Prohibiting Interference with Space-Based Position, Navigation, and Timing

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Abstract

The United States must lead the way in establishing a norm prohibiting interference with satellites and satellite control segments of space-based position, navigation, and timing (PNT) systems. This norm would not prohibit interference with end user equipment and would be consistent with the just war principles of proportionality and discrimination. Prohibiting interference would address potential escalation concerns. These concerns could also be minimized through certain transparency and confidence-building measures (TCBM), including (1) creating a common set of definitions, (2) expressing a noninterference declaratory policy, and (3) information-sharing agreements.

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After the launch of the first satellites by the United States and the Union of Soviet Socialist Republics (USSR) in the late 1950s, numerous foundational, space-related norms of behavior were developed and eventually codified into a series of treaties, the last of which was signed in 1975. Currently it appears unlikely any new space treaties will be agreed upon. This is due to the large number of states with potentially divergent interests and concerns. Among those concerns is the view that retaining the ability to interfere with space capabilities is of greater benefit than retaining access to space capabilities. Even though a new space treaty is unlikely, norms not codified in a treaty still can be useful in favorably shaping behavior in space. Additionally, the strategic environment in which those original norms were established has changed significantly. Instead of two emergent space powers, many states now have a presence in space. Of these, some are full-fledged, established space powers

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with their own organic ability to launch indigenous satellites. Others are emerging space powers with the ability to manufacture and operate their own spacecraft. Finally, numerous aspiring space powers may have space programs but do not yet have the capability to access space services through means other than purchasing them. Significantly, those aspirants are relying on others for space-based position, navigation, and timing (PNT) capabilities. Perhaps more importantly, numerous non-state international and commercial entities also use space-based PNT to pursue their interests. Those interests range from purely commercial economic interests to internationally recognized safety of navigation and safety of life obligations. Non-state entities, as well as established, emerging, and aspiring space powers, are concerned about losing space-based PNT capability during a conflict. In addition, there is great concern that a loss of space-based PNT could lead to an escalated conflict in space or expand from a conflict in space to a terrestrial conflict.

While current space treaties recognize space should be used for "peaceful purposes," the term "peaceful purposes" is not defined.[1] The Outer Space Treaty (OST) does require states to conduct their activities in space with due regard to the interests of other states and to undertake consultations in the event their space activities could potentially interfere with another state's peaceful exploration and use of outer space.[2] However, the OST can be suspended between belligerents during a time of conflict.[3] Additionally, currently no treaties specifically address interference with space-based PNT. This could be an issue since states, non-state international organizations, and commercial entities directly and indirectly rely heavily on space-based PNT capabilities.

Space-based PNT systems consist of satellites, control segments, and end user receivers. Intentional and unintentional interference with the end user receivers has become common enough on military battlefields that the military has developed tactics, techniques, and procedures (TTPs) to specifically address the issue. However, there is increasing concern that the satellites themselves or the control segment could be interfered with, which could have a far-reaching, global impact to all users regardless of whether they are on, or near, a particular battlefield. Interference consists of jamming, spoofing, cyber attack, or physical harm to the satellite or control segments of a space-based PNT system to degrade or disrupt the position or timing signal transmitted.

The United States continues to lead the way in assuring the availability of space-based PNT services. It has clearly recognized the importance of ensuring space-based PNT is available to the rest of the world, both in its policy actions and its space system acquisition actions. In May 2000 the United States discontinued its use of selective availability (SA), which could be used to degrade the PNT signal, and stated it had no intent to ever use SA again.[4] In 2007, the United States went so far as to announce to the world at an International Civil Aviation Organization (ICAO) assembly that it would procure future satellites without SA capability and that GPS III would "deliver signals without any compromise in precision—guaranteed."[5] According to the 2010 US National Space Policy, the United States will "provide continuous worldwide access, for peaceful civil uses, to the Global Positioning System (GPS) and its government-provided augmentations, free of direct user charges."[6]

It is also critical for the United States to retain the ability to use space-based PNT information for its military activities. It makes sense for the United States to lead the way in codifying a norm that prohibits interference with the satellite and control segments of a space-based PNT system during peacetime, crisis, or conflict. Such a proposed norm would not prohibit interference with end user equipment. The norm would be consistent with the long-established just war principles of proportionality and discrimination and would preserve a state's ability to protect itself against precision-guided weapons that rely on space-based PNT. Prohibiting interference with the satellite and control segments of space-based PNT could address potential escalation concerns as well as concerns about significant impacts to international obligations if space-based PNT were unavailable as a result of interference.

This article does not address the localized interference with the end user receivers, which has become almost commonplace and which is confined to a small area rather than a global phenomenon. It first discusses how and by whom space-based PNT is used. Users of space-based PNT vary among military, nonmilitary, and civil and commercial entities in pursuit of an extremely wide variety of interests and activities. Next, it explores the emerging noninterference norm and how it is built on current practices and policies. It also discusses how support for the norm can be extrapolated from norms codified in treaties other than the OST. Finally, it explains how a norm prohibiting interference with the satellite and ground-control segments of space-based PNT, and a norm's

associated transparency and confidence-building measures, are in the best interest of the United States and why they should be incorporated into a considered set of deterrence options.

Space-Based PNT Uses

In the 1950s there were two emergent space powers: the United States and the Soviet Union. Today, there are approximately 60 countries with some sort of presence in space. This presence varies from those such as the United States, Russia, and China, which have a full range of space capabilities, to states like Argentina and Malaysia that are only present in space because of their commercial satellite communications sector. Even the city-states of Singapore and Monaco have a satellite in space. Moreover, a number of non-state players such as commercial consortia and international civil users are also present in space. For example, Intelsat, Eutelsat, SES, and Iridium together own and operate approximately 215 communications satellites; the Regional African Satellite Communications Organization also has a satellite in space. (See appendix for a complete list of states and organizations present in space at the time of this article's writing.)

All these players use space-based PNT capabilities to provide precise orbit determination. Moreover, virtually all states, regardless of whether they own or operate satellites, have some sort of direct reliance on space-based PNT. For example, major communications networks, banking systems, financial markets, and power grids depend heavily on GPS for precise time synchronization. Additionally space-based PNT is used for surveying and mapping, agricultural activities, collecting data regarding the environment, highway and rail transportation, facilitating public safety and disaster relief, and increasing the safety of aviation and marine operations.[7]

Additionally, space-based PNT information is important to international norms regarding safety of life. The *Cosmicheskaya Systyema Poiska Aariyniyich Sudov* (COSPAS)[8] Search and Rescue Satellite Aided Tracking (SARSAT) is an international organization that provides space-based relay of distress signals or alerts from emergency beacons to search and rescue (SAR) authorities internationally.[9] During 2014, close to 2,400 people were rescued during approximately 700 SAR events.[10] SARSAT has been credited with saving 32,000 lives since 1982.[11] Currently 15 percent of the COSPAS-SARSAT locator beacons rely on the US GPS, but future enhancements plan to use two additional space-based PNT

systems: the Russian GLONASS and European Galileo systems.[12] Use of the space-based PNT capabilities is expected to reduce detection and tracking of a beacon to a few minutes rather than a few hours.[13] Additionally, the International Maritime Organization (IMO) has required ships to implement the Global Maritime Distress and Safety System (GMDSS) since 1988, and COSPAS-SARSAT is part of that system.[14] It is important to note participants in COSPAS-SARSAT include both states and non-state international organizations, demonstrating the widespread acceptance of the importance of space-based PNT for safety of life.[15] The inclusion of two additional space-based PNT systems indicates the increasing reliance on those capabilities for the accuracy critical to search and rescue missions.

US Use of Space-Based PNT

With such ubiquitous reliance on space-based PNT, the question of whether interference with the satellite or control segments should be allowed has become urgent. This question is especially germane to the United States. According to Joint Publication 3-14, *Space Operations*, space capabilities in general *enable* the application of the principles of joint operations.[16] However, it also states, "National security objectives and the needs of the supported commander compel the conduct of space operations,"[17] thus indicating the reliance of the United States on space capabilities when conducting military operations. When considering the space capabilities that enable joint operations, space-based PNT assets in particular provide a foundation for a number of other space force enhancement capabilities. While the positional capability is often the capability that comes to mind when considering PNT, it is the precision-timing aspect of PNT that provides the capability to synchronize operations, enable communications capabilities, and enable network and cryptologic synchronization. Space-based PNT also enables precision attack from standoff distances, which reduces collateral damage and US losses.[18] The substantial reliance the United States places on space-based PNT for military operations is reflected in JP 3-14, asserting the necessity to assure friendly use of PNT information and prevent adversary use through deliberate defensive and offensive actions.[19]

Arguably, the United States has an asymmetric advantage in counter-space capabilities, which it might be reluctant to give up. However, that advantage appears to be eroding as Russia and China increase their

counter-space capabilities and indicate their willingness to interfere with satellites.[20] As potential adversaries continue to make progress and US advantage diminishes, it is even more important to assure the integrity of the control and satellite segments of US space-based PNT to ensure the United States can continue to conduct activities at the times and places of its choosing. If interfering with the satellite and control segments of space-based PNT is prohibited, then space-based PNT information should remain available outside a particular battlefield, even though the United States might face localized interference with the end user receivers on that battlefield.

With such a global use of space-based PNT capabilities, one might assume there would be well-established norms of behaviors concerning use of and interference with the use of those capabilities. That assumption would be reinforced by the fact there are organizations dedicated specifically to space-based PNT. For example, The International Committee on Global Navigation Satellite Systems (ICG) was established in 2005 to promote voluntary cooperation on matters of mutual interest to civil space-based PNT.[21] It encourages coordination among providers of space-based PNT, regional systems, and augmentations to ensure greater compatibility, interoperability, and transparency.[22] However, neither the charter of the ICG or other organizations nor the ways in which space-based PNT is used currently explicitly identify any norms about whether interference is prohibited. In the absence of explicit norms, it could be argued that a norm prohibiting interference could actually be emerging since the expectation seems to be that space-based PNT is, and will continue to be, freely available to all users at all times. Since the United States has continually led the way in providing space-based PNT to the world, it is in a particularly good position to lead an effort to codify that expectation into a norm that prohibits interference with the satellite and control satellite segments of space-based PNT.

Development of Noninterference with a Space-Based PNT Norm

In order to understand the rationale behind prohibiting interference with space-based PNT, it is necessary to understand specifically what norms are and how they develop. Norms are commonly understood to be agreed-upon rules for acceptable behavior or conduct.[23] They are internalized and socialized as universal principles guiding international be-

havior. They set standards, encourage good behavior, and discourage bad behavior. They are developed to protect a state's national security and its economic and societal interests in context of the surrounding strategic environment. A norm will only be adopted if it is beneficial (or at least not harmful) to the parties involved. The incredibly widespread use of space-based PNT capabilities, the multitude of uses for space-based PNT, and the fact that space-based PNT capabilities facilitate other capabilities have created an international geopolitical situation in which the availability of space-based PNT is not only desired but is also expected. Arguably, a norm prohibiting interference with space-based PNT is emerging.

The Outer Space Treaty (OST), the primary, overarching space treaty, reflects the broad foundational norms created around fear of nuclear conflict. The numerous space-related norms of behavior that developed during the dawn of the space age were codified in a series of space treaties.[24] Due to the strategic environment of the time, they focused in large part on the prevention of a nuclear war in or from space as an extension of deterrence of terrestrial nuclear war. The space treaties addressed national security, protection of personnel, safety of space activities, and protection of the space environment. Prior to the signature of the OST, nonbinding United Nations General Assembly (UNGA) resolutions reflected those concerns and emerging norms of behavior. The OST cites two UNGA resolutions in addition to the Declaration of Principles for the use of outer space.[25] The resolution relevant to this discussion called on states to refrain from placing nuclear weapons or weapons of mass destruction into orbit or on celestial bodies.[26]

Those norms developed because the Soviet Union and the United States were the only two space powers and could impose order on their respective blocks. No others had any kind of presence in space and effectively had little influence in developing the space norms that were eventually codified in treaties. Since the greatest fear of the United States and Soviet Union at the time was that weapons placed in orbit or on the moon would be destabilizing, it is not surprising that norms about weapons of mass destruction were codified in the OST. However, the concerns of those with a presence in space today are not the same. Those present in space are concerned with being able to use space capabilities to pursue their security, economic, and societal development interests. In particular, they are concerned with being able to use space-based PNT to do so. Those actors are now in the position of shaping an emerging noninterference norm.

Norms are applicable in times of peace, crisis, and conflict. Peacetime norms developed to maintain peace, facilitate commerce, and protect safety of life and navigation. The IMO requires all ships to be fitted with certain search and rescue equipment. One such type of equipment is an emergency position-indicating radio beacon designed to specifically work with COSPAS-SARSAT. Using the space-based PNT portion of COSPAS-SARSAT increases the accuracy of location data to approximately 20 meters from five kilometers.[27] Additionally, space-based PNT has become the primary means of navigation in many maritime applications.[28] The International Civil Aviation Organization also requires aircraft to install emergency locator transmitters.[29] Clearly, space-based PNT capabilities are critical to meeting international obligations regarding protecting the safety of life and navigation. The noninterference norm for peacetime is, in effect, already being established.

Norms for crises and conflict have developed to reduce misperceptions, misunderstanding, and mistrust and to avoid conflict or prevent escalation of a conflict but are not yet formally established. Although a norm may be widely accepted, states may differ in their interpretation of the norm or the actions they can take to implement it. One indication a norm has been widely adopted is its codification in official, binding international treaties as has occurred with the OST. As previously mentioned, an explicit norm for noninterference with the satellite and control segments of space-based PNT has not yet occurred but may be emerging. Norms also may be inferred from the provisions and terms of binding international treaties or from nonbinding instruments such as UNGA resolutions and codes of conduct.

How Are Norms Developed?

Traditionally, norm development has been the purview of state actors. Norms were developed when (1) leading states proposed a new norm, (2) a majority of states followed the proposal, and (3) the norms then were internalized and socialized as universal principles.[30] Norms are typically developed when a large number of states agree on acceptable standards of behavior and conduct their actions accordingly. However, as ever more non-state entities increasingly rely on space-based PNT capabilities to pursue both economic and national security interests, they also are helping to develop a new space norm. Specifically, the development and implementation of agreed-upon standards, practices, and procedure

have become a key factor. This type of norm development, where a large number of entities determines agreed-upon behavior, may also draw on UNGA resolutions and reports. While a resolution is not binding, it does reflect the beliefs of those who sign it. It has been common for this type of norm, developed in this way, to eventually be codified in a binding multilateral treaty much like the 1958 Geneva Conventions on the Law of the Sea codified norms already being practiced.[31] However, it should be noted that there have been no post–World War II examples of norms in general emerging in this manner. Arguably, the norm against using nuclear weapons emerged in this manner and was codified in the numerous bilateral arms control agreements between the United States and Soviet Union. However, that norm was relevant only to those two nuclear powers. Certainly no space-related norms have emerged in this way.

Alternatively, norms may develop when relatively few players with a large interest in the area of concern determine acceptable behavior. This is essentially the model by which the OST came into being. Another good example is found in international civil aviation law. In 1944, only 52 countries signed the Chicago Convention, and for the most part they were those with established or emerging air capabilities.[32] As of 2013, 191 nations had signed the Chicago Convention. Arguably, noninterference with space-based PNT is becoming, or has become, a norm in a similar manner. Since the mid-1990s, only four states and the European Union have developed a space-based PNT capability, and no non-state players have done so. Virtually all states and numerous commercial and international civil entities rely on space-based PNT provided by one of those five states to some extent as they pursue their security and economic interests. For instance, the Chinese Beidou Satellite Navigation System, used by the Chinese government and military, also has been offering navigation services to customers in the Asia–Pacific region since December 2012.[33] Additionally, the Chinese system has been approved for use in maritime operations by the Maritime Safety Committee of the IMO.[34] In another example, the Russian GLONASS services have been freely available to civilian users since May 2007, and Russia has been actively promoting civil use of GLONASS.[35] Finally, the United States has issued a number of statements establishing cooperation relationships with other states with space-based PNT capabilities, as well as those without indigenous space-based capabilities.[36]

These same countries plus India, Japan, and the European Space Agency (ESA) also participate in a number of other international organizations regarding space-based PNT issues.[37] The ICG encourages coordination among providers of space-based PNT systems regional systems and augmentations to ensure greater compatibility, interoperability, and transparency.[38] The ICG serves as a focal point for information exchange on space-based PNT. It has 10 state members (to include the European Union) plus the ESA. It has 11 associate members (to include non-state and commercial organizations) and eight observers.[39] It also promotes the introduction and utilization of space-based PNT in developing countries.[40] Another international organization, United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), also comprises non-state entities as well as state entities. UN-SPIDER ensures all states, international organizations, and regional organization have access to, and develop the capacity to use, all types of space-based information to support the full disaster-management cycle.[41] This information includes space-based PNT as well as remote sensing and satellite communications information. Both of these organizations are composed of non-state entities, states with no indigenous space capabilities, and states that provide space-based PNT.

This widespread dependency on a very small number of states for space-based PNT and the willingness by those states to ensure space-based PNT is globally available are key factors in the emergence of a noninterference norm. The combination of a relatively few, heavily vested players with a large number of dependent users has effectively established the expectation that space-based PNT will always be available for use by all who wish. This expectation arguably was set by the United States itself in 1983 when the Soviet Union shot down Korean Airlines Flight 007, which the Soviet Union claimed had intruded into Soviet airspace. The incident was so horrendous it was widely denounced by the world. Recognizing the critical need for civilian aircraft to know their precise position, Pres. Ronald Reagan immediately declared the United States would provide three-dimensional positional information to civilian airliners when its GPS came online. The United States reinforced the expectation of availability by its actions in 2000 and 2007. Expectation of space-based PNT's continued availability was also strengthened internationally beginning in 1999 when the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) adopted a strategy

to address global challenges of the future by using space capabilities. One action of that strategy was to "improve the efficiency and security of transport, search and rescue, geodesy and such by promoting universal access to space based PNT."[42]

Expectation regarding ever-present availability of space-based PNT has been further reinforced by the existence of organizations such as the previously mentioned ICG and UN-SPIDER. In addition to illustrating the emerging expectation and potential obligation to ensure the availability of space-based PNT, participation in these organizations also provides formal institutional structures to monitor compliance, adjudicate disputes, and provide a forum for regular discussion of space-based PNT issues. The structures provide known processes and organizations so that all parties are familiar with expectations associated with the emergent norms.

A New Norm for Space-Based PNT

The next step in defining and codifying an emerging norm prohibiting interference with space-based PNT is to understand current norms and the rationales behind those norms and associated transparency and confidence-building measures (TCBM). A large part of international maritime, aviation, and land law developed in response to codifying the norm of promoting or maintaining peace. UNGA resolutions and international treaties clearly reflect the importance of maintaining peace and stability between the United States and the Soviet Union. Agreements that codified that norm and its associated TCBMs included bilateral, nonbinding arms control agreements as well as multilateral aviation, naval, and environmental-modification agreements. Unlike the space treaties, each treaty contained language specifically reflecting the desire to avoid conflict. It is possible language found in those treaties could be useful in defining specific language for a norm prohibiting interference with the satellite and control segments of space-based PNT. For example, the United Nations Convention on the Law of the Sea (UNCLOS) states it is "aware of the historic significance of this Convention as an important contribution to the maintenance of peace, justice and progress for all peoples of the world."[43] The Convention of Civil Aviation (Chicago Convention) declares "it is desirable to avoid friction and to promote that cooperation between nations and peoples upon which the peace of the world depends."[44] Article 1 of the United Nations Charter states the UN's purpose is to "maintain international peace and security."[45] Even the

Environmental Modification Convention explicitly states it is "guided by the interest of consolidating peace, and wishes to contribute to the cause of halting the arms race, and of bringing about general and complete disarmament under strict and effective international control, and of saving mankind from the danger of using new means of warfare."[46]

A norm that prohibits interference with the satellite and control segments of space-based PNT, but that retains the right to interfere with the end user equipment, should likewise be grounded in the concept of promoting or maintaining peace. The use of space-based PNT is essential to both maritime and aviation safety of life activities and also essential for disaster mitigation and state capacity building. Language defining the noninterference norm should reflect this. Such language should also act to move the issue outside the space law arena, which is narrowly defined, less mature, and often viewed as insular from other areas of international law. Similar to the UNCLOS language, noninterference language should explicitly recognize that space-based PNT is an important contributor to the preservation of peace and progress for all peoples of the world. It should also promote cooperation as the Chicago Convention does. Finally, it should explicitly state that it is desirable to prevent conflict in outer space.

The challenge to defining a noninterference norm is balancing ongoing expectations and acceptable practices with other established norms. According to the foundational norms codified in the space treaties, space is to be used for peaceful purposes. Article I of the OST states, "Activities in outer space . . . are to be conducted for peaceful purposes"[47] and Article IX of the OST specifies that states are to conduct space operations "with due regard" to the corresponding interest of all other state parties to the treaty.[48] Adding to the tension, the OST says, "States shall carry out activities in outer space . . . in accordance with international law to include the United Nations Charter."[49] Article 51 of the UN charter, which allows for self-defense in the event of "armed attack," therefore applies. States may, and do, interpret armed attack and self-defense differently. Interfering with space-based PNT might or might not be interpreted as an armed attack that requires a response—a response that might be escalatory either in space or on earth. Additionally, those states that rely heavily on space-based PNT for military operations might be so concerned about possibility of interference they might attempt to preemptively disable an adversary's capability. Since states cannot agree on the interpretation of "peaceful purposes" or "armed

attack" it is extremely difficult to determine acceptable behavior or conduct regarding interference with space-based PNT.

Currently, discussions seem to center around how much interference is necessary before a response is appropriate. A norm prohibiting any interference whatsoever with the satellite and control segments of space-based PNT would eliminate that debate. Since the United States relies more on space-based PNT than its potential adversaries, it is vital that it retain access to space-based PNT information. It might even be argued that it is more important the United States retain its own access to uncorrupted space-based PNT information than it is to deny an adversary access to space-based PNT information. Additionally, interference with the satellite or control segment could be more likely to create effects outside a single battlefield, thereby impinging on the United States' ability to conduct other activities outside a particular battlefield. Appropriate TCBMs would clarify the interpretation of the norm and establish the consequences for failure to adhere to the norm.

Preserving the long-established self-defense norm must be balanced against safety of life and safety of navigation. Space-based PNT capabilities are critical to the safety of navigation and safety of life across the world. Norms regarding safety of navigation and safety of life have been codified in both international maritime and aviation law and may be extrapolated to apply to space-based PNT. The Safety of Life at Sea Treaty (SOLAS) has a set of associated standards that require on-board electronic navigation systems. While the United States GPS is not the mandated system, it is used overwhelmingly, although the Chinese Beidou system has recently joined the list of systems that meet the standards.[50] Both the 1958 Convention of the High Seas and the UNCLOS codify an obligation to render assistance to those in danger of being lost at sea. According to the Chicago Convention, "every State must refrain from resorting to the use of weapons against civil aircraft in flight and that, in case of interception, the lives of persons on board and the safety of aircraft must not be endangered."[51]

Aviation and maritime laws and the Laws of Armed Conflict (LOAC) provide a useful basis for determining the legitimacy and desirability of targeting the space portion of space-based PNT capabilities. Although the Chicago Convention requires states to refrain from use of weapons against civilian aircraft, it goes on to say the Convention "shall not be interpreted as modifying in any way the rights and obligations of States set

forth in the Charter of the United Nations."[52] States may take actions consistent with the UN Charter self-defense provisions. However, there is a precedent for limiting or constraining targets during times of conflict. In space, it is an established norm that National Technical Means (NTM) are not to be interfered with since such interference is likely to quickly escalate a crisis between states with significant destructive capabilities. This prohibition on interfering with NTMs was contained in every major arms control agreement between the United States and Soviet Union. Additionally, the Agreement to Reduce the Risk of Outbreak of Nuclear War required the United States and Soviet Union to notify each other in the event of signs of interference with the NTMs.[53] But no established norm exists regarding interfering with non-NTM satellites. Since many states use space capabilities in military and national security activities, they are understandably reluctant to establish a norm that impinges on their ability to neutralize any advantage an adversary gains from using satellites. Moreover, no major space actor will accept constraints on its actions unless it can independently verify compliance with the norm either by use of its own NTMs or other forms of intelligence, surveillance, or reconnaissance under its control or that of trusted partners.[54] However, establishing a noninterference norm could neutralize any relative advantage an adversary could gain by interfering with space-based PNT preemptively to a conflict or during a conflict.

JP 3-14's section on Navigation Warfare (NAVWAR) specifically states the United States will conduct both defensive and offensive actions to assure friendly use of PNT information and deny adversary use of PNT information.[55] It is important to note GPS does more than simply enable land, maritime, and air location and navigation and precision weapons delivery. It also provides exact positioning to other satellites, precise timing to communications satellites, precise timing for cyberspace operations, and positioning information to launch vehicles.[56] Clearly, the United States considers retention of space-based PNT critical. Additionally, space-based PNT also enables more precise attacks, which reduces collateral damage and increases the ability to comply with LOAC.

The Law of Armed Conflict and Space-Based PNT

Under the LOAC proportionality principle, military action must not cause collateral damage that is excessive in light of the expected military advantage. The relative advantages provided by space-based PNT

for military activities have decreased since the 1990s when the United States and Soviet Union had the only space-based PNT systems. China, Europe, and India have now developed their own space-based PNT systems. Japan has developed a space-based PNT augmentation system and just recently changed its laws to allow the use of space for security purposes. States have realized their reliance on space-based PNT has become a great vulnerability and are pursuing non-space-based alternatives.[57] Additionally, relatively little benefit would be gained by interfering with space-based PNT since many space powers have the ability to use more than a single space-based PNT system or are pursuing non-space-based PNT options, thus minimizing any strategic or tactical military advantage. Receivers that use multiple space-based PNT constellations are being developed, eliminating the benefit gained from targeting an adversary's satellites.[58] US national space policy also specifically recognizes foreign PNT services may be used to augment and strengthen the resiliency of GPS.[59] Furthermore, the above states' space-based PNT systems are dual use, which creates a very high level of entanglement with nonmilitary activities and users. The United States recognizes in its own national space policy that space-based PNT is inherently dual use and accordingly will provide continuous worldwide access to its GPS for "peaceful civil uses."[60] With such an entangled situation it is clearly not in the interests of any entity to lose access to space-based PNT.

Since most, if not all, satellites can be used for a military purpose and can also be used by nonmilitary users, a satellite could become a legitimate military objective and subject to attack by an adversary, depending on its use. Because space-based PNT capabilities could be denied to an adversary via narrowly scoped, temporary, and reversible means, space-based PNT would at first glance seem to be a legitimate target under the LOAC principle of proportionality. However, the number of providers that can provide PNT information for users is extremely limited and the impact on some of those users could be literally life-threatening. This could make targeting PNT systems highly unpalatable and might arguably make targeting more difficult under the proportionality provisions of LOAC. Targeting the satellite or control segment of a space-based PNT system could create global impacts to literally billions of users and could be considered to be not proportionate.

Retaining Use of Space-Based PNT

The desire to retain use of space-based PNT by giving up the right to interfere with the satellite and control segments of space-based PNT systems must be balanced with the desire to prevent adversary use of space-based PNT by retaining the right to interfere. Arguably, that balance would seem to weigh in favor of retaining the capability for the United States and other states and international civil and commercial entities. Although militaries have developed tactics, techniques, and procedures for dealing with jamming end user receivers, nonmilitary users have done little if anything. For example, on 31 March 2016, North Korea used radio waves to jam GPS receivers in South Korea. Over 50 airliners and hundreds of South Korean fishing boats were affected, but the US-South Korean military exercises under way were not affected.[61] The 2 April 2014 failure of all 24 of the Russian GLONASS satellites was felt throughout the world, as GLONASS was unavailable for "tractor automation for farming, machine control and robotics in mining and heavy industry, and in the national infrastructure used by surveyors and industry across many countries."[62] Codifying a norm that prohibits interfering with the satellite and control segments of space-based PNT, while preserving the option of disrupting end user equipment, could protect the interests of the United States and others better than denying the use of space-based PNT to an adversary. Such a norm would preserve the use of the space-based PNT capability by all and allow them to meet their security, economic, and societal needs. Ships and aircraft could continue to safely navigate. Search and rescue operations could be swiftly and accurately carried out. Satellite communications and cyberspace activities would continue. Spacecraft and launch vehicles would be able to more safely operate. Finally, military operations could be enabled in such a way as to better meet LOAC obligations. This noninterference norm would protect US interests by ensuring the space-based PNT information it relies on would be preserved.

Given states' general reluctance to give up any strategic advantage, it seems unlikely any would be amenable to a prohibition on interfering with the end receiver segment of space-based PNT as a means of pursuing their security interests. However, this article suggests a constraint on interfering with the satellite and control segments of space-based PNT systems. Moreover, precedence has been set to constrain activities that could be legitimately conducted under LOAC. Protocol IV to the

Convention on the Prohibition or Restrictions of the Use of Certain Conventional Weapons prohibits use of specific weapons (blinding lasers) as a matter of policy. Nations participating in the negotiation of the Convention did not conclude that blinding or a blinding laser weapon caused unnecessary suffering but decided for policy reasons to prohibit their use.[63] Similarly, as a matter of policy, targeting the satellite and control segments of space-based PNT systems during peacetime, crisis, or conflict could be prohibited out of concern for the global consequences gained for a limited, decreasing military advantage.

TCBMs for the Norm

To effectively establish this proposed noninterference norm, appropriate TCBMs need to be created to ensure a common interpretation of the prohibition of targeting the satellite or control segments of space-based PNT, to establish a recognized framework in which players must act regarding space-based PNT, and to provide a means by which "bad actors" may be identified and, if necessary, sanctioned. Successful transparency measures provide ways for parties to practice communication and reduce misperceptions, misunderstanding, and mistrust. Successful measures would decrease the likelihood of escalation of a crisis in space or the expansion of a space conflict to a terrestrial conflict.

Established space powers are understandably reluctant to agree to anything that limits their ability to access and use space in pursuit of their security or economic interests. They are also unlikely to agree to anything that even appears to have the capability to force them to conduct, or refrain from, particular activities. However, emerging and aspiring space powers seem more willing to seek agreements to regulate behavior in space to preserve access to space and protect the domain for equitable use by all. The common objective among all players is to assure access to space and use space in pursuit of their interests. Attempts by the Committee on Peaceful Uses of Outer Space and the UN Conference on Disarmament to address issues such as the use of antisatellite weapons and a potential arms race in space have been largely unsuccessful since they focus on reducing capabilities rather than focusing on the legitimacy of potential targets of those capabilities.

As the United States and others develop counter-space capabilities, they seem to be making threats of retaliation for undesired actions in space more explicit.[64] It is therefore critical that de-escalatory TCBMs

associated with a noninterference norm support a set of coherent deterrence options. TCBMs must address the requirements of each party and must be something each party agrees to follow. A norm prohibiting targeting of the satellite or control segments of space-based PNT is relatively straightforward. However, effective associated TCBMs may be much more difficult to develop.

Transparency measures are necessary to provide states sufficient information to more accurately assess another state's intent. Arguably, transparency measures would only be between states since only states have the capability to interfere with the satellite or control segments of space-based PNT. However, transparency measures could also include non-state actors in a manner similar to the US Space Situational Awareness (SSA) information-sharing agreements. Confidence-building measures should facilitate small, incremental actions that build trust on each side and reassure the other state that actions taken by the first state are not a prelude to an armed attack. However, that level of transparency could cause anxiety on the part of states concerned that the information gained via TCBMs could be used preemptively against them. TCBMs also provide a known framework of acceptable behavior. It becomes easier to identify bad actors as they refuse to adhere to accepted norms and follow accepted TCBMs. Those bad actors may then be more closely watched by the international community, which may exert pressure on them to comply with the norms and TCBMs. Failure to adhere to widely adopted norms and TCBMs could also subject a bad actor to isolation from the rest of the community. For instance, a bad actor might not receive the technical assistance or the resources it needs to conduct its space program. Importantly, the technical assistance in question might not be in the same area as the violated norm. In the case of interference with PNT, it might be possible to renegotiate the SSA data-sharing agreements, spacecraft launch agreements, personnel exchanges, or other partnership agreements as a part of the cost-benefit calculations to deter that bad actor.

Models for TCBMs

It seems best to model new space norms and associated TCBMs on bilateral, rather than multilateral, agreements. Bilateral agreements are easier to negotiate as they focus on the concerns of only two parties. Previous experience during the Cold War recognized the importance

TCBMs played in avoiding escalation into full nuclear war—and those TCBMs were bilateral and narrowly focused. For example, the 1971 US/USSR Agreement to Reduce the Risk or Outbreak of Nuclear War required the United States and Soviet Union to notify each other in the event of an accidental or unauthorized incident that might lead to a nuclear war.[65] An agreement regarding noninterference with the satellite and control segments of space-based PNT could be similarly based on parties informing each other of accidental or unauthorized events that could escalate into conflict. Specifics might include activities that interfere with any of the frequencies used by any of the five space-based PNT providers. Or they might include instances in which a party's space-based PNT system would be unavailable in such ways as to appear as if a state was protecting its system in preparation for other aggressive actions.

In another example, the Agreement Between the United States and Soviet Union to Prevent Incidents on the High Seas was a confidence-building measure intended (and apparently successfully implemented) to prevent actions that could increase tension and the possibility of conflict. It is important to note neither of these two agreements directly affected size, weaponry, or force structure of the two parties.[66] That made both parties more willing to sign the agreements. Similarly, focusing on actual *occurrence* of interference with PNT, versus the *capabilities* to interfere with space-based PNT, would be more palatable to those involved since capabilities would not be impacted. Elements of this type of an agreement could include things such as geographic limitations beyond which localized jamming of user segments is no longer considered local and could be considered a "bad action."

Three additional TCBMs might help create a common interpretation and accepted set of behaviors regarding a noninterference norm. First, states could negotiate an agreement defining nomenclatures. Even if unsuccessful, the communications among those involved in the attempt would be extremely valuable as a way to define expectations. A definition of terms also could lead to better transparency as parties find a common understanding on how a potential adversary might act in a given situation. Any agreements reached also could be provided to broader international organizations as evidence of acceptance of the interpretation of the norm. For example, the ICG holds regional workshops on applications of space-based PNT and provides a publication on current and planned global and regional space-based PNT systems and programs.[67]

In addition to providing information for dissemination as evidence of a norm, negotiations could build on information already discussed in organizations such as the ICGs in order to develop the norm.

Second, each state should develop declaratory policy that it will not interfere with the satellite or control segments of space-based PNT in peacetime, crisis, or conflict. That declaratory policy should actively identify expectations of behavior—particularly, currently unstated expectations. This proposed TCBM is already partially implemented. According to the US National Space Policy, the United States will provide continuous worldwide access to its GPS for peaceful civil uses, and it will provide that access without degrading the signals.[68] Note that the policy states the access is for peaceful civil uses and, furthermore, does not indicate the United States would not interfere with end user receivers as is consistent with the inherent right of self-defense. The US National Space Policy also specifically states foreign PNT services may be used to augment and strengthen the resiliency of GPS.[69] Both of these statements indicate recognition of the importance of space-based PNT and at least a small move toward codifying an expectation the satellite and control segments will not be interfered with. In addition to the official national space policies, speeches, interviews, social media, and testimonies of different organizations are also studied by non-US entities for policy statements and should also be considered. An official declaratory policy loses credibility if governmental organizations are making statements counter to it. A comprehensive strategic communication plan that effectively communicates a declaratory policy against interfering with the satellite and control segments of space-based PNT could decrease uncertainty by sending a consistent message. At the very least, a cohesive strategic communication plan would lessen chances of inconsistent messaging as all players should at least consider how their message could conflict with another agency's message. Inconsistent and confusing messages create potentially dangerous mistrust and uncertainty that could lead to escalation of a conflict in space or expansion of a conflict in space to a terrestrial conflict.

Third, states should develop and implement information-sharing agreements that actively define how the noninterference norm is to be interpreted and the framework for acceptable behaviors. Two different types of agreements could be useful in developing such information-sharing agreements. In the commercial sector, the Space Data Association

(SDA) created agreements in which satellite companies share information to supplement data previously provided by states. It provides a legal and technical framework that states could leverage when developing information-sharing agreements.[70] States could also leverage the SDA itself to conduct what has been called "open" verification that leverages the increasing transparency of space to private observers.[71] In the governmental sector, the notification agreements between the United States and Soviet Union during the Cold War could also serve as a model. Under those agreements, parties explicitly required notification in the event of accidental or unauthorized activities. Similarly, information-sharing agreements associated with a noninterference norm could require parties to notify each other of accidental or unauthorized activities that pose a danger of interference with the satellite or control segments space-based PNT. Depending on the agreement, the notification could be via either formal or informal channels. In general, information-sharing agreements for a noninterference norm should probably be bilateral. Bilateral agreements allow the parties to tailor measures that address each party's concerns. Moreover, bilateral agreements preclude states outside the agreement from negatively influencing the effectiveness of the agreed-upon measures. Although space powers with counter-space capabilities may consider the desires of new or aspiring space powers, bilateral agreements would prevent those entities from having undue influence and could prevent delay in developing and implementing the agreements.

Although it seems to be an appropriate time to develop a noninterference norm with associated TCBMs, monitoring to ensure compliance with the norm is complicated by the fact that current space situational awareness capabilities are not at a level where they may be relied on as a sole source of verification. However, established, new, and aspiring space powers and international commercial entities have entered into space situational awareness information-sharing agreements. These agreements, used primarily to predict potential collisions between space objects, could be leveraged to create more able monitoring capabilities.

Successful transparency measures could lead to successful confidence-building measures as states are able to assure themselves the other states are acting in accordance with agreed-upon TCBMs. That, in turn, helps develop trust or decrease distrust. However, successful confidence-building measures are incremental, iterative actions. Ideally, confidence-building measures will help a state more correctly assess the intentions

of other states as their confidence in each other builds. Each state must believe the other intends to abide by the proposed measure. Declarations by a state that it intends to follow the confidence-building measure may not be believed unless it takes concrete actions to implement the measure. Although United States space policy clearly indicates the importance of GPS, additional steps are necessary to develop an effective TCBM. Fortunately, those steps may have already begun as states with space-based PNT capabilities are beginning to work together to create technical commonalities between the space-based portions of the PNT systems as well as the end user equipment. However, the success of confidence-building measures can only be determined over time.

The Noninterference Norm's Contribution to Deterrence

Successful TCBMs associated with a noninterference norm could contribute to a cohesive set of deterrence options. There are two types of deterrence that should be considered. First, there is "general deterrence," which is based on power relationships and attempts to prevent an adversary from seriously considering *any kind* of military challenge because of expected adverse consequences.[72] General deterrence in the space domain attempts to prevent *any type* of interference by *any actor* against *any type* of space systems. General deterrence is insufficient for the current strategic environment due to the large number of both state and non-state players present in space, the difficulty in attributing interference to a particular actor, and its reliance on adverse consequences. It is essential to note that deterrence has been developed as a way to prevent undesired action between states, not individual citizens or corporations within the state.

In contrast to general deterrence, there is "immediate deterrence," which is specific. Immediate deterrence attempts to forestall an anticipated challenge to a *well-defined* and publicized commitment.[73] It is practiced when general deterrence is thought to be failing.[74] Immediate deterrence would seem to have a higher likelihood of success than general deterrence in the space domain as it is more narrowly focused on particular actors and their actions. Deterring any entity that has any kind of offensive counter-space capability from conducting any kind of interference against any kind of satellite is daunting at best. Additionally, attribution of interference to a particular party can be problematic. On the other hand, deterring interference with the satellite and control segments of space-based PNT ca-

pabilities specifically might be accomplished via immediate deterrence. Although immediate deterrence can be considered less complex since it focuses on a single target, it could also be more complex as deterrence actions must be tailored for specific rather than broad actions and must be tailored for each adversary to be deterred. Additionally, a state must consider not only what an opposing state believes but must consider allies and partners in its calculations, too.[75] Any coherent set of immediate deterrence actions designed to prevent interference with the satellite and control segments of space-based PNT would certainly have to address these factors. Calculations could be further complicated by the presence of non-state international and commercial entities.

Whether considering general deterrence or immediate deterrence, opportunities abound for complications and misunderstandings. Space-based PNT capabilities are dual use and are essential to both military and nonmilitary activities. From a military point of view, it is critical for deterrence measures to succeed because the military relies so heavily on space-based PNT to conduct military operations. From a nonmilitary point of view, it is critical for deterrence measures to succeed since non-space powers and international and commercial entities rely heavily on space-based PNT as they pursue their own economic, security, and development interests. As defined in this article, intentional interference with space-based PNT is escalatory. It represents vertical escalation since it expands terrestrial conflict into another domain, and, if not limited in ways suggested by the proposed norm, attacking the space or control segment represents horizontal escalation affecting many other users not party to the conflict, in contravention of other established principles such as LOAC. It is therefore extremely important to explicitly codify the non-interference norm and the associated TCBMs necessary to deter actions that could escalate conflict in space or expand a conflict in space to a terrestrial conflict. Additionally, a codified norm prohibiting interference with the satellite and control segments of space-based PNT capabilities and effective associated TCBMs is a means by which the United States might preserve its access to the capability during all phases of a conflict.

A codified norm prohibiting intentional interference with satellite and control segments of space-based PNT could inhibit escalation, since there would be no option to interfere with the capability in order to gain the upper hand in a military action. Clearly delineated TCBMs such as well-defined nomenclature could lead to a decrease in misun-

derstandings regarding the interpretation of the noninterference norm. Declaratory policies and information-sharing agreements could reduce misunderstandings and mistrust between the states, which could lead to greater stability as states feel less of a need to preemptively interfere with a space-based PNT system.

Conclusion

It has been six decades since the first satellites were launched and the foundational norms concerning peaceful purposes of space were codified. Yet, there is no agreed-upon definition of peaceful purposes or the threshold for an armed attack, so uncertainty lingers regarding how interference with space capabilities should be addressed. Such uncertainty is destabilizing, and any interference with a space capability has the possibility of escalating a conflict in space or expanding a space conflict into a terrestrial conflict. A wide variety of entities ranging from states to non-state international organizations and commercial organizations use space-based PNT capabilities. Usages may support military operations, economic interests, societal development, or safety of life and navigation activities. The potential impact to the world if intentional interference with satellite or control segments caused worldwide loss of PNT information would be devastating. An expectation that space-based PNT is available and will continue to be available has recently emerged. A general understanding is emerging that the capability will always be available and that interference with the capability is not acceptable.

Those expectations, and the current restraint from interfering with the space and control segments of space-based PNT systems, are proceeding toward a norm that actively prohibits interference. However, that norm and associated TCBMs must be codified in order to create a common interpretation of the norm and define an acceptable framework of behaviors. The language of the norm should explicitly recognize that space-based PNT is an important contributor to the preservation of peace and progress for all peoples of the world. It should also promote cooperation among space-based PNT providers and users. Finally, it should explicitly state that it is desirable to prevent conflict in outer space that could escalate or expand into a terrestrial conflict.

There are at least three potential TCBMs to associate with the noninterference norm. First, a common set of nomenclatures should be created. The negotiation process itself would help define a common interpreta-

tion of, and expectations regarding, the norm. It might also help provide insight on how a potential adversary might respond to a given situation. Second, states should declare that they will not interfere with the satellite and control segments of space-based PNT capabilities. The United States has already implemented this TCBM to some degree through its national space policy, which states it will provide GPS for peaceful civil purposes. Third, states should develop and implement information-sharing agreements whereby they inform each other in the event of accidental or unauthorized activities that could lead to interference with the satellite and control segments of space-based PNT capabilities.

A codified norm prohibiting intentional interference with the satellite and control segments of space-based PNT could inhibit escalation. Clearly delineated TCBMs, such as a well-defined nomenclature, could lead to a decrease in misunderstandings regarding the interpretation of the noninterference norm. Declaratory policies and information-sharing agreements could reduce misunderstandings and mistrust between the states, which could lead to greater stability as states feel less of a need to preemptively interfere with a space-based PNT system. As a matter of security and as a matter of policy, targeting the satellite and control segments of space-based PNT systems during peacetime, crisis, or conflict could be prohibited out of concern for the global consequences gained for a limited, decreasing military advantage. SSQ

Appendix. States and organizations with a presence in space

Country/ Consortium	*Capabilities*	*Users Government/Military/Civil/ Commercial*
Algeria	Earth observation	Government
Argentina	Communications Technology development	Commercial Civil/Commercial
Australia	Communications	Military/Commercial
Austria	Space science Technology development	Civil Civil
Azerbaijan	Communications	Government
Belarus	Earth observation	Government
Belgium	Earth observation Space science	Government/Military/Commercial Civil
Bolivia	Communications	Government

Country/ Consortium	*Capabilities*	*Users Government/Military/Civil/ Commercial*
Brazil	Communications Earth observation Technology development	Commercial Government Civil
Canada	Communications Space science Space observation Technology development	Commercial Government/Civil Government/Military/Commercial Civil
Chile	Earth observation	Government/Military
China	Communications Earth observation PNT Space science Technology development	Government/Civil/Military/Commercial Government/Military/Commercial Military Government/Civil Government/Military/Civil/Commercial
Denmark	Communications Earth observation Technology development	Civil Government Commercial
Egypt	Communications	Government
France	Communications Earth observation Space science Technology development	Military/Commercial Government/Military/Commercial Government Military
Germany	Communications Earth observation Space science Technology development	Government/Military/Civil Government/Military/Civil/Commercial Government/Civil Government/Civil/Commercial
Greece	Communications Earth observation	Commercial Military
India	Communications Earth observation PNT Space science Technology development	Government/Military/Commercial Government/Military/Civil Government Government Government/Civil
Indonesia	Communications Earth observation Technology development	Commercial Government Government
Iran	Communications	Government/Military/Civil/Commercial
Iraq	Earth observation	Civil
Israel	Communications Earth observation	Government/Military/Civil Military/Commercial
Italy	Communications Earth observation Space science	Government/Military/Commercial Government/Military/Civil Government
Japan	Communications Earth observation PNT Space science Technology development	Commercial Government/Civil/Commercial Government Government/Civil/Commercial Government/Civil/Commercial
Kazakhstan	Communications Earth observation	Commercial Government
Laos	Communications	Government

Country/ Consortium	*Capabilities*	*Users Government/Military/Civil/ Commercial*
Luxembourg	Communications	Commercial
Malaysia	Communications	Commercial
Mexico	Communications	Government/Military/Commercial
Monaco	Communications	Government/Commercial
Morocco	Technology development	Government
The Netherlands	Communications Technology development	Civil/Commercial Civil
Nigeria	Communications Earth observation Technology development	Commercial Government Government
Norway	Communications	Government/Commercial
Pakistan	Communications	Government/Commercial
Peru	Technology development	Civil
Philippines	Communications	Commercial
Poland	Space science	Government
Russia	Communications Earth observation PNT Space science Technology development	Government/Military/Civil/Commercial Government/Military/Commercial Military/Commercial Government Military/Civil
Saudi Arabia	Communications Earth observation Space science Technology development	Government/Commercial Government Government Commercial
Singapore	Communications Earth observation Technology development	Commercial Government/Civil/Commercial Civil/Commercial
South Africa	Earth observation Technology development	Military Civil
South Korea	Communications Earth observation Technology development	Government/Military/Commercial Government/Commercial Government
Spain	Communications Earth observation Technology development	Government/Military/Commercial Government/Military Government/Civil
Sri Lanka	Communications	Government
Sweden	Communications Earth observation	Commercial Government/Commercial
Switzerland	Technology development	Civil
Taiwan	Communications Earth observation	Commercial Government/Military/Civil
Thailand	Communications Earth observation	Commercial Government
Turkey	Communications Earth observation Technology development	Commercial Government/Military Civil

Country/ Consortium	*Capabilities*	*Users Government/Military/Civil/ Commercial*
Turkmenistan	Communications	Government/Commercial
Ukraine	Technology development	Civil
United Arab Emirates	Communications Earth observation	Military/Commercial Government
United Kingdom	Communications Earth observation Space science Technology development	Government/Military/Commercial Government/Commercial Government Government/Commercial
United States of America	Communications Earth observation PNT Space observation Space science Technology development	Government /Military/Civil/Commercial Government/ Military/Commercial Military/Commercial Military Government/Military/Civil Government/Military/Civil/Commercial
Uruguay	Technology development	Civil
Venezuela	Communications Earth observation	Government Government
Vietnam	Communications Earth observation	Government Government
European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)	Earth observation	Government/Civil
European Space Agency (ESA)	Communications Earth observation PNT Space science Technology development	Government/Commercial Government/Civil Commercial Government Government/Commercial
Regional African Satellite Communications Organization (RASCOM)	Communications	Commercial

Information in this table is derived from the Union of Concerned Scientists Satellite Database, http://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database#.VwK-xbwYNFI.

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70. Jonty Kasku-Jackson, "International Commercial Avenues to Complement Deterrence Actions," *Space and Defense Journal* 7, no. 1 (Winter 2014): 33–34, http://www.usafa.edu/df/dfe/dfer/centers/ecsds/docs/Space_and_Defense_7_1.pdf.

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