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UN (Jean-Marc Ferré)

Stuxnet, Schmitt Analysis, and the Cyber "Use-of-Force" Debate

By ANDREW C. FOLTZ

All Members shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any state, or in any other manner inconsistent with the Purposes of the United Nations.

—Article 2(4), Charter of the United Nations[1]

One of the many seemingly intractable legal issues surrounding cyberspace involves whether and when peacetime cyber operations constitute a prohibited use of force under Article 2(4) of the United Nations (UN) Charter. Notwithstanding a significant body of scholarly work on this topic and extensive real-world examples from which to draw, there is no internationally recognized definition of a use of force.[2] Rather, what has emerged is a general consensus that *some* cyber operations will constitute a use of force, but that it may not be possible to identify in advance the specific criteria states will use in making such determinations.

As discussed in this article, several analytic frameworks have been developed to help assess when cyber operations constitute a use of force.[3] One conclusion these frameworks share is that cyber operations resulting in physical damage or injury will almost always be regarded as a use of force. When these frameworks were developed, however, there were few, if any, examples of peacetime, state-sponsored cyber coercion. More importantly, the prospect of cyber attacks causing physical damage was largely theoretical.[4] Beginning

Lieutenant Colonel Andrew C. Foltz, USAF, wrote this essay while a student at the Air War College. It won the Strategic Research Paper category of the 2012 Chairman of the Joint Chiefs of Staff Strategic Essay Competition.

in 2007, however, a string of cyber operations—including the 2007 Distributed Denial of Service (DDoS) attack on Estonia, the 2008 DDoS attack on Georgia, and the 2008 discovery that the U.S. Government's most sensitive networks had been compromised—hinted at increased use of the cyber domain by states and their proxies for peacetime coercion. Then, with the discovery of the Stuxnet worm in 2010, which damaged uranium enrichment equipment at a nuclear facility in Iran, theory became reality.

Although Stuxnet has been described as a watershed event, there has been little academic discussion on whether it constituted a use of force.[5] Perhaps this is because it caused physical damage and, therefore, clearly constitutes a use of force under prevailing analytic frameworks. This appears to be the emerging consensus.[6] Although I generally agree with this conclusion, I also believe that by looking beyond the physical damage, Stuxnet provides a unique opportunity to assess the adequacy and continued relevancy of these frameworks.

As a first step toward such an assessment, this article tests one of the more robust frameworks, known as the Schmitt Analysis, by applying it to Stuxnet. Developed in 1999 by Professor Michael Schmitt, it is one of the most academically rigorous and frequently cited frameworks for characterizing cyber operations. The Schmitt Analysis consists of seven factors that states are likely to consider when characterizing cyber activities: severity, immediacy, directness, invasiveness, measurability, presumptive legitimacy, and responsibility. A key feature of the framework is that it remains faithful to Article 2(4) of the UN Charter while at the same time effectively bridging key elements of competing analytic frameworks that do not exhibit such fidelity to the Charter. By focusing this evaluation on Schmitt's model, I expect the results will have implications for the use-of-force debate more generally.

The article begins with a discussion of why, as a practical matter, discerning a peacetime use-of-force threshold in cyberspace is important. Next, I detail the Article 2(4) prohibition on the use of force and the difficulty applying it in the cyber context. I then review Schmitt's model and perform a Schmitt Analysis of Stuxnet. Finally, I examine what the analysis of Stuxnet reveals about the framework's continued utility and relevance. Overall, I find that Schmitt's underlying analytical approach remains sound—that is, the best way to characterize the lawfulness of peacetime cyber operations is to predict how states will characterize them. That said, the Stuxnet analysis reveals several limitations with Schmitt's framework, while also highlighting opportunities to broaden it. More importantly, I conclude that the time has come to relax the model's strict adherence to the UN Charter because Article 2(4) is just one of several factors that states are likely to consider when characterizing the lawfulness of cyber operations.

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Why the Use-of-Force Threshold Matters

Cyberspace represents a strategic vulnerability for many states because it is inextricably tied in to their economies, critical infrastructures, and even their national security apparatus. Compounding these concerns is the fact that a wide range of actors have proven adept at exploiting these vulnerabilities. Cybercrime, for example, is now estimated to exceed $1 trillion globally per year.[7] Even the most secure U.S. defense networks are not immune.[8] The scope of the problem has become so great that some claim the United States is engaged in a cyber war, and that it is losing.[9] The *National Security Strategy* of 2010 notes that "cybersecurity threats represent one of the most serious national security, public safety, and economic challenges we face as a nation."[10] The White House's *International Strategy for Cyberspace* of 2011 goes further by proclaiming: "When warranted, the United States will respond to hostile acts in cyberspace as we would to any other threat to our country," to include a military response.[11]

Against this backdrop, discerning a cyber use-of-force threshold becomes important for a number of reasons. Foremost is that characterizing cyber operations is a precondition to determining which legal regime governs state behavior.[12] If state-sponsored cyber activities constitute a use of force, then international law governing the use of force (jus ad bellum) and the Law of Armed Conflict (jus in bello) apply. In appropriate circumstances, this could trigger a state's right to self-defense and thereby permit a forceful, perhaps even armed response. In contrast, non-state-sponsored cyber operations and operations not amounting to a use of force are traditionally governed by more constrained law enforcement regimes.[13]

The need for clarity has taken on greater importance now that the United States and many of its allies treat cyberspace as a military operational domain.[14] Accordingly, discerning a use-of-force threshold would seem to be necessary for a wide range of peacetime military activities, such as defining the spectrum of permissible peacetime cyber operations, such as computer network exploitation; developing peacetime cyber rules of engagement; identifying appropriate approval authorities; assigning appropriate agency responsibilities and resources; signaling adversaries and allies as part of a deterrence strategy; recognizing when treaty obligations have been triggered; and determining whether UN Security Council authorization is required to conduct certain operations.

The Use of Force in Cyberspace

Notwithstanding the need for clarity discussed above, there is no international consensus on what constitutes a use of force in cyberspace, nor does it appear a mechanical rule is likely to emerge any time soon.[15] This section describes why ambiguity persists and the various solutions that have been proposed to resolve it. After summarizing the relevant law governing the use of force in international relations, I highlight the technical, legal, and political challenges of applying existing norms within cyberspace.

Use of Force Under the UN Charter. Jus ad bellum[16] describes the law governing the transition from peace to armed conflict. Though grounded in customary international law, the black letter principles of jus ad bellum are now contained in Article 2(4) of the UN Charter, which prohibits states from the "threat or use of force" in their international relations. Several features of this prohibition are problematic in the cyber context. First, Article 2(4) only pertains to international relations between sovereign states—it does not proscribe the conduct of nonstate actors,

who appear to be the source of most malicious cyber activity. Also, as noted above, the Charter does not define the phrase *use of force*. Finally, Article 2(4) does not provide any exceptions to the prohibition on the unilateral use of force, nor does it prescribe remedies for unauthorized uses of force. Such exceptions and remedies are found in chapter VII of the Charter which, unlike Article 2(4), is not limited to relations between states and employs thresholds quite distinct from the use-of-force standard.[17] Importantly, it is not the use of force, but rather an "armed attack" that triggers a state's right to use force in self-defense.[18]

Although use of force is not defined, an approximate threshold has emerged through consideration of the Charter's preparatory work, state practice, and *opinio juris*.[19] First, the framers of the Charter took an instrument-based, vice consequence-based, approach to the use of force prohibition.[20] While acknowledging that states are most concerned about the consequences of coercive activities (that is, the degree of injury, deprivation, or destruction), the framers recognized that a consequence-based criterion was too subjective to distinguish lawful from unlawful state coercion.[21] Because the term *force* connotes violence, injury, and destruction—consequences that pose the greatest threat to international peace and security—they adopted the instrument-based use-of-force standard as prescriptive shorthand. According to Professor Schmitt, such an approach "eases the evaluative process by simply asking whether force has been used, rather than requiring a far more difficult assessment of the consequences that have resulted."[22] According to this approach, the Article 2(4) prohibition does not extend to all forms of state coercion. For example, the instruments of economic and political coercion are not prohibited.[23] Less clear, but generally accepted, is that the prohibition is not limited to "armed" force—it may also encompass unarmed, nonmilitary physical force, such as releasing water from a dam.[24] The International Court of Justice highlighted this point in *Nicaragua v. United States* (hereinafter *Nicaragua*), when it concluded that arming and training guerrillas amounted to a prohibited use of force, even though it did not rise to the level of an armed attack.[25] Accordingly, the use of force threshold has traditionally been viewed as lying somewhere between purely economic and political coercion on the one hand and activities that result in physical damage or injury on the other.[26] As discussed below, discerning a clear use-of-force threshold in this gray area—a difficult task even in traditional kinetic context—has proven particularly difficult in the cyber context.[27]

Use of Force in Cyberspace. The difficulty of applying Article 2(4) in cyberspace is that the instrument-based paradigm does not cleanly translate to cyber operations, particularly for gray area operations that do not result in physical harm.[28] According to a strict instrument-based interpretation, even highly disruptive peacetime cyber operations may not qualify as a use of force because they lack the traditional kinetic characteristics associated with armed force.[29] Most commentators reject this strict interpretation because of the potential widespread destabilizing consequences of cyber operations. That said, by focusing on consequences to determine whether prohibited force has been used, these commentators call Article 2(4)'s instrument-based paradigm into question.

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The perceived shortcomings of Article 2(4) have led many to propose a new treaty law to govern cyber operations.[30] Others counter that states are unlikely to negotiate any meaningful treaties in the foreseeable future. They argue that divergent strategic interests and significant attribution problems make treaty enforcement unrealistic. They suggest that existing international norms, though imperfect, are adequate for extrapolating general principles governing the use of force in cyberspace and urge gradual expansion of international norms within the Article 2(4) framework.

Over the past two decades, proponents of this gradualist approach have developed several analytic frameworks to characterize the legality of cyber operations. First is the "effects-based" approach, which states that the quantum of damage, and not the means of attack, is all that matters. The advantage of this approach—which is generally favored by U.S. policymakers and military operators—is that it is fairly simple to apply and it acknowledges that states are principally concerned about consequences. The drawback is that it represents a hard break from the Charter's instrument-based approach and thereby relies on inherently subjective assessments among states that have divergent strategic capabilities, vulnerabilities, and interests. A second approach relies upon kinetic equivalency, arguing that cyber operations constitute a use of force only if the damage they cause could previously have been achieved only by a kinetic attack.[31] This framework generally adheres to the Charter's instrument-based approach, but it struggles to characterize hostile gray area cyber operations—such as projecting false targets on an adversary's early warning radars—that do not result in physical damage. A third approach applies a "strict liability" test for any cyber operations that target a state's critical infrastructure and vital interests because of the severe consequences that could result from such attacks. According to this model, the mere penetration of such systems—such as power production, stock exchanges, and air traffic control—can constitute evidence of hostile intent and thereby trigger the right of self-defense.[32] This framework suffers from the inherent subjectivity of defining what constitutes "critical infrastructure and vital interests," and because it expands the gray area to encompass activities such as computer network exploitation that are not currently prohibited by international law. Professor Schmitt's framework represents the fourth major model.

Schmitt Analysis

Professor Schmitt recognized that discerning the use-of-force threshold is really about predicting how states will characterize and respond to cyber incidents in light of prevailing international norms.[33] To aid in such predictions, his framework bridges the instrument- and consequence-based approaches. In keeping with the Article 2(4) instrument-based standard, his model consists of seven factors that represent the major distinctions between permissible (that is, economic and political) and impermissible (armed) instruments of coercion.[34] When applying these factors, the more closely the attributes of a

cyber operation approximate the attributes of armed force, the more likely states are to characterize the operation as a prohibited use of force. The Schmitt Analysis factors consist of the following:

- *Severity:* Cyber operations that threaten physical harm more closely approximate an armed attack. Relevant factors in the analysis include scope, duration, and intensity.
- *Immediacy:* Consequences that manifest quickly without time to mitigate harmful effects or seek peaceful accommodation are more likely to be viewed as a use of force.
- *Directness:* The more direct the causal connection between the cyber operation and the consequences, the more likely states will deem it to be a use of force.
- *Invasiveness:* The more a cyber operation impairs the territorial integrity or sovereignty of a state, the more likely it will be viewed as a use of force.
- *Measurability:* States are more likely to view a cyber operation as a use of force if the consequences are easily identifiable and objectively quantifiable.
- *Presumptive legitimacy:* To the extent certain activities are legitimate outside of the cyber context, they remain so in the cyber domain, for example, espionage, psychological operations, and propaganda.
- *Responsibility:* The closer the nexus between the cyber operation and a state, the more likely it will be characterized as a use of force.[35]

According to Professor Schmitt, evaluating these factors is an imprecise and subjective endeavor. The factors are useful but not determinative, and they should not be applied mechanically. Rather, they need to be applied holistically according to the relevant context—that is, which factors are important and how they should be weighted will vary on a case-by-case basis. Moreover, he never intended the factors to be exhaustive, though they are often treated as such.[36] Finally, the framework is more useful for post hoc forensic analysis of particular cyber attacks than for characterizing real-time operations.[37]

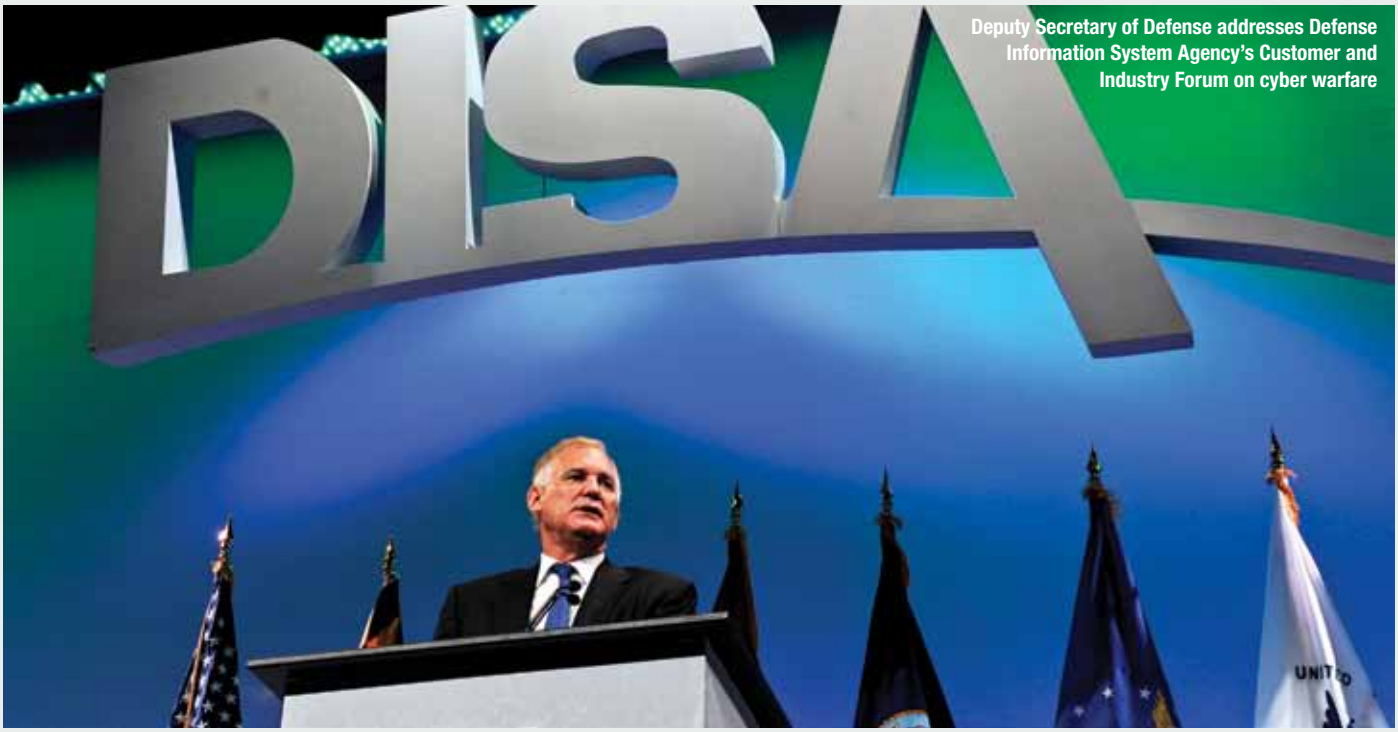
Professor Schmitt also acknowledged that his adherence to the Article 2(4) instrument-based paradigm appears tortuous, particularly given the appeal of simple effects-based frameworks. However, he reasoned that such adherence is necessary to properly describe where the cyber use of force threshold lies under prevailing standards—in contrast to the other leading models, which prescribe new standards for where the use of force threshold *should* lie.[38] He also believed that "reference to the instrument-based shorthand facilitates greater internal consistency and predictability within the preexisting framework. . . . As a result, subscription by the international community is more likely, and application should prove less disruptive and controversial."[39] In the end, the Schmitt Analysis has generally stood the test of time and remains one of the most commonly referenced frameworks for characterizing the use of force in cyberspace.

Characterizing Stuxnet

Stuxnet has been described as a game changer—the first digital "fire and forget" precision-guided munition and perhaps the first peacetime act of cyberwar.[40] According

U.S. Air Force (Lance Cheung)

Analysts attending Defense Cyber Investigations Training



Deputy Secretary of Defense addresses Defense Information System Agency's Customer and Industry Forum on cyber warfare

DOD (R.D. Ward)

to reports, the Stuxnet worm was designed to target gas centrifuges used in Iran's uranium enrichment program in Natanz. Specifically, the worm exploited the software used in programmable logic controllers (PLCs) manufactured by Siemens. These PLCs controlled frequency converter drives that, in turn, controlled the speed of the centrifuges. By manipulating the speed of already temperamental and frequency-sensitive centrifuges over time (weeks and perhaps months), Stuxnet caused as many as 1,000 of the centrifuges to break. Estimates suggest Stuxnet set Iran's nuclear program back by several years.[41]

Although some have described Stuxnet's code as a relatively unsophisticated "Frankenstein patchwork of existing tradecraft, code and best practices drawn from the global cyber-crime community," its true sophistication lies in the synergy of its components and its method of infection.[42] First, Stuxnet's designers required incredibly precise intelligence about Iran's PLCs and frequency converters, as well as the performance parameters of its centrifuges.[43] Second, the malware was self-replicating and designed to infect systems that were not connected to the Internet ("air-gapped"), thereby requiring the use of intermediary devices such as thumb drives. Stuxnet also employed four "zero-day" exploits[44] and two stolen digital signatures to gain access to targeted systems. Finally, Stuxnet appears to have been designed to avoid collateral damage.[45] If the malware did not detect the specific software-hardware configuration associated with Iran's enrichment program, the program would lie dormant. It was also designed to delete itself from thumb drives after infecting three machines, and it contained a built-in self-destruct feature. Thus, even though the worm is reported to have infected more than 100,000 hosts in 155 countries, 60 percent of the infections were localized to Iran, and there are no reports of physical damage outside of Iran.[46] Although no one has claimed responsibility for Stuxnet, it has the signature of a state operation.[47] Most speculation and some anecdotal evidence points to Israel, with possible support from the United States and/or Germany.[48]

Although there is an emerging consensus that Stuxnet constituted a use of force, there is value in looking beyond the physical damage to see what the operation reveals about the strengths and weaknesses of existing analytic frameworks, such as the Schmitt Analysis. Accordingly, the following analysis is offered not only to characterize Stuxnet, but to help evaluate Schmitt's framework.

Severity: According to this criterion, Stuxnet is per se a use of force because it caused physical damage. Moreover, the damage was inflicted upon a critical Iranian interest—its nuclear program. By setting Iran's nuclear program back several years, the duration of Stuxnet's consequences also supports characterizing it as a use of force—though this delay is due to sanctions that bar Iran from legitimately acquiring new centrifuges. It is also worth noting that the scope of the actual damage appears to have been relatively minor and fairly discrete, and that it posed no apparent risk of harm to personnel.

Immediacy: According to this factor, Stuxnet would probably not be viewed as a use of force. The attack, which consisted of at least three waves over 10 months, took time to evolve.[49] More importantly, once a targeted system was infected, it appears the damage took weeks or even months to manifest. Given the nature of how the attack unfolded, there was and remains adequate opportunity for Iran to mitigate the harmful effects and to seek peaceful accommodation. That said, given the physical damage inflicted, immediacy is probably not a factor that warrants much emphasis in this analysis.

Directness: There appears to be a direct causal connection between Stuxnet and the damaged centrifuges.

Invasiveness: Stuxnet represents a significant intrusion on Iranian sovereignty. Not only does it appear to have crossed international borders, but it targeted sensitive and highly secure systems that were air-gapped from the Internet. That said, Stuxnet would have been just as invasive if it had simply collected intelligence on the inner workings of the Natanz facility—an activity the interna-

tional community would likely not regard as a use of force.

Measurability: Taking into account the already high failure rate of Iran's centrifuges, the consequences attributed to Stuxnet appear both quantifiable and identifiable.

Presumptive legitimacy: Stuxnet does not enjoy presumptive legitimacy. Short of UN Security Council authorization or actions taken in self-defense—both of which would constitute *lawful* uses of force—there is no customary acceptance within the international community for damaging another state's nuclear facilities. Even so, it is worth considering the effect of existing Iranian sanctions upon this analysis. First, Iran cannot import or export nuclear-related materials or technology. If such Iranian-owned nuclear materials are discovered outside of Iran, they can be lawfully seized and destroyed. Second, prior to Stuxnet, Iran had been operating its centrifuges for several years in violation of multiple UN Security Council Resolutions.[50] Although these points may relate more to whether Stuxnet constituted a *lawful* use of force, they also seem to bear on the factor of presumptive legitimacy.

Responsibility: Although no state has claimed responsibility for Stuxnet, the worm's purpose and design strongly suggest state involvement. That said, it is possible that Stuxnet was created and launched by nonstate actors—such as Iranian dissidents working with freelance hackers—in which case it would not be subject to international laws governing the use of force.

On balance, the Schmitt Analysis suggests most states would characterize Stuxnet as a use of force. The worm was highly invasive, caused direct and measurable physical damage, lacked a clear presumption of legitimacy, and probably involved state support.

What does the foregoing analysis of Stuxnet reveal about the continued usefulness of Professor Schmitt's framework? Most importantly, the model's underlying analytic approach appears sound—that is, discerning the use of force threshold entails predicting how states will characterize cyber operations. That said, the analysis reveals several limitations with the framework, as well as opportunities for its expansion.

First, it appears that in any given Schmitt Analysis, the characterization of a cyber operation may be derived from a single factor: severity of the consequences. If true, then the framework could arguably be reduced to an effects-based model with little remaining affinity with the Article 2(4) instrument-based paradigm. To illustrate the point, what if instead of damaging Iranian centrifuges Stuxnet achieved the same effects by causing the centrifuges to operate inefficiently or not at all? Except for severity, each of Schmitt's factors would likely be evaluated the same. It is debatable, though, whether the international community would consider such an operation a prohibited use of force. This is not to suggest that the other factors are irrelevant, but it highlights what Professor Schmitt himself acknowledged: "severity is self-evidently the most significant factor in the analysis."[51]

Next, the characteristics of Stuxnet and its intended target suggest at least one additional factor that may be relevant when performing a Schmitt Analysis: apparent compliance with the Law of Armed Conflict (LOAC).[52] Assuming reports are true, the fact that Stuxnet was targeted so precisely and designed to minimize collateral damage

U.S. Navy (Joshua J. Wahl)

Commander of Navy Cyber Forces observes spectral warrior demonstration during exercise Bold Alligator 2012

reveals something about the identity and intent of its creators. First, it reinforces the notion that Stuxnet was a state-sponsored operation, which is important because Article 2(4) only regulates state conduct. Second, it suggests Stuxnet's creators were concerned about complying with LOAC, particularly the principles of military necessity, distinction, and proportionality.[53] Thus, the responsible state apparently regarded Stuxnet as the equivalent of an armed attack and executed the operation as such. Since an armed attack constitutes a use of force, the implication is that states are more likely to characterize cyber attacks as a use of force if they appear to comply with LOAC—even in gray area operations that do not result in actual damage.

A third observation involves one of the most technically challenging aspects of cyber operations: attribution. For Article 2(4) and the principles of jus ad bellum to apply, the responsible party must be identified as a state.[54] As noted above, without reliable attribution states generally must respond to cyber operations as a law enforcement problem. Yet each of the prevailing frameworks, including the Schmitt Analysis, treats attribution as a condition precedent to any use-of-force analysis.[55] In other words, without attribution, a Schmitt Analysis offers limited practical value. But if state attribution can be established, it is questionable whether a Schmitt Analysis would be necessary because more revealing indicators should be discernable, such as motive and intent.

Next, to the extent state attribution bears on the characterization of cyber operations, so too should the victim state's response. As the International Court of Justice noted in *Nicaragua*: "it is the State which is the victim of an armed attack which must form and declare the view that it has been so attacked."[56] Although Iran has acknowledged the presence of Stuxnet in its systems, it has denied any significant damage and has never claimed that it was subject to an armed attack. As U.S. Cyber Command's top lawyer, Colonel Gary Brown, has commented: "Iran's 'non-position' on the Stuxnet event has been frustrating to practitioners in the field of cyberspace operations. Finally, there was a well-documented, unambiguous cyber attack to dissect! And yet there was little official discussion of the issue because Iran passed up its opportunity to complain of an unjustified attack."[57] Unfortunately, Professor Schmitt's framework does not address the implications of such state inaction. It remains to be seen what, if any, impact Iran's "non-position" has on the development of use of force norms in cyberspace.

A more significant observation relates to Professor Schmitt's premise that states will principally rely upon existing norms, particularly Article 2(4), when making use-of-force determinations in cyberspace. As some commentators predicted—and Stuxnet demonstrated—Article 2(4) has proven to be a "weak constraint on offensive cyber-attacks."[58] This is due, in part, to the difficulty of observing, measuring, and attributing cyber operations. More importantly, it reflects the fact that international law is not static and that the principles of jus ad bellum are not the exclusive province of the UN Charter.[59] Whereas contemporary interpretations of Article 2(4) reflect the distribution of traditional instruments of power—that is, political, military, and economic strength—the current array of cyber capabilities and vulnerabilities does not mirror the traditional distribution.[60] Consequently, states with significant cyber capabilities or vulnerabilities—regardless of their political, military, or economic strength—are likely to consider factors well beyond Article 2(4) when characterizing the legality of cyber operations. Such additional considerations may include relative cyber strengths and vulnerabilities; strategic risks and opportunities; scope of potential consequences; ability to control escalation; effectiveness of cyber deterrence; potential reactions by adversaries, allies, and international organizations; domestic politics; state declaratory policies; emerging state practice (including state inaction); attribution problems; and other legal, political, and technical constraints.[61] Moreover, given the novelty of cyberspace, different

Commander of U.S. Fleet Cyber Command and U.S. 10th Fleet addresses Information Dominance Corps

U.S. Navy (Shauntae Hinkle-Lymas)

states will likely weigh their strategic risks and opportunities very differently.

Perhaps these additional considerations explain why there has been so little academic debate about the legal implications of Stuxnet. Even though most states would probably agree that Stuxnet constituted a use of force under Article 2(4), they may be reluctant to characterize the attack as *unlawful* since, by targeting an illicit program in a pariah state, it was justifiable. In this regard, it is worth noting that Stuxnet's objective was consistent with multiple UN Security Council mandates and it promoted those mandates without resorting to *armed* force. Thus, it remains to be seen whether Stuxnet represents a new form of tacitly condoned cyber vigilante-ism, or whether the perpetrator(s) will eventually be held in contempt. Either way, Iran's "non-position" has made it easy for the international community to sidestep the issue.

policymakers and cyber practitioners must be prepared to operate in an ambiguous and contested legal environment

Conclusion

Although Professor Schmitt's analytic approach to characterizing cyber operations remains sound, the analysis of Stuxnet reveals several shortcomings with his model. These include severity of the consequences as a potentially determinative factor, attribution as a condition precedent to a use of force analysis, and failure to account for a victim state's "non-position" toward a particular cyber operation. This analysis also reveals at least one additional factor states may consider when characterizing cyber operations—whether an attack appears to comply with LOAC.

More importantly, this analysis suggests the time has come to relax the model's strict adherence to the Article 2(4) instrument-based paradigm. By tying his framework to Article 2(4), Professor Schmitt anticipated more consistent, predictable, and relatively objective characterizations of force in cyberspace. However, state practice over the last decade suggests that states will treat Article 2(4) as just one of several factors to consider when characterizing cyber operations.[62] As Professor Schmitt himself acknowledged, as state practice emerges, other considerations and normative approaches—such as greater emphasis on consequences—may come to dominate the analysis.[63] In light of recent events in Estonia, Georgia, and Iran, it appears that time has come.

The Schmitt Analysis of Stuxnet also has implications for the broader debate over the use of force in cyberspace. For one thing, the lack of discussion over the legal implications of Stuxnet demonstrates that states are unlikely to reach consensus on what constitutes a cyber use of force any time soon. The lack of a discernable threshold also suggests that state-sponsored gray area cyber attacks are more likely.[64] Consequently, policymakers and cyber practitioners and their legal advisors must be prepared to operate in an ambiguous and contested legal environment, while at the same time shaping new norms of acceptable state conduct.[65] In the end, these evolving norms are not likely to be constrained by Article 2(4)'s narrow prohibition on the use of force. Rather, they will likely reflect the new realities and unique features of cyberspace, such as cyber's potentially devastating consequences, the nontraditional distribution of cyber capabilities and vulnerabilities, and the international community's response (or lack thereof) to seminal events like Stuxnet. **JFQ**

NOTES

[1] United Nations (UN), *Charter of the United Nations and Statute of the International Court of Justice* (San Francisco, CA: UN, 1945).

[2] Michael N. Schmitt, "Computer Network Attack and the Use of Force in International Law: Thoughts on a Normative Framework," *Columbia Journal of Transnational Law* 37 (1999), 925. See also U.S. Senate, *Advance Questions for Lieutenant General Keith Alexander, USA Nominee for Commander, United States Cyber Command: Before the Senate Armed Services Committee*, 11th Cong., 11th sess., April 15, 2010, 11.

[3] Walter Gary Sharp, Sr., *Cyberspace and the Use of Force* (Falls Church, VA: Aegis Research, 1999), 140; and David E. Graham, "Cyber Threats and the Law of War," *Journal of International Law & Policy*, 4 (2010), 91–92.

[4] Isaac R. Porche III, Jerry M. Sollinger, and Shawn McKay, *A Cyberworm That Knows No Boundaries* (Washington, DC: RAND, 2011), ix.

[5] Duncan B. Hollis, "Could Deploying Stuxnet Be a War Crime?" OpinioJuris.org, January 25, 2011; Gary D. Brown, "Why Iran Didn't Admit Stuxnet Was an Attack," *Joint Force Quarterly* 63 (4th Quarter 2011), 70–73; and John Richardson, "Stuxnet as Cyber Warfare: Applying the Law of War to the Virtual Battlefield," Social Science Research Network Working Paper, 2011.

[6] Ibid.; Michael N. Schmitt, interview by the author, December 1, 2011; and Colonel Gary D. Brown, interview by the author, December 2, 2011.

[7] *Information Operations Primer* (Carlisle Barracks, PA: U.S. Army War College, November 2011), 23.

[8] Ellen Nakashima, "Cyber-Intruder Sparks Massive Federal Response—and Debate Over Dealing With Threats," *The Washington Post*, December 9, 2011.

[9] See "Mike McConnell on how to win the cyber-war we're losing," *The Washington Post*, February 28, 2010; Richard A. Clarke and Robert K. Knake, *Cyber War: The Next Threat to National Security and What To Do About It* (New York: Harper-Collins Publishers, 2010); Ryan Singel, "Is the Hacking Threat to National Security Overblown?" *Wired Magazine*, June 3, 2009; and Bruce Schneier, "The Threat of Cyberwar Has Been Grossly Exaggerated," *Schneier.com*, July 7, 2010.

[10] *National Security Strategy* (Washington, DC: The White House, May 2010), 27.

[11] *International Strategy for Cyberspace: Prosperity, Security, and Openness in a Networked World* (Washington, DC: The White House, May 2011), 14.

[12] Charles J. Dunlap, Jr., "Perspectives for Cyber Strategists on Law and Cyberwar," *Strategic Studies Quarterly* (Spring 2011), 84; and Eneken Tikk, Kadri Kaska, and Liis Vihul, I*nternational Cyber Incidents: Legal Implications* (Tallin, Estonia: NATO Cooperative Cyber Defence Centre, 2010), 79.

[13] Dunlap, 84.

[14] See Department of Defense (DOD), *Department of Defense Strategy for Operating in Cyberspace* (Washington, DC: DOD, July 2011), 5; *National Security Strategy*, 22; and *International Strategy for Cyberspace*, 14.

[15] As one commentator has noted, "Although the application of the UN Charter Article 2(4) to CNA [computer network attack] is an intellectually interesting question, there is reason to wonder whether, as a practical matter, the issue ever will arise in a context requiring an actual decision. The most important obstacle may be the difficulty of attributing CNA to State action. Moreover, even if State use of CNA were to emerge as a recognizable phenomenon, such CNA would have to occur in relative isolation in order squarely to pose the relevant legal issue. Because this seems improbable, it likely will be a long time, if ever, before the practice of States, decisions of the International Court of justice (ICJ), or other recognized sources of international law yield a clarification of how Article 2(4) applies to CNA." Daniel B. Silver, "Computer Network Attack as a Use of Force under Article

2(4) of the United Nations Charter," in *Naval War College International Law Studies* 76; Computer Network Attack and International Law, ed. Michael N. Schmitt and Brian T. O'Donnell, 77–78 (Newport, RI: Naval War College Press, 2002).

[16] Latin for "right to the war," more commonly understood as the "right to wage war." The principles of jus ad bellum are distinct from the related principles of jus in bello—or the Law of Armed Conflict (LOAC)—which govern how armed conflict is conducted.

[17] For example, compare Article 39's "breach of the peace" and "aggression" thresholds; Article 41's "measures short of armed force" standard; Article 42's "such action by air, sea, or land forces as may be necessary" language; and Article 51's "armed attack" threshold for self-defense actions.

[18] Schmitt, "Computer Network Attack and the Use of Force," 920.

[19] Ibid.," 905–907. *Opinio juris* means a sense of legal obligation. In the international law context, it is used to judge whether State practice and adherence to norms is due to a sense of legal obligation, vice political expediency, or convenience. *Duhaime.org Legal Dictionary*, available at <www.duhaime.org/ LegalDictionary/O/OpinioJuris.aspx>. When opinio juris exists and is consistent with nearly all state practice, customary international law emerges. For example, Article 38(1)(b) of the Statute of the International Court of Justice accepts "international custom" as a source of law, but only where this custom is: (1) "evidence of a general practice," and (2) "accepted as law."

[20] See, for example, Schmitt, "Computer Network Attack and the Use of Force," 909; and Duncan B. Hollis, "Why States Need an International Law for Information Operations," *Lewis & Clark Law Review* 11 (2007), 1040.

[21] Schmitt, "Computer Network Attack and the Use of Force," 914.

[22] Ibid., 911.

[23] Ibid. A compelling argument does exist, however, that political and economic coercion that threatens the territorial integrity or political independence of another state constitutes an unlawful use of force under Article 2(4). See Sharp, 89–90, 118.

[24] Sharp, 101.

[25] *Nicaragua*, para 228. According to the ICJ, the distinction between the threat or use of force (including armed force) and an armed attack is based on the operation's "scale and effects." *Nicaragua*, para. 195.

[26] Schmitt, "Cyber Operations in International Law," 155.

[27] See Matthew C. Waxman, "Cyber-Attacks and the Use of Force: Back to the Future of Article 2(4)," *The Yale Journal of International Law*, 36 (2011), 445–447.

[28] Hollis, "Why States Need an International Law for Information Operations," 1040.

[29] Ibid., 1041. Professor Schmitt highlighted this dilemma: "The advent of cyber operations threw the instrument-based approach into disarray by creating the possibility of dramatically destabilizing effects caused by other than kinetic actions." Schmitt, "Cyber Operations in International Law," 177.

[30] See Clarke and Knake, 219–255; Hollis, "Why States Need an International Law for Information Operations," 1053; and Silver, 78.

[31] See Hollis, "Why States Need an International Law for Information Operations," 1041; and Graham, 91.

[32] Sharp, 129–131; and Hollis, "Why States Need an International Law for Information Operations," 1041.

[33] Schmitt, interview by the author. In this regard, Professor Schmitt noted that states would likely seek to balance the conflicting objectives of maximizing their own freedom of action in cyberspace while avoiding the harmful consequences caused by adversaries. See also Schmitt, "Cyber Operations in International Law," 155.

[34] Schmitt, "Computer Network Attack and the Use of Force," 914.

[35] Professor Schmitt's responsibility factor is best understood as a measure of the degree of state attribution, although he did not describe it as such. State attribution is an important part of his model because Article 2(4) and customary international laws only govern the use of force between states.

[36] Schmitt, interview with author. See also, Michael N. Schmitt, "The Sixteenth Waldemar A. Solf Lecture in International Law," *Military Law Review*, 176 (2003), 417.

[37] Schmitt, interview with author.

[38] Schmitt, "Computer Network Attack and the Use of Force," 917.

[39] Ibid.

[40] See, for example, Lukas Milevski, "Stuxnet and Strategy: A Special Operation in Cyberspace?" *Joint Force Quarterly* 63 (4th Quarter 2011), 64; and Porche, Sollinger, and McKay, 1.

[41] See Kim Zetter, "How Digital Detectives Deciphered Stuxnet, the Most Menacing Malware in History," *Wired.com*, July 11, 2011; Porche, Sollinger, and McKay; Nicolas Falliere, Liam O Murchu, and Eric Chien, *W32.Stuxnet Dossier* (Symantec, February 2011); and Hollis, "Could Deploying Stuxnet Be a War Crime?"

[42] Milevski, "Stuxnet and Strategy," 66 (citing James P. Farwell and Rafal Rohozinski, "Stuxnet and the Future of Cyber War," *Survival* 53, no. 1 [January 2011], 24.).

[43] According to reports, representatives from the International Atomic Energy Agency who had inspected Natanz did not even have this level of information. Ibid., 65.

[44] A *zero-day threat* is a software vulnerability unknown to the user or software developer that can be exploited before the vulnerability can be fixed.

[45] Richardson, 7.

[46] Falliere, Murchu, and Chien, 10. Despite early speculation that Stuxnet damaged an Indian satellite, the claim has never been substantiated.

[47] Porche, Sollinger, and McKay, 8.

[48] Zetter; Brown, "Why Iran Didn't Admit Stuxnet Was an Attack"; Richardson, 30; and William J. Broad, John Markoff, and David E. Sanger, "Israeli Test on Worm Called Crucial in Iran Nuclear Delay," *The New York Times*, January 15, 2011.

[49] Falliere, Murchu, and Chien, 8.

[50] See, UN Security Council Resolutions 1737 (2006), 1747 (2007), 1803 (2008), and 1929 (2010).

[51] Schmitt, "Cyber Operations in International Law," 156.

[52] The Law of Armed Conflict (LOAC)—also known as the Law of War and International Humanitarian Law—is the body of law governing the conduct of armed conflict. It is derived from both customary international law and treaty law, including The Hague and Geneva Conventions. The basic principles of LOAC include: military necessity, unnecessary suffering, distinction, proportionality, and chivalry. *Air Force Operations & The Law: A Guide for Air, Space & Cyber Forces* (Maxwell AFB, AL: The Judge Advocate General's School, 2009), 13–20.

[53] Ibid.

[54] Herbert S. Lin, "Offensive Cyber Operations and the Use of Force," *Journal of National Security Law & Policy* 4 (2010), 77.

[55] Schmitt, interview with author.

[56] *Nicaragua*, para. 195.

[57] Brown, "Why Iran Didn't Admit Stuxnet Was an Attack," 71.

[58] Waxman, 426.

[59] Graham, 88.

[60] Waxman, 448–458.

[61] Ibid. See also Graham, 89.

[62] Waxman, 448–458; and Sharp.

[63] Schmitt, "Computer Network Attack and the Use of Force," 917.

[64] As representatives from NATO's Cooperative Cyber Defence Centre of Excellence (CCDCOE) have noted: "it is the general murkiness, the lack of clear policies and procedures, the lack of direct evidence of the attacking entity's identity that may make such attacks even more attractive. In such a volatile environment, by deliberately remaining below the threshold of use of force and at the same time using national policy cover as shield against investigations and prosecution, an attacking entity may believe there is less likelihood of reprisal even if the attacker's identity is suspected." CCDCOE, *International Cyber Incidents: Legal Implications*, 103.

[65] Waxman, 426; Silver, 75.