow China's timetable for successful conflict termination, but it is a bold assumption that the US would not continue any conflict until it had inflicted significant losses on Chinese forces and regained military advantage. While "gray zone' efforts by China can circumvent America military power, open conflict would bring this power into play in ways that would put Chinese naval, air and space assets at considerable (and at least for now, unacceptable) risk.

Chinese space activities to date have been demonstrations of prowess and national strength while developing operational capabilities, including anti-space capabilities targeted at the United States. China will continue to develop anti-satellite capabilities (and other advanced military capabilities) to narrow the scope for US action and to decrease the likelihood of US success if conflict arises. However,

coercion in space has been difficult to manage and the use of force in space will occur only when China has decided upon armed conflict, something it will for now try to avoid.

Space (and cyberspace) challenge efforts at controlling escalatory risk through geographic limitations to conflict. Chinese writings refer to space as the "commanding heights in strategic competition,"[11] one of the new technologies that (along with cyber) have expanded the domain for conflict. Space occupies an anomalous position, with American space assets providing tempting and vulnerable targets whose destruction would provide real operational advantage, but that also bring the risk of making any conflict "strategic" rather than the limited war China would prefer.

An attack on an American space asset orbiting over China, producing no casualties or dramatic photos, may seem ideal as a demonstration of nationalist resolve. A demonstration of the ability to inflict harm in space without damaging a satellite may be even more attractive as a warning to potential opponents about the danger of conflict with China. However, the experience of the 2007 anti-satellite test, which was badly coordinated within the Chinese government, provoked an unexpectedly hostile global reaction, and led to a US counter-demonstration, show the limits of coercion in space.

China will weigh the value of conflict and escalation from the perspective of advancing its goal to attain dominance in ways that create the least risk for continued party rule. China is uncertain about US military capabilities, overestimates them, and knows these capabilities can inflict immense harm without the use of nuclear weapons. The outcome of any conflict with the US after the initial Chinese move remains uncertain and likely unfavorable, a point the US would do well to emphasize.

The "Bottom Line"

Military tensions between China and the US continue to grow, largely because of China's behavior, and are exacerbated by perceptions of strategic intent on both sides. Pragmatism suggests that China's interests are best served by avoiding armed conflict with the US, while exploiting coercive military actions that stay below the threshold of the use of force. Domestic factors may undercut pragmatism as the Party's leaders maneuver to retain strict control of politics and the economy, but the trend seems to be one of building military capabilities and presence that will eventually position China to force the US to accede to Chinese interests without the use of force.

So, if we were to predict likely Chinese calculations on attacking US space assets, it would be to reserve these attacks to the onset of armed conflict but then to move rapidly and violently to paralyze American decision making. Armed conflict would arrive at the end of a series of incremental moves intended to achieve China's objectives, put the US in an untenable position, and prepare it for success in combat if this was necessary. Armed conflict against the US, within the confines of localized war, would itself not be incremental. We should expect China to employ deterrence, using threat and coercive acts, not only to prevent US attacks but to outmaneuver, outbuild, and displace it.

Conflict with China will intensify, but this conflict will not easily fit paradigms inherited from the Cold War because of China's different strategic culture. The "bottom line" for China is to make progress towards its regional and international objectives without provoking the use of force by its opponents. China uses coercive acts, but has itself avoided the use of force, placing the US in a situation to which it is ill-prepared to respond (Green et al., 2017). In contrast, space is a domain where the US retains an advantage. Coercion is of limited value, action against US space assets requires direct engagement

[11] http://www.xinhuanet.com/english/china/2015-05/26/c_134271001.htm

that greatly increases the risk of escalation. A Chinese attack on space assets would provide benefits only in the event of a war the Chinese cannot reasonable expect to win without significant losses, or even win at all.

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PART II CHINESE PERSPECTIVES ON SPACE

Chapter 4. Space and Information Warfare: A Key Battleground for Information Dominance

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The Evolution of Chinese Thinking on Space: First Gulf War to "Information Dominance"

Throughout the 1990s, even as the Chinese view of future warfare and the role of information was evolving, the PLA was also developing its views on space warfare. Assessing other peoples' wars, the Chinese concluded that future wars would include space warfare as an integral part of operations. This was not so much because of the importance of space systems—due to their growing role in providing the information support necessary for the successful conduct of future local wars—but more because of their performance and requirement under modern, high-technology conditions or informationized conditions.

Indeed, PLA assessments of American and Russian military operations, beginning with the use of space in the first Gulf War, concluded that space-based information played an outsize role. Therefore, in the event of a conflict, the PRC must strive to deny an adversary the ability to use space freely.

In particular, the PRC's shift towards joint operations, which began in the 1990s, highlighted the importance of space. As envisioned by the PLA, joint operations would involve multiple services operating together across significant distances. The Gulf War, for example, sprawled across some 140 million square kilometers, and included forces ranging from armored units to aircraft carriers and long-range bombers (Wang & Zhang, 2000, p. 400). The ability to coordinate such diverse forces spread across a variety of domains would therefore require not only extensive communications, but also precise navigation and positioning information, both for units and for the growing plethora of precision munitions. Joint operations were therefore seen as requiring the ability to command and control operations across not only the traditional domains of land, sea, and air, but increasingly outer space.

In this light, space capabilities were recognized as playing an essential role in any effort to wage a "local war under modern, high-tech conditions." According to PLA estimates, the 70 satellites that were ultimately brought to bear against Iraq provided the US with 90% of its strategic intelligence, and carried 70% of all transmitted data for Coalition forces (Gao, 2001, p. 54). Indeed, these assets were the first to be employed, since they were essential for the success of all subsequent campaign activities. As one Chinese analyst observed, "Before the troops and horses move, the satellites are already moving" (Gao, 2005). PRC writings from the mid-1990s through the early 2000s reflect a steady evolution from seeing space as important to seeing it as decisive (See PLA Encyclopedia Committee, 1997, 2002).

Given the importance of such support from space systems, victory in future "local wars under modern, high-technology conditions" was already recognized as requiring not only one's own unfettered access to space, but also the denial of the same ability to the adversary. By preventing the enemy from obtaining the amount of information they required, it would be far more difficult for them to coordinate their forces and operations. As important, by preventing them from operating in the manner to which they were accustomed (and had trained), they would be far less efficient and flexible, and therefore more vulnerable to Chinese actions. In effect, by degrading adversary space capabilities, the enemy would suffer from a slower OODA (observe-orient-decide-act) loop. Space information support was therefore increasingly seen as complemented by offensive space operations (which somewhat aligns with Western concepts of counter-space operations).

This shift may also have been a reflection of the ongoing development of Chinese concepts of future warfare. As part of the PLA's "new historic missions," Hu Jintao in 2004 made clear that the PLA must secure China's interests in outer space, as well as the electromagnetic spectrum (2004). The incorporation of the space domain into the specific range of PLA responsibilities reflected the steadily growing emphasis placed upon establishing space dominance, as part of the larger effort to secure information dominance.

Indeed, as the PLA shifted from preparing to fight "local wars under modern, high-technology conditions" to fighting "local wars under informationized conditions," space was increasingly seen as part of those "informationized conditions." As PLA writings note, "informationized conditions" did not simply refer to computers and cyberwarfare. Instead, it involves the acquisition, transmission, and exploitation of all forms of information. Space plays a central role in all these tasks. In the 2006 edition of *The Science of Campaigns*, it is specifically stated that "the space domain daily is becoming a vital battle-space…. Space has already become the new strategic high ground" (Zhang, 2006, p. 87).

Similarly, in the 2013 edition of *The Science of Military Strategy*, space is deemed the "high ground in wars under informationized conditions," tied to the struggles in networks space and the electromagnetic spectrum as key future battlegrounds (Academy of Military Science Military Strategy Research Office, 2013, p. 146-147). In the Chinese conception, space is important for the advantage it confers with regards to the ability to collect, transmit, and exploit information, rather than for its own sake. As other Chinese analysts conclude, "space operations will be a core means of establishing information advantage" (Yuan, 2008, p. 324).

Chinese military planners are therefore preparing to undertake a range of space actions, should that be necessary. That readiness is facilitated by the reality that the PLA runs China's space facilities.[12] These include a range of anti-satellite tests in 2007, 2010, and 2013. This last test is especially notable, as it is assessed as demonstrating an ability to threaten targets as far as the geosynchronous belt, over 26,000 miles away (Weeden, 2014). This is the first time that any nation has tested a weapon explicitly intended to hold satellites in that orbit at risk.

The ability to hold at risk the entire range of orbital regimes is tied to the Chinese emphasis on establishing "information dominance" in order to win future conflicts. Chinese analysts have long recognized, since at least the first Gulf War twenty-five years ago, that space is a key means of

[12] Up until December 31, 2015, the PLA was managed by several General Departments which oversee all the armed forces, including all the services. These were the General Staff Department (GSD), the General Political Department (GPD), the General Logistics Department (GLD), and since 1998 the General Armaments Department (GAD). These Departments comprised the membership of the Central Military Commission (CMC) until 2004, when the PLA Navy, PLA Air Force, and Second Artillery were added to the CMC.

providing information support to terrestrial forces. Consequently, the emphasis upon establishing space dominance, as part of the struggle for information dominance, has become more explicit.

Chinese authors believe that without space dominance, one cannot obtain information dominance and aerial dominance, and therefore one cannot achieve land or maritime dominance. Space will therefore inevitably be a battleground, if only in order to deny an adversary the ability to use it freely (Ye, 2007, p. 154). Consequently, the space arena will be one of the very first scenes of conflict, as the two sides struggle for control of space. Neither side can afford to neglect this theater, as it will be a central determinant of who will secure information dominance (Chi & Xiao, 2005, p. 38-39).

Space dominance entails not only the ability to provide information support to the PLA, but also to deny an adversary the ability to exploit space to gain information. The American reliance on space systems, in particular, has been remarked upon in various Chinese military writings. Nor is American dependence upon space unique, in the Chinese view. PLA writings indicate that they are also closely observing other nations' space developments. Russian space developments in particular seem to garner heavy Chinese attention. The Chinese military textbook *Military Astronautics* discusses Russian as well as American aerospace forces (Chang, 2005, p. 219-220). The 2013 edition of *The Science of Military Strategy* observes that Russia has made space a major focus of its military refurbishment effort, and that Moscow has increased its investments in the space sector as the Russian economy has improved (Academy of Military Science Military Strategy Research Office, 2013, p. 180).

Five Styles of Military Space Operations

PLA analysts believe that military space operations are likely to entail five broad "styles (*yangshi*; 样式)" or mission areas: space deterrence, space blockades, space strike operations, space defense operations, and provision of space information support (this section draws upon Jiang, 2013, p. 126-154). It is important to recognize that such operations will most likely not be undertaken by themselves, but in the context of a larger, joint campaign. Nonetheless, the purpose of all such operations is ultimately to effect information dominance by securing space dominance.

Two areas of particular note for this study are space deterrence and space blockade.

A Deterrence or Escalation Ladder

Space deterrence is 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. Space deterrence incorporates a "deterrence ladder," roughly analogous to an "escalation ladder." The rungs include:

Displays of space forces and weapons (kongjian liliang xianshi; 空间力量显示). Such displays involve the use of various forms of media to highlight one's space forces, and are ideally complemented by political and diplomatic gestures and actions, such as inviting foreign military attaches to attend weapons tests and demonstrations.

Military space exercises (kongjian junshi yanxi; 空间军事演习) are undertaken as a crisis escalates, if displays of space forces and weapons are insufficient to compel an opponent to alter course. They can involve actual forces or computer simulations, and are intended to demonstrate one's capabilities but also military preparations and readiness.

Space force deployments (kongjian liliang bushu; 空间力量部署). This involves moving assets that are already in orbit and/or reinforcing current assets with additional platforms and systems. It is intended to create local superiority of forces so that an opponent will clearly be in an inferior position, and is seen as a significant escalation of space deterrent efforts.

The Chinese term the final step of space deterrence as "*space shock and awe strikes (kongjian zhenshe daji*; 空间震慑打击)." If the three previous, non-violent deterrent measures are insufficient, then the PLA suggests engaging in punitive strikes, so as to warn an opponent that one is prepared for full-blown, comprehensive conflict in defense of the nation. Such strikes are seen as "the highest, and final technique (*zuigao xingshi he zui hou shouduan*; 最高形式和最后手段)" in seeking to deter and dissuade an opponent.

It is important to note here that the Chinese concept of space deterrence is not focused on deterring an adversary from conducting attacks against China's space infrastructure, per se. Instead, it is focused on employing space systems as a means of influencing the adversary's overall perceptions, in order to dissuade or compel them into acceding to Chinese goals. Thus, it is not so much deterrence ***in*** space, as deterrence ***through space means***.

Space Blockade

Space blockades involve the use of space and terrestrial forces to prevent an opponent from entering space, and from gathering or transmitting information through space. There are several different varieties of space blockade activities.

One is to *blockade terrestrial space facilities*, including launch sites; tracking, telemetry, and control (TT&C) sites; and mission control centers. They can be disrupted through the use of kinetic means (e.g., special forces, missiles), or through computer and information network interference.

Another means is to *obstruct orbits*. This can include actually destroying satellites that are in orbit, or else obstructing orbits, such as by creating clouds of space debris or deploying space mines. By threatening the destruction of adversary satellites (without necessarily doing so), one might limit the function of those satellites (e.g., by limiting their maneuvers).

Another alternative is *the obstruction of launch windows*. If one can delay a launch, whether through interfering with its onboard systems or otherwise disrupting the schedule, then a satellite may not be able to reach its proper orbit.

Finally, one can impose an *information blockade*. These include disrupting data links between satellites and ground stations; interfering with the satellite's data transmissions; tampering with the satellite's control software; or damaging the satellite's sensors. In each case, the intent is to effect a "mission kill," whereby the satellite cannot perform its functions, but is not necessarily destroyed.

Holistic Approach

Whether it is space deterrence, space blockade, space offensive operations, or space defensive operations, the Chinese pursue a holistic approach. Securing space dominance includes attack and defense of not only orbital systems, but also terrestrial facilities (launch sites, mission control centers), and the data and TT&C links that bind the entire structure together. Similarly, the Chinese see soft- and hard-kill against the full range of targets as an integrated portfolio of options.

For the PLA and Chinese security decision-makers, the Information Age and the Space Age are inextricably linked. Both have been heavily influenced by the growth in computing power and the role of telecommunications. Indeed, China's first series of satellites, the Dongfanghong-2, were communications satellites, rather than early warning satellites. Consequently, "seizing the space information advantage as a high ground is the first decisive condition for seizing information dominance, space dominance, air dominance, naval dominance, land dominance, and therefore the initiative in wartime" (Lanzhou Military Region Headquarters Communications Department, 2003).

Asymmetric Dependence on Space in "Local Wars"

For Chinese military planners, the importance of space is further underscored by certain geographic and strategic realities. China, even now, is not oriented towards mounting extensive military operations far from its shores, but remains focused on such flashpoints as Taiwan, the Korean peninsula, the South China Sea, and the Sino-Indian border. For the PRC, the consistent concern since the 1980s has been on "local wars." Such wars are not only limited in means, but also are expected to occur mainly on China's periphery.

Consequently, the PLA can bring to bear substantial resources, drawn from across the entire country if necessary, in order to establish information dominance. Mobilized civilian assets, ranging from fishing boats for maritime surveillance to the militia for camouflage and deception operations, can supplement regular PLA forces. Shorter-range assets from fast attack craft to older fighter aircraft can similarly be employed to deny and counter adversary forces, including information collection platforms. Communications can be sustained through fiber optic cable (which is difficult to monitor), cell phones, line-of-sight radios, as well as satellite communications, enhancing communications security and providing redundancy. In many ways, China does not need space for the PLA to operate in accordance with its doctrine.

By contrast, the United States is an expeditionary military, operating far from American shores. In time of conflict, it is therefore much more reliant upon space-based systems even for operational communications, especially to coordinate disparate, separated forces, as well as for intelligence collection against targets typically halfway around the globe. As important, American military planners have chosen to rely on space-based assets for positioning, navigation, and timing, whether it is aircraft routing, shipborne navigation, or weapons guidance. The combination of geostrategic conditions and weapons acquisition policies make American forces much more dependent upon space.

In short, in the struggle for information dominance, because of the asymmetric strategies and starting conditions, there is a resulting asymmetric dependence on space.

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Chapter 5. The Nine Distinctions

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When we ask about US and Chinese differences in thinking about space, mirror imaging can be dangerous. Certainly, there are similarities with US thinking.[13] But what concerns me is where I think China is right and where the differences with the US occur. So, I want to talk through nine distinctions that matter in terms of how we understand the Chinese view.

Nine Distinctions: Where China has it Right and China Differs from the US

1. Status Quo vs Revisionist: The US is a status quo power, while China is a revisionist power. The US wants to continue to protect its position and protect our freedom to intervene in the areas that China would consider its near-abroad. The US wants a free hand to affect interests around the globe while paying no cost in space. In addition, as the hegemon, the US has to pursue global public goods and disproportionately shoulder a position of environmental stewardship regarding debris. The US must also show restraint [in anti-satellite operations] so as not to encourage others to "build stones against our glass houses." On the other hand, China seeks to expand its power to control and influence their status in all domains.
2. Functional vs. Geographic: China views space strategically different compared to the United States. The US thinks about space principally in terms of functionality. While I agree that the PRC have very strong linkages between how they view space and its information importance in warfare, I think the key difference is that to a greater extent that I think than we, in the US military side are thinking about it, China thinks of space geographically. This is a healthier balance. I think this forms a very key difference in space, where we have to draw a fairly significant distinction between how China looks at cyber and nuclear. I think that in many ways, it is important to understand China's behavior, and that the US should be concerned with the Chinese. I suspect that over time, we will see continuity in how China approaches territorial consolidation, not only in their near-abroad but also in space.

[13] Certainly, China sees space as a place of U.S. vulnerability. That word—vulnerability—came up over-and-over when I visited China. Certainly, space is a place where they will threaten to impose costs, so as to avoid U.S. intervention in other domains, like air and sea. Certainly, China recognizes that the U.S. has more to lose in space--both in terms of military cost, as well as to larger societal costs, and China might perceive that it has vertical escalation dominance if a conflict could be confined to the space domain. Certainly, Chinese recognize how integral space is to the U.S. and how losing space capabilities pulls apart other functions in the other domains. So, there is certainly a dominant strategy where they can hope to deter intervention by threatening space, and if the US is not deterred, to pull apart the force multipliers that underpin our advantage. Certainly, their use of information dominance--to make their own forces more "Joint", to consider "non-contact, long-range conflict"--these are fairly symmetric. Moreover, I think they start from a position of few regrets, that "no mother cries for a dead satellite on orbit."

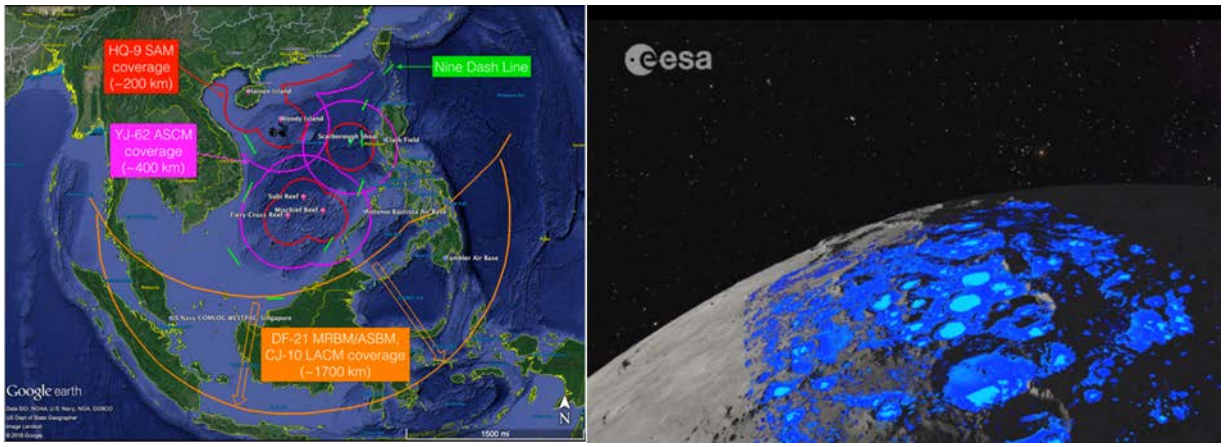

Figure 5.1. Military Geography SCS Islands (Wang, 2016) and Lunar Solar and Water Resources at Pole (European Space Agency, 2017).

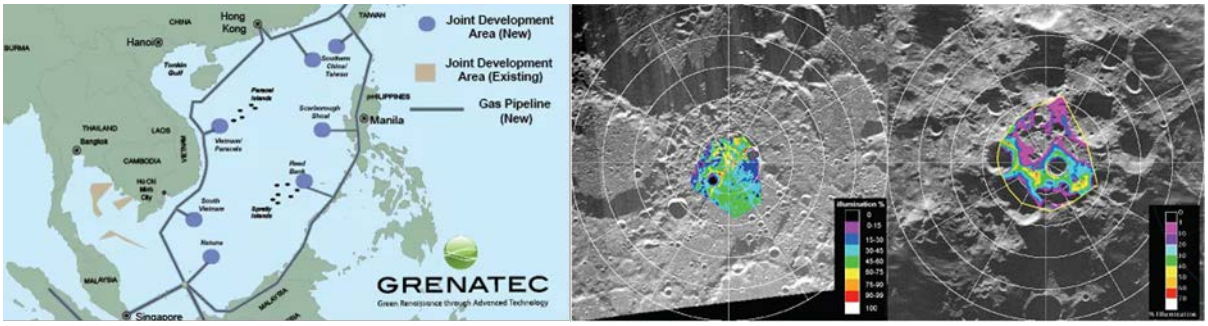

Figure 5.2. Fossil Fuel Resources in SCS (Taggart, 2016) and Lunar Fuel and Energy Rich Zones (Wingo, 2008)

The Chinese are also viewing space as a place that has valuable things to go and get—just like an island in the South China Sea. The Moon and the poles of the Moon in particular have the kind of utility that Hawaii or the Rock of Gibraltar might have. That there are places that allow you to constrain logistics that allow you to have the equivalent of coaling stations that give you territories, from which national power emerges. One example is their interest in the potential viability of extracting helium three, which is a fusion fuel (Beck, 2016). Another is that if you can launch from the moon, it is 22 times less energy and everything you need is available to build solar powered satellites.[14] If you can build a solar powered satellite, you can completely shift all the power dynamics on Earth.[15] Given the substantial energy resources in space, the Chinese are going to think about the Moon less in terms of information and like the islands on the South China Sea. Above are two illustrations. Figure 5.1 looks at the military geography of the South China Sea compared to one of the lunar poles with a geography of comparable advantage. Figure 5.2 showcases key fossil fuel resources in the South China Sea compared to a resource map of the Lunar Poles assessed to be rich in resources (water & sunlight).

[14] Numerous articles exist on the PRC Space Solar Power program. http://billionyearplan.blogspot.com/2011/09/china-unveils-plan-to-orbit-solar-power.html

[15] For example: *"The development of a solar power station in space will fundamentally change the way in which people exploit and obtain power," Professor Wang Xiji to CAS"Whoever takes the lead in the development and utilization of clean and renewable energy and the space and aviation industry will be the world leader" cited at http://billionyearplan.blogspot.com/2011/09/*

3. Conventional vs Irregular (Insurgent): I think that we start from a position that is very conventional whereas I think they start from a more insurgent or irregular framework. The PLA was birthed as an insurgent force. We are thinking about fostering and specifically trying to limit a war whereas, they are looking at actions to compel or deter as part of a larger political strategy that is on a political offensive. So, they have an insurgent mindset where they are trying to change the system in important ways and space is going to provide them with some interesting direction to go. In contrast, the United States, with its conventional military culture, is somewhat uncomfortable with unconventional approaches—and is certainly not well organized to do gray zone conflict deliberately designed to be below the level of war.

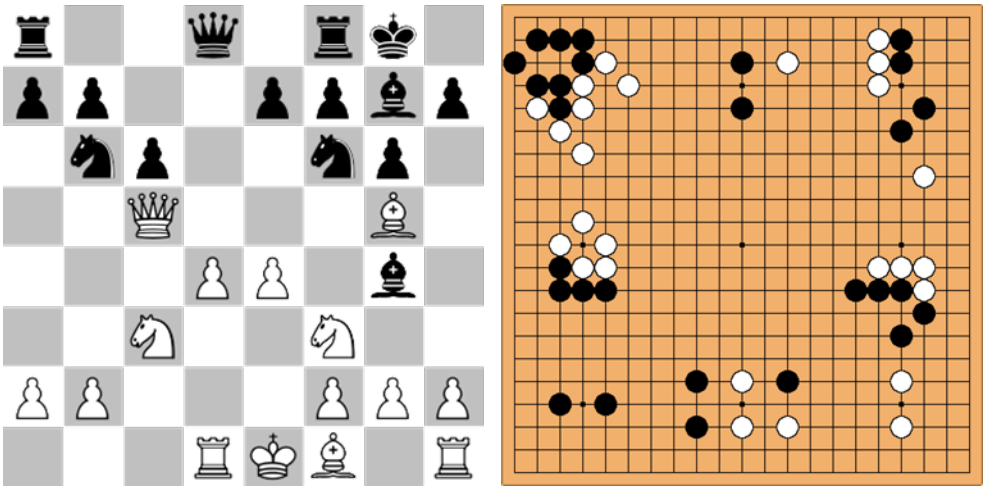

Figure 5.3. Chess Board[16] vs Go Board[17]

4. Chess (Maneuver/Attrition) vs. Go (Additive/Linking/Encircling): US military thinking about war fighting is maneuverist and attritive or subtractive, where, like chess, you are constantly removing pieces from the board. The Chinese, however, start their thinking in terms of preparation, in a way very similar to their game of Go, where it is positional and additive. Our bias is toward maneuver, while their bias is towards position. What has been and will be important in viewing Chinese behavior, is that they try to take up the position and reinforce their legitimacy and then later, they take up a military position to defend that. You can see this behavior their One Belt One Road (OBOR) initiative, such as in the South China Sea where they are changing geography by creating artificial islands.
5. Present vs. Future Focus: There is a difference in focus on present versus future, which is largely because China has the initiative over whether or not to pursue some aggressive goal in its near-abroad. The US is very concerned about PRC threats in the present. While the PRC is very slowly building to "win without fighting." When you think through the differences in how we think about conflict, I think US thinks that, "Hey, the supreme word of victory is to crush your opponent" whereas for them there's this Sun Tzu dictum that you don't even go to war unless you've already

[16] Image from http://images-free.net/content/black-and-white-chess.html
[17] Image from https://senseis.xmp.net/?LargeBoards

won[18], and that supreme excellence consists in subduing your enemy without fighting.[19] I think that they have the luxury on their end of being able to take a longer view in designing for compellence and coercion less in the present and more in the future. Not to say that they're not already doing it successfully meeting some of their ends today, but I think to a certain extent we have mistaken on what is "the larger muscle movement" here, and I'll talk more about that in a bit.

6. Divided Lanes vs. Comprehensive Spacepower: The key difference in how we think about space and how they think about it is divided lanes versus integrated. On our end, we are structurally configured so that our space capabilities are split into intelligence organizations, civil space organizations, military capabilities, and a largely unmanaged commercial sphere. Whereas China is organizationally much more integrated to look at space as comprehensive power, and that is going to have important possibilities for the future.

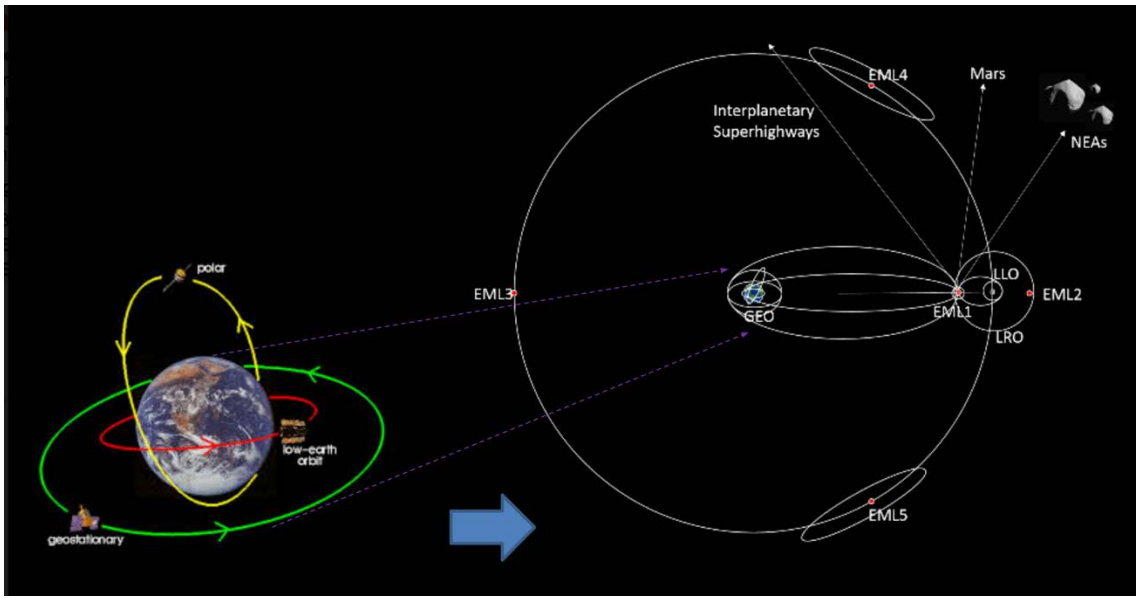

Figure 5.4. A Geo-Centric vs Cis-Lunar View

7. Geocentric vs. Cis-Lunar: Another difference, at least in terms of a strategic offensive, is that our thinking about space is extremely geocentric. However, whilst we look at the ability of space to affect things on the Earth, China is much more able to think about space in a broader sense. They are certainly thinking about a cislunar perspective, out to the Moon.[20]

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[18] Victorious warriors win first and then go to war, while defeated warriors go to war first and then seek to win. Sun Tzu; Thus it is that in war the victorious strategist only seeks battle after the victory has been won, whereas he who is destined to defeat first fights and afterwards looks for victory. Sun Tzu; The art of war teaches us to rely not on the likelihood of the enemy's not coming, but on our own readiness to receive him; not on the chance of his not attacking, but rather on the fact that we have made our position unassailable. Sun Tzu

[19] Supreme excellence consists in breaking the enemy's resistance without fighting. Sun Tzu; The supreme art of war is to subdue the enemy without fighting. Sun Tzu; In the practical art of war, the best thing of all is to take the enemy's country whole and intact; to shatter and destroy it is not so good. Sun Tzu

[20] For example, *"The Moon could serve as a new and tremendous supplier of energy and resources for human beings… This is crucial to sustainable development of human beings on Earth…Whoever first conquers the Moon will benefit first."* -- Ouyang Ziyuan, chief scientist of China's Moon exploration program, Chinese Academy of Sciences (CAS) and *"Our long-term goal is to explore, land and settle* [the Moon]"—Wu Weiren, Chief Designer

8. Prestige & Nuclear vs Industrial & Economic: The United States, because of its Cold War history, principally looks at space through the lens of nuclear, prestige, and strategic Intelligence, Surveillance, and Reconnaissance (ISR). The Chinese certainly recognize those benefits, but their dominant lens for viewing space is through economic and industrial might that space provides to military capabilities in general.
9. Strategic Strength vs. Tactical Engagement: There are two things that should concern the US. First, is the lesser problem of "how do we deter them from using an obvious advantage of attacking our vulnerable high payoff satellites so that we can intervene and maintain the status quo in our favor?" Second is the more important question of "how do we answer their challenge on space industrialization and development, which threatens to establish an industrial and logistical system that's supplants our dominant position in space?" However, this second threat is both unrecognized by national and DoD leadership; and it also exists in a "somebody else's problem (SEP) field." As *The Hitchhiker's Guide to the Galaxy* novels describe, invisibility is very hard, but what's remarkably easy is to establish a "somebody else's problem field,"[21] where you just walk by because it's not my problem. Here, the DoD does not consider it within its job to maintain parity in space exploitation and development, and only considers what could be current military threats. Further, NASA does not consider geopolitical elbowing and a larger logistical capabilities as within their sphere. Moreover, even if we recognize it as a national security problem, the civil and commercial aspects which are so crucial to success lie outside the DoD's control.

The Real Threat: "One Ladder" into Space

In summary, we have a sort of an insurgency, waged in a public space, with displays of grandeur to establish legitimacy—to pursue a sort of "mandate of heaven" in the regions above—that extends the "one belt, one road" concept into "one ladder" into space.

Thus, I'm concerned that we don't even see the right threats. The threat that we focus on is "what if something in the South China Sea, for instance, extends into space?" But the true threat to our larger national interest are China's attempts to build a cislunar architecture, which would bring far more important capabilities and establish industrial logistical systems.

I liken this to the age of exploration. You could have found people worrying about the effect of shore-to-ship artillery. But what ought to really concern you is that an opponent was planning and financing trips to the New World to establish colonies, and was developing a global navigation capability.

The key difference is the Chinese primacy of logistical, positional infrastructure in their strategic approach to building of strength: first, you build up your own strength, and then, once that strength is there, you can provide compellence. The US must recognize that this underlying effort to build

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Moon Missions CNSA and "China would next begin to exploit Earth-Moon space for industrial development." – Lt Gen Zhang Yulin, PLA

[21] An S.E.P. field can be found in Chapter 3 of Douglas Adam's Life, The Universe and Everything (Hitchhiker's Guide to the Galaxy)(Del Rey, 1995). "Somebody Else's Problem field, or SEP, is a cheap, easy, and staggeringly useful way of safely protecting something from unwanted eyes. It can run almost indefinitely on a torch (flashlight)/9 volt battery, and is able to do so because it utilises a person's natural tendency to ignore things they don't easily accept, like, for example, aliens at a cricket match. Any object around which an S.E.P. is applied will cease to be noticed, because any problems one may have understanding it (and therefore accepting its existence) become Somebody Else's Problem. An object becomes not so much invisible as unnoticed." From: http://hitchhikers.wikia.com/wiki/Somebody_Else%27s_Problem_field

roads for wealth in the beyond,[22] otherwise why they "Slough off the cicada's golden shell"[23] these cislunar efforts will form an outflanking maneuver. One illustration of this confluence of thinking is Lt. Gen. Zhang Yulin's dual role as a military officer and deputy of their lunar exploration program (Pollpeter, Chase, & Heginbotham, 2017).[24] As stated by Lt Gen Zhang: "*China would next begin to exploit Earth, moon, space for industrial development. The goal would be the construction of space solar power satellites that would beam energy back to Earth*" (Whittington, 2016).

China has vast ambitions (see Goswami, 2018) to access the material and energy resources available in the space domain and use those resources to sustain national advantage through a linked industrial-military strategy. That cannot but have significant consequences.

We're Playing Chess, They're Playing Go. Have They Already Set Up to Win?

This game is not unwinnable. To quote a beautiful line from Sun Tzu, "*The opportunity to secure ourselves against defeat lies in our own hands*."[25] They are not 10 ft. tall. But the key problem is that we need to recognize this alternate avenue of competition that might be absolutely essential to how they are posturing themselves for long-term strength deterrence and compellence—which is to create the infrastructure and the position of power. Because of our biases, we are letting it happen without putting down our own Go pieces. That becomes a problem over time.

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[22] "To become rich, one must first build roads."—Chinese proverb; Be not afraid of going slowly; be only afraid of standing still.—Chinese proverb; We can move the entire mountain one piece at a time.—Chinese proverb; An iron rod can be ground down to become a needle.—Chinese proverb; Each generation will reap what the former generation has sown. To enjoy the benefits of one's predecessors.—Chinese proverb; "Industries are the roots; culture and statecraft the flowers of a nation," says a Chinese proverb; Before an army [starts] moving, it has to have provisions—Chinese proverb

[23] "Slough off the cicada's golden shell (金蟬脫殼／金蝉脱壳, Jīn chán tuō qiào) Mask yourself. Either leave one's distinctive traits behind, thus becoming inconspicuous, or masquerade as something or someone else. This strategy is mainly used to escape from enemy of superior strength." From the 36 Strategems, https://en.wikipedia.org/wiki/Thirty-Six_Stratagems

[24] PLA Strategic Support Force Deputy Commander Maj Gen Liu Shangfu is also deputy commander of China's lunar exploration program.

[25] From BrainyQuote, https://www.brainyquote.com/quotes/sun_tzu_398639

http://www.airuniversity.af.mil/Portals/10/SSQ/documents/Volume-12_Issue-1/Goswami.pdf

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Chapter 6. China's Strategy and Goals in Space

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Chinese policy circles view outer-space policy and goals as akin to the 1940s 'spirit of the Long March' that liberated China from Japanese occupation and established the People's Republic of China in 1949 (Lau, 2016). Those within the Communist Party of China (CPC) call this the 'spirit of aerospace' and believe this spirit will lead to rejuvenation of the Chinese nation (Mai, 2017). In 2016, China's top policymaker in space, General Zhang Yulin, former Deputy Chief of the Armament Development Department of the Central Military Commission, now the PLA's Strategic Support Force (SSF) asserted that "The earth-moon space will be strategically important for the great rejuvenation of the Chinese nation" ("Exploring Earth-Moon Space," 2016). This thrust on outer space has the personal support of President Xi Jinping, who views China's space policy and goals as integral part of China's national development and security goals ("Backgrounder," 2017; "China says space program," 2016). In his report to the 19th National Congress of the CPC in 2017, Xi highlighted the critical need to turn the PLA into a force capable of domination in the air, sea, land and space domain by 2050.[26] On April 24, 2018, on China's third Space Day celebration, China National Space Administration (CNSA) released a video stating China's ambitions to build a lunar colony by 2030 ("China video on lunar base,2018). Ye Peijian, head of China's Lunar Mission stated that,

> The universe is an ocean, the moon is the Diaoyu Islands, Mars is Huangyan Island. If we don't go there now even though we're capable of doing so, then we will be blamed by our descendants. If others go there, then they will take over, and you won't be able to go even if you want to. This is reason enough ("Space: The next South China Sea," 2018).

This strategic shift in rewarding space achievements is visible in Xi's promotion of space scientists to plum political positions that would earlier have gone to local party leaders. For instance, in 2016, former General Manager of the China Aerospace Science and Technology Corporation, Ma Xingrui, was made Governor of Guangdong, China's largest economic province; and in 2017 with Yuan Jiajun, former China Academy of Space Technology president, was appointed acting governor of Zhejiang, the power base of President Xi Jinping (Mai, 2017).

Given this rise in the 'spirit of aerospace' and 'space dream' ("Space exploration part of Chinese dream", 2013), it is useful to ask: how is this reflected in China's strategy regarding outer-space? Here I first describe three Chinese goals in space, and then describe the Chinese strategy to achieve these goals.

[26] Full Text of Xi Jinping's Report at 19th CPC National Congress, China Daily, November 4, 2017 at http://www.chinadaily.com.cn/china/19thcpcnationalcongress/2017-11/04/content_34115212.htm (Accessed on August 8, 2018).

China's Goals in Space

China's long-term goals in space fall under three distinctive categories. First, their long-term investment in space-based resources. Second, their utilization of space for diplomacy. Third, their development of space capacity for military advantage. I discuss each in turn.

Space-based resources

China's discourse on space is changing from one determined more by 'prestige-seeking,' to one based more on generating capacity and resources for space industrialization. Given the vast economic potential that lies in outer space resources, China is already shifting a major part of its resources to invest in research on Space Based Solar Power (SBSP), Asteroid Mining, and developing capacity for permanent presence in space (Goswami, 2018a). The China Academy of Space Technology have established a timeline to achieve the first commercial level SPS in Geosynchronous Earth Orbit (GEO), by 2050. Given that China met its previous space goals within the 20-year timeline they had set themselves, including manned missions and indigenously building cargo space craft, I argue that the SBSP goals will be tackled with equal determination (Goswami, 2018a; Wenyu, 2017).

One of the biggest advocates of SBSP is Wang Xiji, the chief designer of China's fist rocket, the Long March 1. Li Ming, Vice President of CAST, believes that once China establishes a permanent space station by 2020-22, it will open pathways for space solar power and deep space exploration. Long Lehua, the chief designer of China's carrier rockets, at China Academy of Launch Vehicle Technology (CALT) supports this perspective. He specifies that China is aiming to build low cost vehicles that can enter space rapidly and promote a commercial space industry. Asteroid mining is now reflected in China's White paper on space and viewed as an integral part of China's national strategy ("Riding an asteroid," 2017; "China's space activities," 2016). Pei Zhaoyu, Deputy Director of the Lunar Exploration and Space Program at China National Space Administration (CNSA) stated that China is planning four step deep space exploration missions before 2030, including probes to MARS, asteroids and Jupiter China outlines roadmap," 2018).

Space as a diplomatic tool

China views its space program as an integral part of its diplomacy, to include creating leverage, build reputation, and craft international partnerships. Regionally, Xu Dazhe, Vice Minister of China's Ministry of Industry and Information Technology, specified that China views its international space activities as part of the "One Belt One Road" initiative and aims to build an Asia-Pacific focused space cooperation ("SCIO briefing," 2016).

China has also extended its space diplomacy globally. On 28 May 28 2018, China announced that, in cooperation with the United Nations Office for Outer Space Affairs, its space station is open for participation by all UN member states (Goswami, 2018b). This UN body's involvement adds credibility to China's efforts. Applications to participate in scientific experiments on the space station were also extended to academia, private and public companies (United Nations Office for Outer Space Resources, 2018). Significantly, all such applications will be screened by China's space agency and will be woven into a bilateral agreement.

In an interview with China Central Television, Bai Mingsheng, chief designer of China's first cargo spacecraft Tianzhou-1, said, "China might be the only country that will run a space station in the foreseeable future. We could invite other nations to carry out experiments on [our] space station, making it an international scientific platform for all humankind" (China's space station, 2017).

Space as military advantage

Thirdly, China aims to develop space capacity for military advantage. China has already developed its anti-satellite program to the point where it has demonstrated its capability to destroy a satellite in 2007. China is deeply concerned with US missile defense and views the United States dependency on satellites for military operations a vulnerability in case a conflict breaks out. Thinkers within China, like Wang Cheng, noted in a July 5, 2000, article "The US Military's 'Soft Ribs,' A Strategic Weakness," that "For countries that can never win a war with the US by using the method of tanks and planes, attacking the US space system may be an irresistible and most tempting choice" (Pontin, 2007).

The institutional arrangements to build military capacity are already in place, with China recently creating a Strategic Support Force (SSF). This SSF forms a fifth military arm, besides its army, navy, air force and Rocket Force.[27] China's SSF is tasked with space, cyber, and electronic warfare, and strengthening the PLA's joint operations. The basic strategy behind its space force is to create military advantage for itself in the strategic frontier of space that could have cumulative impact for a conflict with the US on earth (Kania, 2017). While inspecting the SSF in August 2016, Xi stated that "the strategic support force is a new type of combat force to secure national security and an important aspect of the PLA's joint operations system" ("Strive to build a strong modern SSF", 2016). The SSF is guided by the policy document "Innovative Development 20" that lays stress on a technology-intensive force to deal with future combat scenarios, across the space, cyber and electromagnetic domain ("Innovation drives a new quality combat engine", 2016).

China's Strategy to Achieve These Goals

Below I outline five aspects of the strategy by which China will seek to achieve these goals. Firstly, China's strategy seeks to use an incremental approach to develop its space capacities for both civilian and military use. Start by establishing a permanent space presence, and once accomplished, further invest in deep space exploration. Developing, for instance, nuclear propelled space crafts by 2040, as was reported on the front page of the *People's Daily* ("China to achieve Major Breakthrough", 2017), aimed for mining asteroids and deep space exploration, could serve both purposes; space exploration and rapid military presence (Chen, 2017). With an anticipated launch date in 2020, the Long March 8, China's heavy lift rocket, is a significant addition.

Secondly, China aims to build legitimacy for its presence and activities in space. For instance, offering the use of its space station to the world helps creates stakeholders in its space program. Like China's OBOR where economic presence then creates the need for military support and protection of its projects in foreign countries, it would only seem logical that China's growing economic presence in space will have to be protected from potential threats (Kania, 2017, p. 50).

China also aims to build legitimacy by constituting norms, in particular through the 'first presence' rationale as it has done regarding its claims to the South China Sea islands (Chang, 1991). For instance, consider a situation where China comes into possession of an asteroid rich in minerals worth billions of dollars. If a fellow explorer also claimed the right to exploit that asteroid, how would such a dispute be resolved?

[27] For more analyses, please see Kevin L. Pollpetter, et.al. (2017). The creation of the PLA's Strategic Support Force and its implications for Chinese military space operations, *RAND.* Retrieved from https://www.rand.org/pubs/research_reports/RR2058.html

China's initiatives in space include legitimization processes by cooperating with international agencies like the UN, build partnerships with countries along the OBOR route, (China and Romania already have a Memorandum of Understanding (MoU) on space), and then constitute an alternative regime for resolving disputes that arise in a Chinese-led space sector. This aspiration to be the global leader in space technology by 2045 was brought out in a report by the China Aerospace Science and Technology Corp (CASC) in November 2017 (China aim to be world-leading, 2017).

Third, by becoming the global leader in specific space technologies, China aims to develop and lead the norms and regulations for outer-space once such technologies become common-place. One example is work on human settlement of space, such as testing the biology of mouse embryos in space. Another is quantum computing, particularly for communications. Regarding its OBOR initiatives on earth, China plans to establish dispute resolution mechanisms to settle differences for OBOR countries—for which the headquarters of this would be in Beijing with branches in Xi'an and Shenzhen (Lu & He, 2018)—and a similar exercise is plausible regarding a China led space sector.

Fourth, regarding their space force, the strategic thinking will likely draw on ideas of both 'area denial' and 'active defense.' Official Chinese narratives claim their military culture is mostly defensive, and such a similar rationale will be utilized regarding their growing civilian and military space capacity.

Fifth, civil-military integration in space. In China, the People's Liberation Army (PLA) is the military arm of the CPC. The PLA acts in defense of both the Chinese state and the party. One would anticipate this broader principle to also apply in the space domain.

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PART III FURTHER CORE DIMENSIONS

Chapter 7. A Japanese Perspective on Space Deterrence and the Role of the Japan-US Alliance in Sino-US Escalation Management

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Targeting space assets is an attractive option for adversaries. They are vulnerable but critically important for military operations, so there are a lot of incentives for attacking space systems. Their vulnerability means they needs to be protected by deterrence, but space-for-space retaliation does is problematic. Thus, resilience and declaratory policy regarding thresholds and measures of response play an important role for managing escalation management in space.

Here, I consider space operations from a Japanese perspective and focus on three areas:

(1) Space in "Gray Zone conflict;"
(2) Escalation management;
(3) The Japan-US alliance: this not only aids the US through Space Situational Awareness (SSA) data sharing, but also through improved resilience and collective retaliation.

"Gray-Zone" Conflict

One of the highlights of the Japanese National Security Strategy (NSS), approved in December 2013, is the issue of "gray-zone" conflict (Ministry of Defense, 2016). Gray Zone conflict is necessarily *limited* conflict, sitting between "normal" competition between states and what is traditionally thought of as war (Wright, 2017). Japan is likely facing gray-zone tactics or actions that are difficult to identify as military in nature. These actions could certainly be considered offensive in intent and viewed as a threat to the territorial integrity. The reason why the NSS put emphasis on gray-zone conflict is the possible conflict scenario with regard to Senkaku islands issues. China has been taking actions with coast guard vessels or even fishing boats that seem to claim as if Senkaku islands are territorial jurisdiction of China.

These actions are indeed not military actions per se. However, it is considered to be an act of aggression if these vessels penetrate in territorial waters of Japan. If these vessels are unarmed, Japanese Coast Guards are responsible and capable of rejecting them. But if they are armed with and intend to land on the islands, Coast Guards may not be sufficient forces to deny these actions. In this case, it would become the responsibility for the Maritime Self-Defense Force. However, what if it was not clear whether or not these fishermen were armed? Would Japanese forces, which are heavily constrained by law and Rules of Engagement, be able to use force? Such gray-zone situations provide very difficult legal and political challenges.

Space is a gray-zone case

Space, in fact, is another case of gray-zone. There are no rules for regulating armed conflict (*jus in bello*) in space. Any attack on space assets, using either kinetic or non-kinetic forces, is not prohibited by international rules, though states are requested to refrain from intentionally creating space debris by Debris Mitigation Guidelines adopted by UN Committee on Peaceful Use of Outer Space (UNCOPUOS) (United Nations Office of Outer Space, 2018). A number of multilateral negotiations have attempted to set up rules and regulations in space, but as Brian Weeden's chapter describes in this volume, none have succeeded so far.

Furthermore, it is not easy to attribute who or what caused an attack on space assets. Space assets are a mere dot on a radar screen and the health of spacecraft can only detected by telemetry. If the telemetry shows something went wrong, it is hard to identify what caused the malfunction. Whilst SSA activities might capture the moment when a missile or any kinetic force took down a satellite, unfortunately the coverage of radar and telescopes to monitor orbital objects has many blind spots. Finding the aggressor of non-kinetic attack is even harder.

Vulnerability of spacecraft

One problem in defending one's own assets in space is that spacecraft are difficult to defend. The satellites and other space objects in orbit are travelling in first astronautical velocity (9.7km/s or roughly 28,000km/h) and they must be light in order to carry a large mass into such high speed (Joseph, 2005). Protection of spacecraft with heavy shields is not a viable option, and probably would not effectively protect from a high velocity attack anyway. Thus, spacecrafts are quite vulnerable and this encourages the aggressor to attack first for reducing war-fighting capabilities.

The other problem is that most of spacecrafts are unmanned. If there is any attack against spacecrafts, there will be no immediate casualties. Thus, the aggressor might think that attacking spacecrafts is the first stage of escalation ladder.

Deterrence in gray-zone

Deterring actions in gray-zone conflict is, by nature, difficult. First, if one tries to apply a deterrence by denial approach in space, one has to deny an attack on space assets or to prepare alternative non-space measures. A state would need to be able to defend against kinetic ASAT attacks by ground-based missiles, which would require the ability to shoot down a missile targeting a space asset. While not impossible, this is nonetheless extremely difficult and most nations prefer to reserve their ballistic missile defenses for prevention of attacks on their homelands, not their space assets. Additionally, deterrence by denial would require defending against non-kinetic attacks, meaning a state needs the ability to protect its satellites' communication systems. Again, this is possible, but it is extremely difficult to guarantee to protect radio wave interference and cyber-attacks. Further, a state may develop non-space systems as alternatives, but it is almost impossible. One may navigate vessels with stars and sextant, but cruise missiles or drones cannot fly without GPS.

Second, deterrence by punishment is also very difficult. As discussed above, it is hard to establish who did what in space. The loss of satellite capabilities may be caused by attack but gathering evidence to determine the aggressor is very difficult due to gaps in SSA coverage. It may also be difficult because the failure may have caused by non-intentional accident or natural causes, such as a solar flare or collision with space debris. Moreover, SSA alone cannot identify the intention of objects movements in space. If the SSA information from monitoring space is supported by other

intelligence sources, it may be possible to establish who did what in space, but again, it requires a lot of work and time.

Escalation Management in Space

If a confrontation between the US and China escalated towards the level of armed conflict, space as a gray-zone would be the first target for a number of reasons. These include the lack of international rules for attacking space assets, low expectation of casualties, spacecraft vulnerability, the ease of disguising actions as accidents or natural causes, and the significant degradation of the adversary's capabilities. Thus, the management of escalation in space domain needs to begin with the pre-war gray zone situation.

Declaratory policy

Before the escalation of the conflict to an armed one, the United States needs to declare the threshold of armed conflict in space. If there is a sudden loss of space systems without any plausible cause of unintentional attack, which means no identifiable space debris in collision course or no information about harmful solar activities, the United States will assume the failure is caused by intentional attack. This declaratory policy marks the indication of the US action in times of conflict.

Proportionality

One difficult aspect of escalation management is that there is no clear proportional equivalent to the value of space assets. The US is heavily dependent on the space system not only for military purposes, but also socio-economic purposes. The loss of space capability will certainly have great impact on military operations and its survival. On the other hand, China is not as dependent as the US for space systems. Although China has been rapidly modernizing its military structure and investing in research and development of space systems, its operation is limited in a regional context where space capability is not necessarily critical and can be replaced by terrestrial one.

The value of one satellite for the US is not equal to the value one satellite for China. Thus, if the US destroying one Chinese satellite is not a proportional response to the US losing one satellite, then US declaratory policy should clearly outline what the loss of one US satellite does mean and define what sort of proportional, retaliatory measures could be taken against China. Such proportional measures would involve non-space actions, including the use of terrestrial forces.

Cross-domain deterrence

To manage escalation, it is important to define what sort of measures are proportional for retaliating against intentional attacks on space systems, and also to ensure China and third parties understand these actions so that the retaliation is not seen as disproportionate. So, what are appropriate measures? Crucially, they must involve both space and terrestrial measures. For example, the US should take out a space asset equivalent to the one that was attacked, and additionally take out ground infrastructure that provides a similar function to the US space systems.

The danger of cross-domain deterrence is that this terrestrial retaliation may be understood by the Chinese as an over-retaliation. Unlike the case of space-to-space tit-for-tat, the terrestrial attack is more visible and tangible form of conflict. It may induce some emotional responses in both countries, and that may step up the level of conflict. It is thus important to design the retaliatory measures and

declare them before the armed conflict begins. Such declaration may avoid misperception and miscommunication between the US and China.

The Role of Japan-US Alliance

The Japan-US alliance can help achieve deterrence and so prevent potential adversaries from undertaking hostile actions against the two countries' space assets.

Japan can contribute to the global SSA network

First, Japanese SSA installations will help cover blind spots, including the spaces above North Korea and China. Japan is upgrading its telescope and radar facilities in Okayama prefecture in order to be able to detect space objects 10cm in diameter (Japan Aerospace Exploration Agency, 2018). Also, the Japanese Ministry of Defense is installing additional radars in Yamaguchi prefecture in western edge of Honshu (the main island) for strengthening SSA capabilities. Japanese participation in the SSA network is extremely important because the current network of SSA does not cover western Pacific and Asian regions.

Second, the Japan-US alliance must work together to improve detection of non-kinetic ASAT activities. This is because whilst effective SSA increases the cost of hostile actions against space systems, particularly kinetic attacks, that does little to prevent non-kinetic activities. The allies need to share information so as to quickly and accurately identify and attribute such attacks, with the goal of increasing the economic and social costs to any adversary of taking such actions by providing evidence of hostile activities to the international community.

Resilience of space systems

Third, the Japan-US alliance can work together to improve the resilience of space systems. Resilience (or mission assurance) is necessary because space assets are vulnerable. If the functions of space assets are taken away intentionally or unintentionally, they need to be replaced in as short a period of time as possible by alternative assets. Those alternative assets could be the assets of allied or friendly countries. The Japan-US alliance would be able to provide ideal alternative assets for each of the two partner nations because the assets of both countries are interoperable and easily replaceable.

Planning possible retaliation

Finally, the Japan-US alliance implies a 'deterrence through punishment' approach by planning possible actions including economic sanctions and cyber and/or military retaliation for attacks on the space assets. Although the rules and regulations on how to respond to attacks on space assets are not yet defined under international law, the alliance should use the Bilateral Planning Mechanism in the new Defense Guidelines issued in 2015 (Ministry of Defense, 2015) to prepare for the worst-case scenario and demonstrate its determination to employ appropriate measures to retaliate in case of intentional attacks on space assets.

This planning is very important because of the gray-zone nature of space. It will not be clear who did what in space. So, both Japan and US can prepare for all possible scenario and define what kind of actions needs to be taken in each case. Japan, in particular, requires those planning since it has variety of constraints and conditions for taking aggressive actions. However, one of the constraints, which is to exercise collective self-defense with the United States in joint operations, has partially lifted, thanks to the peace and security legislations passed the Diet in 2015 (Fujishige, 2015).

Conclusion

Space deterrence uses quite different logic from nuclear deterrence. Many space systems *per se* are not weapons systems, and are used for both military and civilian purposes. Protecting space systems from intentional attack by an adversary requires complex and calculated measures because of the differences of values and importance of space assets for both countries. In order to avoid misunderstanding and misperception, it is important for each country to define its actions and send clear messages. The threshold of retaliatory action should be communicated, as well as possible measures to be taken and the predictable consequence of those actions.

Space is an ideal environment for "gray-zone" activities, so deterrence by denial or punishment do not work as expected. Space also presents juicy targets for gray-zone conflict. Thus, declaratory policy is extremely important. The US should declare what constitutes armed conflict and how it will retaliate. The retaliatory measures need to be cross-domain, but the US should clearly state that it will retaliate proportionally to attacks on satellites.

The Japan-US alliance plays an important role for escalation management and deterrence in the West Pacific—not only sharing SSA data—but also improving resilience and planning retaliation. The alliance should put more weight on the deterrence equation and provide alternative sources for space-based services. This would negate the effectiveness of attacks by adversary on space systems, and help prevent attacks on the assets of both Japan and the US.

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Chapter 8. Norms of Behavior and Potential Conflicts in Space

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"As with past frontiers, it is those who show up, not those who stay home, who create the rules and establish the norms in new areas of human activity."
– Scott Pace, Executive Secretary, National Space Council, remarks before the Galloway Space Symposium, December 13, 2017

Norms of behavior are a topic that many are familiar with but most struggle to define. In sociology, norms are defined as informal understandings that govern the behavior of members of a society (Scott & Marshall, 2009). The field of international relations defines norms as standards of appropriate behavior for actors with a given identity (Bjorkdahl, 2002). In the space context, norms have come to mean both "top down" high-level principles intended to inform the development of new international legal regimes and "bottom up" best practice guidelines intended to inform day-to-day operations (Schaffer, 2017).

The air, maritime, and even cyber domains are replete with examples of successful norms that increase the safety and efficiency of activities while also providing a measure of geopolitical stability and security benefits. Yet despite sixty-plus years of human activities in space, the space domain has yet to see the same development of norms. This is partly because human activities in space to this point have been largely limited to those of large governments and have been free from armed conflict—conditions that have limited the incentives to create norms of behavior and instead favored maximum freedom of action for all involved.

Recent trends in the space domain are changing the equation. The space domain is rapidly becoming more like the air, land, and maritime domains with the globalization of capabilities, burgeoning commercial activities, and tighter integration into all levels of military activities. The return of great power competition has created greater geopolitical tensions and concerns over future conflicts on Earth extending into space. As a result, there is a growing push from the United States and other countries for initiatives to develop norms of behavior for space activities that can help prevent future conflicts, or at the very least mitigate their harmful effects, and complement efforts to defend and protect military space capabilities (Schulte & Schaffer, 2012). Developing norms of behavior can also help with escalation dynamics, as they can help distinguish between routine and unusual behaviors. This distinction can aid risk and threat identification, particularly in a regime that has increasing commercial activities, and enable better signaling of intent.

This chapter discusses norms of behavior for space activities with a focus on military activities and potential conflict. It begins with an overview of recent initiatives to develop norms of behavior for space activities, including the reasons why they were successful or not. It then proposes ideas and concepts for future initiatives that could be undertaken to strengthen the safety, stability, and sustainability of the space regime, and concludes with an argument why the United States should actively engage in bilateral and multilateral fora to develop norms of behavior for space.

Recent Norm-Building Efforts for Space

Over the last decade, there have been three major multilateral efforts to develop norms of behavior for space. Although not all were specifically aimed at addressing security issues, they are useful examples to examine as they elide some of the procedural, political, and substantive challenges that future efforts to establish norms are likely to face.

International Code of Conduct for Outer Space

The first norm-building effort was the European Union-led International Code of Conduct (ICOC) for Outer Space Activities. The concept of the ICOC was formulated by European leaders during the mid-2000s to make progress on space security issues in the face of continued geopolitical deadlock at the Conference on Disarmament and a US presidential administration that opposed the development of new legal regimes for space that limited freedom of action (Broad & Chang, 2010). The idea was to develop a set of voluntary "rules of the road" that could serve as transparency and confidence building measures (TCBMs) to enhance the safety, security, and sustainability of space (European Commission, 2015). In December 2008, the member states of the European Union (EU) approved the first draft of the code of conduct. After the 2009 Lisbon Treaty gave the EU new powers to engage in foreign and security policy making, the High Representative of the Union for Foreign Affairs and Security Policy to was given a mandate in September 2010 to conduct multilateral negotiations on the ICOC. The European External Action Service held multiple rounds of open consultations, culminating in a meeting in New York in August 2015 to try and finalize the negotiations. However, the final meeting failed to produce a consensus document, and instead the matter was referred to the United Nations General Assembly and remains in limbo (Krepon, 2015).

The ICOC failed to achieve traction for multiple reasons. The first is that it faced a mix of outright opposition and belated support from the United States. Domestically, Republicans in Congress considered the ICOC to be "stealth arms control" and took measures to try to limit US support. The Obama Administration supported the ICOC on paper but chose not to take an active role in promoting or negotiating it. The second major reason the ICOC failed was disagreement over the issue of self-defense (Rajagopalan, 2015). Article 4.2 of the ICOC reiterated the right of States to exercise individual or collective self-defense under Article 51 of the United Nations Charter. Originally included as a nod to the US domestic critics, Article 4.2 was opposed by several developing countries who felt it was a loophole to allow the weaponization of space and created hesitation in many other countries who were not sure what it allowed or did not allow. The third major reason it failed was due to objections over the process (Johnson, 2014). Many developing countries felt they had been excluded from the process and did not have enough of a voice. Some also objected to its development outside of the United Nations process. Russia, with assistance from China, was able to leverage these concerns to sway many of the developing countries against the ICOC during the final negotiations in 2015 (Krepon, 2015). Although still voluntary, the ICOC would have been the first major international agreement on security-related space activities.

United Nations Group of Governmental Experts on Transparency and Confidence Building Measures in Outer Space Activities

The second norm-building effort was the United Nations Group of Governmental Experts (GGE) on Transparency and Confidence Building Measures in Outer Space Activities. The GGE on Space TCBMs was formed by then-Secretary General Ban Ki-Moon in 2011 after a request from the First Committee on the UN General Assembly (United Nations General Assembly, 2011). The GGE on Space TCBMs consisted of fifteen international experts nominated by Member States who were tasked with

examining and reporting on methods for improving cooperation in space, and on reducing the risks of misunderstanding, mistrust, and miscalculations. The GGE's recommendations included taking steps such as increasing information exchange on space policies and military space expenditures, forecast natural hazards in space, and international orbital break-ups (United Nations General Assembly, 2013).

The GGE on Space TCBMS was mostly successful in its efforts. The experts were able to reach consensus and published their report in July 2013. The United Nations General Assembly endorsed the report and encouraged all member nations review and implement the proposed measures through relevant national mechanisms on a voluntary basis. However, to date there has been little actual steps taken to formally implement the major recommendations of the GGE's report aside from a joint meeting of the UN First and Fourth Committees (Hitchens, 2015). As a result, there is still a lack of transparency in military and dual-use space activities that could be a source of future misperceptions and tensions.

Long-Term Sustainability of Outer Space Activities Working Group

The third norm-building effort is the Long-Term Sustainability (LTS) of Outer Space Activities Working Group within the United Nations Committee on the Peaceful Uses of Outer Space. Created in 2010, the LTS Working Group was tasked with producing a consensus report containing voluntary best-practice guidelines for all space actors to help ensure the long-term sustainable use of outer space. The LTS Working Group explored guidelines in four areas: (1) sustainable space utilization supporting sustainable development on Earth; (2) space debris, space operations, and tools to support space situational awareness sharing; (3) space weather; and (4) regulatory regimes and guidance for new actors in the space arena.

Despite troubles along the way, the LTS Working Group was able to reach consensus on more than 20 draft guidelines. Initial progress on creating draft guidelines was hindered by increasingly belligerent Russian statements and obtuse proposals for additional guidelines following the European and American sanctions after the annexation of Crimea and invasion of Ukraine. However, unlike what happened during the final ICOC negotiations, Russia was unable to convince other countries, including China and Brazil, to oppose the LTS effort, and progress eventually continued. Consensus was reached on an initial set of 12 guidelines in February 2016 (Weeden & Samson, 2018b) and an additional nine guidelines, along with the perambulatory text, were agreed to in June 2018 (United Nations Office for Outer Space Affairs, n.d.). However, Russian obstruction prevented agreement on a General Assembly Resolution adopting the guidelines.

Future Efforts to Build Norms for Space Conflicts

Future conflicts in space could have devastating consequences for the long-term sustainability of space and the ability to use space for benefits on Earth. Thus, it is important that the United States looks to ways to prevent space from becoming the flashpoint for future conflicts, or from future conflicts on Earth from extending into space. Although not the entire answer, initiatives to develop norms of behavior can help in this regard. These future norm-building efforts can be grouped into two categories: efforts to create norms that help prevent future conflicts in space, and efforts to create norms that help manage the disastrous impacts from future conflicts in space.

Norms to help prevent future conflicts

Norm-building efforts that help prevent future conflicts would essentially be extensions of the concepts and recommendations from the GGE on Space TCBMs. The main goal would be to develop norms that reducing the risks of misunderstanding, mistrust, and miscalculations that could spark or escalate conflict in space. I describe three areas on which to focus.

(1) Norms of behavior for rendezvous and proximity operations (RPO) in space. RPOs involve the deliberate altering of a satellite's trajectory so that it comes close to another space object. In recent years, RPO technologies have started proliferating to more countries and private sector entities and are being explored for a wide range of civil and commercial applications such as satellite servicing and removal of space debris. Developing norms of behavior for civil and commercial RPO would not only increase the safety and efficiency of such activities, but also help discriminate them from potential hostile military activities in space.

(2) Norms of behavior for how militaries interact with each other in space. In a period of growing competition, innocuous or accidental behavior could be mistaken as a hostile or aggressive act, and during actual crisis, a mistake or accident could serve as the spark that escalates a situation towards armed conflict. An excellent model for this type of norm would be the Incidents at Sea Agreement, which was a treaty signed by the United States and Soviet Union in 1972 that outlined how American and Soviet ships and aircraft should interact with each other ("Agreement Between the Government", n.d.). The Incidents at Sea Agreement included steps to avoid collisions, maintaining safe distances, use of signals when maneuvering in close proximity, and avoiding activities that could be interpreted as hostile attacks. As the United States, Russia, China, and other countries increase their national security activities in space, they should consider negotiating a similar bilateral or multilateral "incidents in space agreement" to outline steps that can be taken to reduce misperceptions and increase stability in space (Listner, 2009).

(3) *Norms of behavior for the testing and development of counterspace weapons.* Over the last two decades, the United States, Russia, and China, among other countries, have been developing and testing a range of counterspace capabilities to deceive, disrupt, deny, degrade, or destroy space systems (Weeden & Samson, 2018a). Some of these counterspace capabilities are non-kinetic or reversible, while others involve the use of ASAT weapons to destroy satellites. Previous destructive ASAT tests have created thousands of pieces of orbital space debris, which pose a long-term hazard to commercial, civil, and military space activities (Weeden, 2010). Surprise ASAT testing could be highly escalatory and create misperceptions of actual attacks, particularly if a country has limited space situational awareness. Thus, it behooves all countries to encourage norms of behavior in ASAT testing to prevent, or at the very least minimize, the creation of long-lived orbital debris and provide prior notification of tests (Porras, 2018).

Norms to manage conflicts

Although every effort should be taken to try to prevent future conflicts from extending into space, we also must consider the possibility that they still might. While conflict may not yet be entirely preventable, humanity has taken steps to limit the indiscriminate nature of conflict and minimize the humanitarian suffering it creates. This includes development of International Humanitarian Law (IHL), also known as the Law of Armed Conflict (LOAC), which includes both formal treaties, agreed to by states and state practice that has over time developed into customary international law. IHL defines the circumstances by which states may use armed force, and limits the effects caused by armed conflict.

One important norm-building initiative for space would be the development of a manual on how IHL applies to conflicts in outer space. Such manuals already exist for the maritime, air, and cyber domains, and were developed by experts and practitioners to provide advice to military lawyers on the application and use of IHL in their respective domains. While not binding agreements, the manuals have nonetheless had an impact on how militaries conduct activities in peacetime, periods of tension, and armed conflict. Two efforts have begun to develop such a manual for space: (1) the Manual on International Law Applicable to Military Activities in Space (MILAMOS), led by McGill University in Canada (Manual on International Law Applicable to Military Uses of Outer Space, 2018); and (2) the Woomera Manual, led by the University of Adelaide in Australia and Exeter University in the United Kingdom (The Woomera Manual on International Law of Military Space Operations, 2018). Both are in their early stages, and it remains to be seen if they will be successful.

Importance of US Engagement on Norms

The United States has historically played a key role in shaping the few norms and legal principles that already exist in space. The peaceful uses of outer space, the principle at the heart of international space law, arose from the US desire to be able to use space for intelligence purposes (Loverro, 2017). As a result, the United States was able to influence the outer space legal regime in a way that greatly benefited its national security priorities and capabilities.

However, in recent years, US influence in the key multilateral fora that are actively discussing norms has waned. This is partly due to domestic politics, as seen in the ICOC negotiations, and partly due to the lack of a clear vision for what the goal of such engagement should be (Loverro, 2017). As was seen during the ICOC and LTS Working Group, Russia and China have been able to exploit the absence of the United States to try and shape the discussions towards their benefit.

As the current trends in the space domain force new thinking and discussions on the future of the space governance regime, the United States should once again be a force for increased order in space. That begins by seizing the diplomatic initiative to push for the creation of new norms of behavior in space that reflect US principles and priorities and serve as the foundation for an updated governance regime that enhances the safety, security, and stability, and sustainability of future outer space activities.

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Lt Col Peter Garretson

Lt Col Peter Garretson is an Instructor of Joint Warfare at Air University's Air Command and Staff College (ACSC), and lead for the Air University Space Horizons Initiative, which seeks to "Re-imagine Spacepower in the Age of Asteroid Mining." Lt Col Garretson has participated in numerous OSD and USAF wargames focused on Future Warfare and the role of space in future conflict. He is the former Chief of USAF Future Technology, and has served at the Defense Advanced Projects Agency (DARPA) as a Service Chief Fellow, and a Los Alamos National Laboratory as an Academy Research Associate. He has been a strategy and policy advisor to the Chief of Staff of the Air Force on Space and Great Power conflict in Asia. He was the first serving military officer to be detailed as a visiting fellow to Asia's #1 think tank, the Ministry of Defense Funded Institute for Defense Studies and Analysis (IDSA) in New Delhi, India, where he worked with India's President Dr. APJ Kalam on long-term US-India collaboration in Space. Lt Col Garretson has over 50 publications including on the topics of space governance, space policy, space based solar power, asteroid mining, planetary defense, strategic culture, and US military strategy and security cooperation in Asia.

Namrata Goswami

Dr. Namrata Goswami is an author, strategic analyst and consultant on counter-insurgency, counter-terrorism, alternate futures, and great power politics. After earning her Ph.D. in international relations, she served for nearly a decade at India's Ministry of Defense (MOD) sponsored think tank, the Institute for Defence Studies and Analyses (IDSA), New Delhi, working on ethnic conflicts in India's Northeast and China-India border conflict. She is the author of three books, "India's National Security and Counter-Insurgency," "Asia 2030," and "Asia 2030 The Unfolding Future." Her research and expertise generated opportunities for collaborations abroad, and she accepted visiting fellowships at the Peace Research Institute, Oslo, Norway; the La Trobe University, Melbourne, Australia; and the University of Heidelberg, Germany. In 2012, she was selected to serve as a Jennings-Randolph Senior Fellow at the United States Institute of Peace (USIP), Washington D.C. where she studied India-China border issues, and was awarded a Fulbright-Nehru Senior Fellowship that same year. Shortly after establishing her own strategy and policy consultancy, she won the prestigious MINERVA grant awarded by the Office of the US Secretary of Defense (OSD) to study great power competition in the gray zone of outer space. She was also awarded a contract with Joint Special Operations University (JSOU), to work on a project on "ISIS in South and Southeast Asia." With expertise in international relations, ethnic conflicts, counter insurgency, wargaming, scenario building, and conflict resolution, she has been asked to consult for audiences as diverse as Wikistrat, USPACOM, USSOCOM, the Indian Military and the Indian Government, academia, and policy think tanks. She was the first representative from South Asia chosen to participate in the George C. Marshall European Center for Security Studies NATO Partnership for Peace Consortium (PfPC) 'Emerging Security Challenges Working Group.' She also received the Executive Leadership Certificate sponsored by the Harvard Kennedy School of Government, National Defense University (NDU), and the Asia Pacific Center for Security Studies (APCSS). Currently, she is working on two book projects, one on the topic of 'Ethnic Narratives,' to be published by Oxford University Press, and the other on the topic of 'Great Power Ambitions" to be published by Lexington Press, an imprint of Rowman and Littlefield.

Dr. James Lewis

James Andrew Lewis is a Senior Vice President and Program Director at CSIS where he writes on international affairs and technology. Before joining CSIS, he worked at the Departments of State and Commerce as a Foreign Service Officer and as a member of the Senior Executive Service. His government experience includes work on politico-military and intelligence-related issues, as a negotiator on conventional arms and military technology, and in policy development for national security space and information technologies (include groundbreaking policies on commercial remote sensing and encryption). His diplomatic experience includes negotiations on military basing in Asia, the Cambodia Peace Process, and the Five-Power talks on Arms Transfers. Dr. Lewis led the US delegation to the Wassenaar Arrangement Experts Group on advanced civil and military technologies. He was assigned to US Southern Command and US Central Command. He has authored numerous publications since coming to CSIS, including the bestselling "Cybersecurity for the 44th Presidency," and is an internationally recognized expert on cybersecurity. Dr. Lewis was the Rapporteur for the UN's 2010, 2013 and 2015 Group of Government Experts on Information Security and has led a long running Track II Dialogue on cybersecurity with the China Institutes of Contemporary International Relations. Dr. Lewis is frequently quoted in the media and has testified numerous times before Congress. He received his Ph.D. from the University of Chicago.

Bruce W. MacDonald

Bruce W. MacDonald is an Adjunct Professor at the Johns Hopkins University School of Advanced International Studies, where he teaches the SAIS course on Nuclear Nonproliferation, and consults on nuclear, military space, and cyber security policy issues. He is the author of the 2016 book Crisis Stability in Space: China and Other Challenges, with contributions from ADM Dennis Blair and others. He is an adjunct senior fellow for National Security Technology at the Federation of American Scientists and co-led the FAS studies on China and Missile Defense (published in 2015 as Dragon Shield) and on Multi-Polar Missile Defense Dynamics (published in 2017). He was Senior Director to the Congressional Commission on the Strategic Posture of the United States, supporting the commission led by former Secretaries of Defense William Perry and James Schlesinger. He prepared numerous papers and briefings on nuclear/space/Russia/China strategic posture issues, led Commission expert Tiger Teams, and helped draft the Commission's well-received 2009 final report. He has participated in many Track 1.5 and Track 2 dialogues with Chinese, Russian, South Korean, and other counterparts.

MacDonald worked on BMD and larger strategic nuclear issues in the Clinton White House as Senior Director for Science and Technology on the National Security Council staff and in the Office of Science and Technology Policy. He was a professional staff member for the House Armed Services Committee responsible for oversight of Air Force, BMD, military space, and strategic forces acquisition budgets and staffed a senior member of the Senate Defense Appropriations Subcommittee. At the State Department, MacDonald analyzed strategic forces, ballistic missile defense (BMD), and arms control, and served on the US START delegation in Geneva. He was the State Department's principal strategic BMD expert in the crucial 1977-1983 years when numerous BMD initiatives were developed. He performed advanced BMD studies for the Army's Ballistic Missile Defense Agency and assessed Navy theater missile defense programs in its support of an OSD/JCS BMD review. He performed numerous studies for DOD's SALT Task Force and supported senior interagency groups at the State Department through his leadership of the START Policy Interagency Working Group. MacDonald, a member of the Council on Foreign Relations and the American Institute of Aeronautics and Astronautics, is an

honors graduate of Princeton University, with a BSE and MSE in aerospace engineering, and an MPA in Economics and Public Policy from Princeton's Woodrow Wilson School of Public and International Affairs.

Dr. Kazuto Suzuki

Kazuto Suzuki is Vice Dean and Professor of International Politics at Public Policy School of Hokkaido University, Japan. He graduated Department of International Relations, Ritsumeikan University, and received Ph.D. from Sussex European Institute, University of Sussex, England. He has worked in the Fondation pour la Recherche Strategique in Paris, France as assistant researcher and the Associate Professor at the University of Tsukuba from 2000 to 2008, and moved to Hokkaido University. He also spent one year at Woodrow Wilson School of Public and International Affairs at Princeton University from 2012 to 2013 as visiting researcher. He served as an expert in the Panel of Experts for Iranian Sanction Committee under the United Nations Security Council from 2013 to July 2015. He has contributed to the drafting the Basic Space Law of Japan, and serves as a member of Sub-committees of industrial policy and space security policy of National Space Policy Commission. His recent work includes Space and International Politics (2011, in Japanese, awarded Suntory Prize for Social Sciences and Humanities), Policy Logics and Institutions of European Space Collaboration (2003) and many others.

Dr. Brian Weeden

Dr. Brian Weeden is the Director of Program Planning for Secure World Foundation (SWF) and has nearly 20 years of professional experience in space operations and policy.

Dr. Weeden directs strategic planning for future-year projects to meet the Foundation's goals and objectives, and conducts research on space debris, global space situational awareness, space traffic management, protection of space assets, and space governance. Dr. Weeden also organizes national and international workshops to increase awareness of and facilitate dialogue on space security, stability, and sustainability topics. He is a member and former Chair of the World Economic Forum's Council on the Future of Space Technologies, and is also a member of the Advisory Committee on Commercial Remote Sensing (ACCRES) to the National Oceanic and Atmospheric Administration (NOAA).

Prior to joining SWF, Dr. Weeden served nine years on active duty as an officer in the United States Air Force working in space and intercontinental ballistic missile (ICBM) operations. As part of US Strategic Command's Joint Space Operations Center (JSpOC), Dr. Weeden directed the orbital analyst training program and developed tactics, techniques and procedures for improving space situational awareness.

Dr. Weeden holds a Bachelor's Degree in Electrical Engineering from Clarkson University, a Master's Degree in Space Studies from the University of North Dakota, and a Ph.D. in Public Policy and Public Administration from George Washington University in the field of Science and Technology Policy.