LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

LLNL-TR-738786

The Significance of Strategic Foresight in Verification Technologies: A Case Study of the INF Treaty

H. N. Toivanen

September 21, 2017

Disclaimer

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

The Significance of Strategic Foresight in Verification Technologies: A Case Study of the INF Treaty

September, 2017

CGSR

Center for Global Security Research

LAWRENCE LIVERMORE NATIONAL LABORATORY

LLNL-TR-738786

The Significance of Strategic Foresight in Verification Technologies: A Case Study of the INF Treaty

Henrietta Toivanen[1*]

Research Intern
Center for Global Security Research, Lawrence Livermore National Laboratory

Table of Contents

[1*] Henrietta Toivanen is a PhD student at the Woodrow Wilson School of Public and International Affairs at Princeton University.

The author would like to thank Dr. William Dunlop, Dr. Stan Fraley, Ambassador Ron Lehman, Ambassador Steven Pifer, Ms. Carolyn Pura, and Ambassador John Woodworth for sharing their thoughts and insights in their interviews. Further thanks belong to Dr. Mona Dreicer, Dr. Brad Roberts, Dr. Bruce Goodwin, Mr. Wes Spain, and Dr. Jacek Durkalec for valuable feedback in editing the paper.

Executive Summary

Verification technologies can serve as important tools of statecraft in arms control efforts beyond providing monitoring capabilities and deterring noncompliance. The INF Treaty provides an insightful case study of the strategic side of verification technologies, illuminating how these capabilities can be used to shape negotiation positions and treaty content, provide domestic and international assurance, and manage tensions in the treaty implementation process.[1] Operationalizing verification technologies in this way expands the tools available at the diplomatic and policy levels, but it requires foresight and preparedness to identify and develop the relevant technical capabilities.

The INF Treaty, which eliminated and prohibited ground-launched ballistic and cruise missiles with ranges between 500 and 5,500 kilometers, is considered one of the important inflection points in the U.S.-Soviet relations during the Cold War. In addition to its impact at a strategic level, the treaty had an important impact in opening up the Soviet society and enhancing interactions between the East and the West. During the treaty process, technical expert communities played a critical role in conceptualizing, negotiating, and implementing the verification provisions that employed on-site inspections, radiation detection equipment, and other innovative but intrusive mechanisms. The organization and coordination of the technical communities allowed the developed capabilities to be communicated to the diplomatic level, allowing these technical capabilities to shape the outcome of the treaty negotiations. Overall, the innovative verification approaches implemented in the INF Treaty, and the way in which they were operationalized as strategic tools in the treaty process, resulted both from top-down and bottom-up relationships between the technical experts and the interagency and diplomatic officials.

During the INF negotiations, verification technologies were used as leverage to shape the content and structure of the treaty by both the United States and the Soviet Union. The two most prominent instances of this took place when the United States was able to pressure the Soviet Union to shift its negotiating position towards the elimination of the INF systems in the summer of 1987; and when later that year, the Soviet Union was able to negotiate an exception to the treaty provisions without compromising on the United States' ability to verify Soviet compliance. In both of these cases, the preparedness of the U.S. technical communities in arms control verification became instrumental for allowing the verification technologies to make a difference in the trajectory of the negotiations.

During ratification, technical verification methods were used as an assurance mechanism by the United States, both at the domestic and international levels. Domestically, the Reagan administration was able to use the innovative verification approaches to alleviate concerns about Soviet cheating in the Senate, where skeptical factions raised concerns about U.S. capabilities to

[1] Throughout this paper, 'strategic' refers to the use of verification technologies and arguments to pursue longer-term, broader political aims than the shorter-term, direct functions associated with verification (to provide detection capabilities, deter noncompliance, and produce reassurance about compliance intentions). This distinction between the strategic and substantive functions of verification are discussed at length in the chapter "Substance, Structure, and Strategy in Verification Politics" by Nancy Gallagher in *The Politics of Verification* (Baltimore, MD: Johns Hopkins University Press, 1999), 27-56.

monitor Soviet compliance. Internationally, strict verification played an important role in convincing European NATO allies of continued U.S. commitment to their security and ensuring the ability to detect Soviet treaty violations.

After entry-into-force, verification became a way to reduce the fundamental political tensions between the two treaty partners and served as a moderating force for arguments about the insufficiency of the verification protocol, as well as for the unbearable intrusiveness of the inspections. While technical implementation details became entangled in the political competition between the United States and the Soviet Union, the U.S. technical community was ultimately able to offer sufficiently trustworthy and validated technologies that adhered to the legal and practical standards of both sides.

The most important finding of this case study is that technical preparedness had an important impact, but only after a period of latency. The verification approaches used in the INF Treaty were developed before the topic was raised in the negotiations, and thus the capabilities were available when certain political shifts had occurred. Had there not been foresight to develop these capabilities in advance, however, they might never have been conceptualized in time to play a role in the treaty process.

The enabling factor for this foresight was the willingness of policymakers and technical experts to ask the 'what if' questions, even when the political realities were not yet conducive. Commissioning technical experts to freely explore and imagine verification tools and approaches, some of which may have been contrary to the prevailing U.S. policy positions, made a significant contribution later in the treaty process. Eventually, the forward-looking verification technologies and ideas were consciously employed by diplomats and policymakers as a strategic tool to shape the outcome of the treaty process, from negotiating to practical implementation. Had the anticipatory research and development efforts not been made, the capabilities would not have been available when they were needed by diplomats.

I. Introduction

The Intermediate-Range Nuclear Forces (INF) Treaty is considered one of the inflection points in the Cold War, contributing to a shift in the relations between the United States and the Soviet Union, and paving the way to ending the confrontation between the two states. As the treaty was being negotiated, diplomats from both states were aware of the groundbreaking nature of the engagement, but also acknowledged the uncertainties and risks associated with the treaty. This was particularly evident in the process of negotiating the verification provisions.

The verification debates and associated technologies discussed during the negotiation, ratification, and implementation processes became important and necessary strategic tools for the INF negotiators, shaping the outcome of the treaty process. The technical communities in the United States and the Soviet Union played a critical role in facilitating the treaty process at each stage and, as will be argued in this paper, had an impact in making the treaty possible.

This paper will explore three questions on the role that verification technologies played in the INF Treaty process, with a particular focus on the perspective of the United States – both diplomatically and technically.[2] First, did the existence of technical verification capabilities make a difference in shaping the outcome of the INF Treaty during the negotiation, ratification, and implementation processes, and if so, how? Second, how did the technical communities become involved and how were they organized and coordinated? Third, how did the experiences regarding the use of verification technologies in the INF Treaty influence subsequent arms control efforts and set a precedent for cooperative verification measures?

The first section provides an overview of the history of the INF Treaty, setting the context for the following parts of the paper. The second section explores the role that verification technologies played by explaining how they were employed strategically during the negotiation, ratification, and implementation stages. It will identify how the technologies had an impact: as leverage to shape the content and structure of the treaty; as an assurance mechanism at the domestic and international levels; and as a source of flexibility to reduce the fundamental political tensions between the two treaty partners. The third section illustrates how the organization and coordination of the technical communities helped make the technical capabilities available to the negotiators and policymakers, thereby allowing verification technologies to facilitate the different stages of the treaty process. The final section makes the case for how the INF Treaty established important precedents for future arms control treaties by providing compelling lessons on how technology can promote engagement between two adversarial states, and a cautionary example of how the efforts can become a source of further tensions.

[2] The asymmetry in technical preparedness between the United States and the Soviet Union gave the United States a relative advantage in using verification technologies and arguments strategically. The Soviet Union also benefited from this technical preparedness during the treaty process. For discussion about Soviet thinking on the technical and strategic sides of verification, see Nancy Gallagher, *The Politics of Verification* (cited above) and Aleksander Savel'yev and Nikolay Detinov, *The Big Five: Arms Control Decision-Making in the Soviet Union* (Westport, CT: Praeger, 1995).

II. History

The history of the INF Treaty, which eliminated and prohibited ground-launched ballistic and cruise missiles with ranges between 500 and 5,500 kilometers, spans from late 1970s to its conclusion in 1987.[3] The treaty-accountable systems for the Soviet Union were the intermediate-range missiles SS-4, SS-5, SS-20, and the SSC-X-4 cruise missile, and the shorter-range INF systems SS-12 and SS-23, as outlined in Article III on the treaty.[4] For the United States, the Pershing II and the BGM-109G were the intermediate-range systems that were eliminated, and the Pershing IA the shorter-range INF system.[5] By May 1991, the treaty-accountable systems had been eliminated from all of the 130 and 31 Soviet and U.S. sites, respectively.[6]

The aspiration to negotiate an arms control agreement over short- and medium-range nuclear missiles emerged in the United States in the late 1970s, as a result of various geopolitical shifts and changes in both U.S. and Soviet nuclear forces. The Soviet Union made significant improvements in its strategic capabilities during the 1970s and overcame earlier technological failures, allowing it to ultimately reach strategic parity with the United States in the second half of the decade.[7] The newly deployed SS-20 intermediate range missiles shifted the strategic balance in the European theater, as it increased the mobility, accuracy, and survivability of Soviet nuclear forces.[8] The development and deployment of SS-20s eliminated the superiority of the United States and NATO in Europe and "was viewed by many in the West as a primary tool of political intimidation during a crisis, as well as a flexible system for fighting a nuclear war in Europe."[9] Overall, the European concern was that the new Soviet INF systems would decouple Europe from the United States in security terms, decreasing U.S. preparedness and willingness to use nuclear forces in European NATO members' defense.[10]

---

[3] U.S. Department of State, "Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Elimination of their Intermediate-Range and Shorter-Range Missiles (INF Treaty)," accessed July 12, 2017, https://www.state.gov/t/avc/trty/102360.htm.

[4] Ibid.

[5] Ibid.

[6] U.S. Department of Defense, Defense Threat Reduction Agency, "On-Site Inspections Under the INF Treaty," accessed July 16, 2017, http://www.dtra.mil/Portals/61/Documents/History/On-Site%20Inspections%20INF%20Treaty-opt.pdf, 5.

[7] Andrew Goldberg, "Moscow's INF Experience," in *The Other Side of the Table: The Soviet Approach to Arms Control*, ed. Michael Mandelbaum (New York: Council on Foreign Relations Press, 1990), 91.

[8] For a fuller analysis, see James Cant, "The Development of the SS-20s: a Case Study of Soviet Defence Decision making During the Brezhnev Era," PhD diss., University of Glasgow, Department of Politics, 1998, http://theses.gla.ac.uk/4814/1/1998CantPhD.pdf.

[9] The strategic impact of the SS-20 deployment can been debated, as argued by Rose Gottemoeller: "The final legacy of the INF Treaty that has powerful resonance today is the understanding that INF systems were never central to deterrent capabilities for the United States or Russia. After all, theater targets can be covered by strategic missiles. This is a notion that was quite well understood when the INF Treaty was completed." Rose Gottemoeller, "Looking Back: The Intermediate-Range Nuclear Forces Trety," Carnegie Endowment for International Peace, June 1, 2007, http://carnegieendowment.org/2007/06/01/looking-back-intermediate-range-nuclear-forces-treaty-pub-19419.

[10] Comment by Steven Pifer, August 18, 2017. Ambassador Pifer served at the U.S. Embassy in Moscow when the INF Treaty was negotiated and implemented.

These improvements in the Soviet Union's nuclear capabilities were also paralleled by steady increases in its conventional forces in Europe.[11]

These shifts induced the Western alliance to compensate for the lost strategic superiority, leading NATO to pursue the Pershing II and BGM-109G Ground Launched Cruise Missile (GLCM) systems in 1979 and deploy them starting in December 1983 as a part of the dual-track decision.[12] As the Soviets continued to increase the number of SS-20 launch complexes through the 1970s and into the 1980s, these decisions risked establishing a cycle of heightening tensions and strategic competition.[13] These deployment decisions also gained a place in the public consciousness and precipitated an active debate, reflecting how this competition over military capabilities was one front of the more fundamental rivalry between the two superpowers over political dominance in Europe and the rest of the world.[14] Geopolitical shifts, such as the Soviet invasion of Afghanistan in December 1979 and the Iranian revolution and hostage crisis the same year, highlight the intensity of the global tensions in which the deployment decisions were made.

NATO's choice to improve military capabilities in the European theater, however, was only one dimension of the strategy that the alliance adopted. In its December 1979 meeting, NATO made a dual-track decision to complement the improvements in NATO's military capabilities with a diplomatic route that would create "a parallel and complementary arms control effort to obviate the need for such deployments."[15] There was a recognition among NATO member states that the quantitative and qualitative changes in Soviet capabilities required a reaffirmation of the credibility of NATO's European forces, but also that a strategy of constraining Soviet build-up could be complementary, rather than contradictory, to the first approach.[16] The meeting communiqué encouraged the United States to pursue bilateral arms control negotiations over theatre nuclear forces in Europe, without specifying numeric limits or timelines.[17]

---

[11] Goldberg, "Moscow's INF Experience," 91.

[12] Thomas Graham Jr. and Damien LaVera, *Cornerstones of Security: Arms Control Treaties in the Nuclear Era* (Seattle, WA: University of Washington Press, 2003), 512.

The primary reason for the NATO decision to deploy Pershing II and GLCMs was to reinforce the 'coupling' of Western Europe to the U.S. strategic deterrent, because the deployment of SS-20s was seen as a Soviet effort to decouple the European and U.S. security frameworks. Some argued that this would not be necessary, because the mere deployment of a system that threatens U.S. allies will not automatically constitute decoupling and require a counter-response, given existing U.S. security commitments to Europe. At the time, however, the fear of decoupling was heightened by the decline of US conventional military capabilities in Europe and a growing sense of isolationism, both products of the Vietnam War. The weapons deployments were seen by many as the only way to counter the potential decoupling effects of the SS-20s. Later, the rationale for pursuing the 'global zero' proposal in the INF negotiations was that the removal of both the U.S. and Soviet deployments would re-establish the integrity of coupling Europe to U.S. strategic deterrent, on the basis of the tactical and battlefield systems that would remain in the region. Comment by Dr. Ron Lehman, August 20, 2017.

[13] John Pike, Charles Vick, Mirko Jacubowski, and Patrick Garrett, "RT-21M / SS-20 Saber," Federation of American Scientists, https://fas.org/nuke/guide/russia/theater/rt-21m.htm.

[14] For debate over various theoretical perspectives into this, see James Cant, "The Development of the SS-20s: a Case Study of Soviet Defence Decisionmaking During the Brezhnev Era," PhD diss., University of Glasgow, Department of Politics, 1998, http://theses.gla.ac.uk/4814/1/1998CantPhD.pdf.

[15] NATO, "NATO Update: 1979," accessed July 13, 2017, http://www.nato.int/docu/update/70-79/1979e.htm.

[16] Cant, "The Development of the SS-20s," 77.

[17] Ibid., 78.

Early arms control efforts were impeded by the Soviet precondition that NATO's deployment decision of new ballistic and cruise missiles must be revoked, before any serious discussions could be started.[18] A shift in this position, however, allowed preliminary talks to begin in late 1980. The U.S. starting position, which was developed in consultation with NATO allies, was that the eventual agreement must:

> (1) provide for equality both in limits and rights between the United States and the Soviet Union;
> (2) be strictly bilateral and thus exclude British and French systems;
> (3) limit systems on a global basis;
> (4) not adversely affect NATO's conventional defense capability; and
> (5) be effectively verifiable.[19]

The requirement of effective verifiability became a defining issue for the new Reagan administration that took over the negotiations in January 1981. The emphasis on verification had both ideological and political undercurrents. Politically, in the early years of the first Reagan administration, the United States had yet to deploy the new NATO missiles in Europe. The Soviet Union was running a strong public relations campaign against these deployments, influencing the domestic politics in the European countries where the systems would eventually be stationed, in non-deploying countries, and even in the United States.[20] Thus, the negotiations became wrapped in U.S.-Soviet competition, where making the other side yield would constitute an important political victory. For this reason, the U.S. adamantly held ground on its verification position.

On the other hand, ideologically, the Reagan administration considered the INF negotiations an important dimension of the competition over ideas that the Cold War represented. The INF Treaty negotiations, and specifically the debate over its verification, provided an opportunity to confront Soviet values and challenge Soviet legitimacy. In 1983, President Reagan reflected his views that the Soviet leadership "reserve these rights to break a promise, to change their ways, to be dishonest, and so forth, if it furthered the cause of socialism," because they believed that "promises are like pie crust, made to be broken."[21] Verification provided an avenue for the Reagan administration to promote the ideas of openness and transparency, while keeping the Soviet side in check with respect to its commitments.

Yet, the Reagan administration recognized – as reflected in its support of NATO's dual-track decision – that arms limitations could also contribute to U.S. objectives and European security.

---

[18] Graham Jr. and LaVera, *Cornerstones of Security*, 513.

[19] Ibid.

[20] Interview with Dr. Ron Lehman. During the early INF negotiations, Lehman served as the Deputy Assistant Secretary of Defense; as the Senior Director for Defense and Arms Control on the National Security Council; and as a Special Assistant to the President. Later in the negotiations, he was Deputy Assistant to the President for National Security and led the START I negotiations in Geneva. During ratification, he served as the Assistant Secretary of Defense; and during implementation as the Director of the Arms Control and Disarmament Agency.

[21] "Remarks and a Question-and-Answer Session with Reporters on the Second Anniversary of the Inauguration of the President," January 20, 1983, http://www.presidency.ucsb.edu/ws/?pid=41498, cited in Nancy Gallagher, *The Politics of Verification* (Baltimore, MD: Johns Hopkins University Press, 1999), 186.

President Reagan thus characterized arms control engagement as a mutually beneficial transaction, providing both sides an incentive to reach an agreement:

> We're going to continue, because we believe that the Soviet Union has some problems of their own that have to be resolved. And in these negotiations that are going on, we think that it would be in their interest as well as ours. That's why we are so hopeful and optimistic that something can be gained here, that they cannot go on down the road they're going in a perpetual arms race. And so this [deployment of NATO INF systems] is one of the things in connection with our own arms race. It gives us a leverage that has brought them to the table in the first place.

This characterization of the negotiations, however, created an inherent need for the Reagan administration to ensure Soviet compliance with future treaty commitments, since cheating would entail relative gains for the adversary. Especially considering the poor compliance record of the Soviet Union on past agreements, the verification provisions contained in the INF Treaty would need to be airtight.[22] Thus President Reagan's hands were tied and his position on verification was locked tightly in place.[23] Overall, the political, ideological, and strategic links between the Reagan administration's credibility and effective verification explains why it was so critical to solve the verification challenges that eventually emerged.

The deployment of NATO intermediate-range systems in December 1983 broke apart the first round of negotiations.[24] The talks were reconvened in January 1985, with a joint agreement to pursue negotiations over strategic nuclear weapons, intermediate-range nuclear weapons, and space weapons "in their interrelationship," although the two sides did not agree on what that would entail.[25] Mikhail Gorbachev's rise to Soviet leadership provided President Reagan with a new counterpart and created new momentum for the negotiations. The talks continued through the October 1986 Reykjavík Summit, where the two sides established agreement on INF systems in Europe.[26] In June 1987, the formal Soviet and U.S. positions finally aligned with respect to a global elimination of INF systems.[27]

Substantial issues remained unresolved until the end of the negotiations. The U.S. and Soviet perspectives on verification were deeply divided, including domestic differences that were manifested in contentious debates between domestic political factions in each state, on the benefits and costs of

---

[22] Gallagher, *The Politics of Verification*, 184.

[23] Extensive literature on costly signaling illuminates how tying hands is one form of credibly communicating interests in negotiations, see for example James Fearon, "Signaling Foreign Policy Interests: Tying Hands Versus Sinking Costs," *The Journal of Conflict Resolution*, Vol. 41, No. 1.

[24] Amy Woolf, Paul Kerr, and Mary Beth Nikitin, *Arms Control and Nonproliferation: A Catalog of Treaties and Agreements* (Washington, D.C.: Congressional Research Service, 2012), 6.

[25] Mary Cooper, *Arms Control Negotiations, Editorial Research Reports 1985 (Vol I.)* (Washington, D.C.: CQ Press, 1985), http://library.cqpress.com/cqresearcher/document.php?id=cqresrre1985022200.

[26] The key problem was that the Soviet negotiators agreed to include the Asian deployments only in the sense that they would be allowed to keep SS-20s East of the Urals, but the United States could not keep weapons in Europe. Soviet missile deployments in Asia were one particularly difficult dimension of the negotiations for the United States, because of the impact they would have on U.S. alliance relations. The negative reaction from U.S. Asian allies for any residual Soviet forces in the region was a key reason motivating the global zero proposal. These states felt that the enhanced security in the European theater was made at the expense of Asia and would disproportionately deteriorate their security conditions. This also led to concerns in the United States about the treaty's proliferation impacts in Asia. Comments by Dr. Ronald Lehman, August 20, 2017.

[27] Woolf, Kerr, and Nikitin, *Arms Control and Nonproliferation: A Catalog of Treaties and Agreements*, 6.

verification.[28] During the final months of the talks, the U.S. and Soviet negotiating teams, while managing the divided perspectives in their countries' domestic political coalitions, worked to establish consensus on the treaty's verification provisions.

The most contested issue was that of on-site inspections, which the Soviets had opposed since the beginning of the negotiations, arguing that remote monitoring using national technical means (NTM) would be sufficient for verifying treaty compliance.[29] This reflects the general Soviet position on verification at the time, which was also manifested in test ban negotiations.[30] There were some exceptions to this position, such as the Joint Verification Experiment that took place parallel to the INF negotiations.[31] In general, however, the Soviet Union viewed intrusive on-site inspections as a source of espionage and subversion, which made the state intensely opposed to allowing these provisions.[32] The United States pushed for an intrusive verification regime, which was ultimately adopted in the treaty text. At this stage, however, failure to agree on verification measures could have collapsed the entire treaty negotiations:

> Work in fall 1987 focused on verification issues and drafting treaty language, with the U.S. delegation tabling a detailed inspection protocol in September. The inspection protocol was the longest and most complex of the treaty provisions; its most difficult and controversial element was the management of the verification problem created by the fact that the first stage of the SS-20 was *de facto* identical with the first stage of the SS-25 ICBM, and both were produced at the same facility. This was not disclosed until the final weeks of the negotiations; it would have been a treaty-breaker if the verification modalities had not been resolved.[33]

As will be discussed in detail, these issues were ultimately resolved and the final treaty text contained a verification regime that "was the most detailed and stringent in the history of nuclear arms control" to that date.[34] In addition to the treaty text, on December 8, 1987, President Reagan and General Secretary Gorbachev signed three additional documents outlining the verification provisions:

---

[28] An analytical framework, based on two-level games, has been developed in Gallagher's *The Politics of Verification* (cited above), based on Robert Putnam's "Diplomacy and Domestic Politics: The Logic of Two-Level Games," *International Organization* 42, No. 3 (1988), pp. 427-460).

[29] National technical means (NTM) refer to state-controlled intelligence capabilities aimed at detecting noncompliance, including imaging reconnaissance satellites, aircraft radars and optical systems, sea- and ground-based radar and antenna systems, radio-technical reconnaissance, and many other classified mechanisms. (U.S. Congress, Office of Technology Assessment, *Verification Technologies: Measures for Monitoring Compliance with the START Treaty* (Washington, D.C.: Government Printing Office, 1990), http://govinfo.library.unt.edu/ota/Ota_2/DATA/1990/9029.PDF; also William Burr, "The Secret History of The ABM Treaty, 1969-1972," National Security Archive Electronic Briefing Book No. 60, November 8, 2001, http://nsarchive.gwu.edu/NSAEBB/NSAEBB60/index2.html.)

U.S. Department of State, *The INF Treaty: Negotiation and Ratification*, 6.

[30] See Gallagher, *The Politics of Verification*.

[31] During the last year of negotiation of the INF Treaty, U.S. and Russian negotiators agreed on the Joint Verification Experiment, under which U.S. personnel could be on-site at Semipalatinsk to measure the yield of a Soviet nuclear test, and Soviet personnel could be on-site at the U.S. testing site in Nevada. Comment by Steven Pifer, August 18, 2017.

[32] Interview with Dr. Ron Lehman, July 12, 2017.

[33] Avis Bohlen, William Burns, Steven Pifer, and John Woodworth, "The Treaty on Intermediate-Range Nuclear Forces: History and Lessons Learned," *Brookings Arms Control Series*, Paper 9, December 2012, https://www.brookings.edu/wp-content/uploads/2016/06/30-arms-control-pifer-paper.pdf, 12.

[34] U.S. Department of State, "INF Treaty."

Memorandum of Understanding (MOU) on Data; the Protocol on Elimination; and the Protocol on Inspection.[35]

The treaty and additional documents provided for five types of on-site inspections: baseline, elimination, close-out, quota, and portal inspections.[36] The baseline inspections would be carried out soon after the treaty's entry into force and were to confirm the technical details of the missiles, their launchers, and their deployment environment.[37] They would also confirm the declared numbers of the treaty-limited items at the facilities.[38] The elimination inspections would be carried out during the three-year elimination period, allowing inspectors to monitor the host state rendering the weapons system impossible to be redeployed. This included cutting the missiles longitudinally and destroying missile stages with high explosives.[39] Close-out and quota inspections could be requested on a short timeline and would provide inspectors with a 24-hour period to identify signs of noncompliance at missile bases, either within 60 days of the elimination of treaty-accountable systems (close-out inspections) or after a close-out inspection has been conducted (quota inspections; during the first 13 years after the treaty's entry-into-force).[40] Lastly, portal monitoring inspections were conducted at the missile production plants to ensure that no treaty-accountable systems were produced or exited the facility.[41]

To alleviate concerns about covert SS-20 deployments, the use of radiation monitoring equipment was acceptable only under two circumstances during on-site inspections, so that the Soviet Union conversion of former SS-20 missile bases to SS-25 bases could be monitored.[42] First, the United States could use portable fast-neutron detectors to confirm the type of missiles deployed at the bases. The detectors would be used in the quota inspections after the bases have been 'closed-out' and converted to deploying only SS-25s.[43] The internal differences between the two missile types – the SS-20 has three warheads, whereas the SS-25 has only one – make it possible to distinguish between them.[44] The neutron counters would measure the longitudinal signal from the top of the deployed missiles, and then be compared to previously conducted baseline measurements to confirm that they are SS-25s, as opposed to SS-20s.[45] If after repeated measurements this confirmation could not be

---

[35] Ibid.

U.S. Department of Defense, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, "Treaty Compliance: Intermediate-Range and Shorter-Range Nuclear Forces (INF) Treaty," accessed July 16, 2017, http://www.acq.osd.mil/tc/treaties/inf/index.htm.

[36] Joerg Menzel, "Experience with Implementation of the INF Treaty," *INMM 31st Annual Meeting* (1990), 78.

[37] Ibid., 79.

[38] Comment by Steven Pifer, August 18, 2017.

[39] Menzel, "Experience with Implementation of the INF Treaty," 79.

[40] Ibid., 80.

[41] The portal monitoring inspections could not confirm that no treaty-accountable items were produced, since U.S. inspectors could not enter the facility itself. The inspections could only confirm that no treaty-accountable items exited the facility. Comment by Steven Pifer, August 18, 2017.

[42] Menzel, "Experience with Implementation of the INF Treaty," 80.

[43] Ibid.

[44] Ibid., 81.

[45] Ibid.

achieved, the inspectors had the right to request visual inspection from within the canisters.[46] Additionally, in each quota inspection, one canister would always be opened.[47]

The second condition where radiation equipment could be used was at the missile plants, in the Soviet Union (Votkinsk Machine Building Plant in the Urals) and in the United States (Hercules Rocket Motor Production Plant in Magna, Utah).[48] The Votkinsk plant was the final assembly facility for both SS-20 and SS-25 missiles, and the Hercules plant produced the rocket motors and missile stages for the Pershing II missiles.[49] The Soviet side never used its authority to deploy radiation detection equipment for monitoring the Hercules facility, but the United States did at Votkinsk. The United States was authorized to have access to all vehicles that could carry treaty-accountable missiles and use an x-ray machine (Cargoscan) to image the missiles that had been placed inside canisters.[50] In addition, U.S. inspectors could open up to eight of the canisters annually for visual inspection.[51]

[46] Ibid.

[47] Ibid.

[48] Ibid., 77.

[49] Ibid., 80.

[50] Ibid.

[51] Ibid.

III. Role of Verification Technologies and Technical Communities

Verification technologies played a critical role in shaping the INF Treaty and making its provisions acceptable to both sides, serving different purposes during the negotiation, ratification, and implementation processes. During treaty negotiations, verification technologies were used as leverage to shape the content and structure of the treaty; during ratification, verification was used as an assurance mechanism both at the domestic and international levels; and during implementation, it reduced the fundamental political tensions between the two treaty partners.

The organization and coordination of the technical communities played a critical role in facilitating the impact that verification technologies had during each of the three stages. After capabilities and concepts were developed at the technical level, the challenge of communicating them to the diplomatic level emerged. As will be illustrated, the framework for doing this in the United States employed personal and institutional contacts, development of a new agency to implement the verification mission, and other communication mechanisms to officials in Washington, Moscow, and Geneva. In addition to use of effective communications strategies, there was an effort to keep a degree of separation between negotiators and technical experts to maintain objectivity in judgements regarding the effectiveness of verification mechanisms.[52]

The technical communities and the policy makers had distinct roles. The diplomats involved in the treaty negotiations and the interagency officials developed the technical verification requirements.[53] These were then presented to the technical community, most importantly to the U.S. national laboratories, who proposed ways to fulfill the verification needs. There would be several competing technical solutions and approaches, several of which would be funded and developed. The goal was to maximize the probability of finding at least one practical and fieldable approach. By awarding parallel projects, the resources were spread across various national laboratories, thereby increasing support for the arms control efforts and avoiding adversarial competitive dynamics.[54]

In parallel to this top-down process, there was a bottom-up effort where the technical community actively proposed verification solutions and provided continuous support to the treaty negotiators. This process was more constrained, however, as the negotiating team was constrained by the instructions coming from the White House and the U.S. interagency process. This added to the feedback loop between the technical community and the negotiations to ensure that the negotiations proceeded towards the intended U.S. position and that the technical solutions facilitated this progress, rather than created unwanted interference.[55]

Negotiation Process

The United States and the Soviet Union were able to deploy verification technologies strategically in the negotiations process, because the technologies had been developed by the U.S.

[52] Interview with Dr. Ron Lehman, July 12, 2017.

[53] Interview with Dr. William Dunlop, August 4, 2017. Dr. Dunlop served as a Program Leader for Proliferation Prevention and Arms Control at Lawrence Livermore National Laboratory.

[54] Interview with Dr. William Dunlop, August 4, 2017.

[55] Ibid.

technical community, in anticipation of future treaty verification needs. This was most evident in two instances. First, in the summer of 1987, verification technologies were used by the United States as a leverage to pressure the Soviet Union to shift its negotiating position towards the elimination of the INF systems. The basis for this was that it is easier to verify the complete absence of treaty-limited items than to verify a numerical limit. Second, later that year, the Soviet Union came to realize that its long-range missile, SS-25, would be in violation of one of its prioritized treaty provisions, which stated that neither party could produce, flight-test, or otherwise retain the stages or launchers of the treaty-limited systems. While the provision was meant to prevent the United States from using the stages of Pershing II missiles, it also affected the Soviet SS-25, whose first stage was identical with that of the treaty-limited SS-20. Verification technologies allowed the treaty partners to carve out an exception for the SS-25, because the United States would be able to distinguish between the two missiles and thus satisfy U.S. verification demands.

During the first stage of the INF negotiations (1981 and 1983) verification was not a key issue because there was no established understanding of what would need to be verified.[56] The Soviet position was to freeze or reduce the weapons systems, whereas the U.S. sought their complete elimination.[57] This difference in positions prevented detailed engagement on verification issues, although some initial discussions began. Rhetorical references were made by the U.S. side, which referred to 'effective verification' in order to mark its position.[58] The U.S. negotiators knew that in prior arms control talks the Soviet Union had insisted on minimum levels of intrusiveness and access, so only national technical means (NTM) were used for verification.

When the negotiations re-started in 1985 and the Americans deemed that the Soviet Union was serious about making progress, the U.S. technical community embarked on a more profound effort to consider verification needs and develop the technical capacity to fulfill potential treaty provisions. While the National Security Council was driving the political negotiations forward, it delegated the verification mission to different interagency groups, including the INF Interdepartmental Group (INF IG) and the Consolidated Verification Group (CVG; a joint group with the START IG).[59] These interagency groups were co-chaired by the Department of State and Defense and involved representatives from various relevant governmental agencies and departments. The Arms Control Research Coordination Committee (ACRCC) was formed in 1984 to coordinate

---

[56] Interview with Steven Pifer, July 20, 2017.

[57] This issue was complicated by the differing definitions of 'strategic systems' between the United States and the Soviet Union, who disagreed which systems should be limited under the INF and START Treaties. Comment by Dr. Ron Lehman, August 20, 2017.

[58] Interview with Ambassador John Woodworth, July 26, 2017. Ambassador Woodworth served as the Deputy Negotiator and Representative of the Secretary of Defense to the INF negotiations.

The Reagan Administration moved away from the concept of "adequate verification" because "adequate" was defined as a situation in which no cheating would be possible that could change the military balance. Some people argued that nothing could change the nuclear balance so that any nuclear treaty would be adequately verifiable no matter what its terms. The Reagan Administration introduced the concept of "effectively verifiable," a more involved concept that took into account possibilities of cheating of military significance that were less than altering the military balance, but also detailed obligations, extensive data and transparency, and explicit mechanisms for enforcement. Some argued that NTM alone would be "adequate." Overall, effective verification pushed the envelope of cooperative transparency and intrusive rights. Comment by Dr. Ron Lehman, August 20, 2017.

[59] Michael Krepon, "U.S. Government Organization for Arms Control Verification and Compliance" in *Verification and Compliance: A Problem-Solving Approach,* eds. Michael Krepon and Mary Umberger (Cambridge, MA: Ballinger, 1988), 287.

the research and development efforts, and chaired by the Arms Control and Disarmament Agency. It included representatives from the Office of the Secretary of Defense, Defense Nuclear Agency, the Joint Chiefs of Staff, the Departments of State and Energy, CIA, and NASA.[60]

This decentralized structure and resulting institutional competition created friction in the decision-making process, as well as a permissive, relatively independent environment for the technical communities to conceptualize verification approaches and introduce them to the U.S. negotiating team.[61] However, sometimes mixed messages were received. In one case, "President Reagan approved highly technical and sweeping proposals for on-site inspections produced by interagency committees only to reverse himself when the primary focus of interagency concern switched from the technical to the policy issues involved."[62] These circumstances are partially explained by changes in U.S. negotiators' knowledge of the involved weapons systems and the challenges associated with their verification. Shifts in the interagency dynamics, however, are also a part of explanation.

The technical community within the United States started to prepare for the prospects of arms control with the Soviet Union earlier, before concrete negotiations for an INF Treaty began. In 1976, the director of the Arms Control and Disarmament Agency, Dr. Fred Iklé, had proposed a study, "Verification of Arms Control Options in the 1980s" to initiate the development of arms control strategies by focusing on U.S. verification capabilities first.[63] This proposal ultimately evolved into a national security study memorandum that would focus on the mid-term future and consider arms control opportunities that were not yet under discussion.[64] It was considered important to understand the capabilities and limitations of the intelligence community in these early stages, even though concerns were expressed that these studies were premature and would divert resources from issues of higher priority. The ACDA study, chaired by a representative of the Director of Central Intelligence with participation from ACDA, assessed the verification capabilities of the Intelligence Community, as well as analyzed the cover, concealment, and deception capabilities of the Soviet Union and the risks that they would create for arms control agreements.

These efforts created an initial understanding of the Intelligence Community's technical preparedness for verification, however more impactful decisions were made some years later at the Office of the Secretary of Defense (OSD). In the early 1980s, the Defense Science Board conducted a study that explored existing arms control verification capabilities and the technical community's preparedness to implement potential verification missions.[65] As a result, OSD became interested in exploring these questions further, even though the political prospects of arms control with the Soviet

---

[60] U.S. Congress, Office of Technology Assessment, *Verification Technologies: Managing Research and Development for Cooperative Arms Control Measures* (Washington, D.C.: U.S. Government Printing Office, May 1991), 5, http://ota.fas.org/reports/9127.pdf.

[61] Krepon, "U.S. Government Organization for Arms Control Verification and Compliance," 289.

[62] Ibid.

[63] Director of Central Intelligence, "ACDA-Proposed Study, "Verification of Arms Control Options in the 1980s,"" June 30, 1976, https://www.cia.gov/library/readingroom/docs/CIA-RDP79M00467A002700120007-3.pdf.

[64] Director of Central Intelligence, "ACDA-Proposed NSSM on "Verification of Arms Control Options in the 1980's,"" October 5, 1976, https://www.cia.gov/library/readingroom/docs/CIA-RDP79M00467A002700120002-8.pdf.

[65] Interview with Dr. Stan Fraley, July 26, 2017. Dr. Fraley served as an Advisor to the Office of the Secretary of Defense and as the U.S. Chair of the U.S./Soviet Working Group for the Inspection Protocol of the INF Treaty.

Union were highly uncertain.[66] Despite this, there was a critical mass of policymakers who were willing to ask the 'what if' questions and had the foresight to start filling the gaps in U.S. technical preparedness for the possible future arms control scenarios.

As a result, the Department of Defense contracted Sandia National Laboratories to explore and develop potential verification methods for the INF and START Treaties. This 3-year study focused on on-site inspection procedures, designing tags and seals, perimeter portal monitoring methods, and other technical approaches to monitor the items and facilities that might be included in future arms control agreements. In addition, Lawrence Livermore National Laboratory and Los Alamos National Laboratory conducted radiation measurement studies of missiles and warheads.[67] By 1987, there was a good understanding within the U.S. national laboratories and other segments of the technical community of the feasibility of using particular verification measures. More specific designs were developed starting in 1986, including the On-Site Inspection Project's full-scale demonstration complex.[68]

The preparations involved research on verification ideas that were considered unimaginable at the time, and in some cases, that were in contradiction with current U.S. policy positions. For example, Sandia National Laboratories explored tags and seals as a mechanism to count missiles, delivery vehicles, and other treaty-accountable items, as well as portal-perimeter monitoring of missile production or assembly facilities, but it seemed inconceivable to many that the Soviet Union would allow the United States with the authority to monitor its capabilities at this level of detail. Furthermore, there was no consensus across the U.S. defense community that American weapons systems would be subjected to these types of verification approaches.[69] Nevertheless, the technical communities were allowed to explore and imagine approaches that could have relevance in the future, with a high level of independence from current geopolitical conditions.[70]

The OSD continued to support these research and development efforts, even though they were also faced with opposition from those who considered it a waste of resources and intellectual capital.[71] According to the opposing arguments, the Soviet Union would never agree to on-site inspections or other more intrusive verification methods, so it is pointless to spend time on these efforts.[72] Despite a high level of uncertainty, the studies continued to explore the various types of verification technologies.These research and development efforts became instrumental for creating confidence among U.S. negotiators that strict verification provisions for the INF Treaty could be fulfilled technically. There was some indication of a potential shift in the Soviet Union's willingness to accept intrusive verification measures, through the 1986 Stockholm Document. It provided the conclusions from a two-year engagement process at the Confidence- and Security-Building Measures

---

[66] U.S. Congress, Office of Technology Assessment, *Verification Technologies: Managing Research and Development for Cooperative Arms Control Measures*, 2-3.

[67] Interview with Dr. Stan Fraley, July 26, 2017

[68] U.S. Congress, Office of Technology Assessment, *Verification Technologies: Managing Research and Development for Cooperative Arms Control Measures*, 3.

[69] Comment by Steven Pifer, august 18, 2017.

[70] Interview with Dr. Stan Fraley, July 26, 2017.

[71] Ibid.

[72] Ibid.

and Disarmament in Europe (CSCE).[73] Both the United States and the Soviet Union actively participated in the process, which was independent of the INF negotiations, and agreed on a set of common principles for confidence-building mechanisms and cooperative verification efforts.[74] Importantly, on-site inspections were agreed to, in principle, which signaled a major change in the Soviet position on verification and raised the possibility of negotiating on-site inspection protocols.

The knowledge and capabilities that had been acquired within the U.S. technical community not only gave the United States both credibility and confidence that effective verification could be achieved, but also allowed the U.S. negotiators to use these capabilities as a form of leverage. As the INF Treaty negotiations continued in Geneva, the United States formally raised the issue of verification in May 1986.[75] American negotiators had made clear throughout the years that stringent verification provisions would be pursued for the INF Treaty, but now the U.S. negotiators laid out the more specific demands.

These requirements were driven by genuine verification needs, but were intentionally hedged to pressure the Soviet negotiators to shift their negotiating stance. By demanding strict inspections, a known pressure point for the Soviet Union, American negotiators established leverage for narrowing the divide between the two states' demands and incentivizing the Soviets to yield to the U.S. position. Since the Soviet position remained to limit and not eliminate the INF systems, the United States demanded that special deployment zones be established for the remaining missiles, and that strict counting and inspection procedures be applied. This would include tracking missiles at the production and storage facilities through tags and seals; monitoring the portals of the facilities; and observing the destruction process of the missiles that were eliminated.[76] These methods were outlined at the Reykjavík Summit in October 1986.[77] There was an understanding within the U.S. negotiating team that it could give in on these verification demands, if the Soviet Union yielded on its position, because the verification of the complete elimination of a weapons system is inherently easier than the monitoring of limitations.[78]

---

[73] "Document of the Stockholm Conference: On Confidence- and Security-Building Measures and Disarmament in Europe Convened in Accordance with the Relevant Provisions of the Concluding Document of the Madrid Meeting of the Conference on Security and Co-operation in Europe," September 19, 2986, accessed July 17, 2017, http://www.osce.org/fsc/41238?download=true, 14.

[74] Stuart Croft, *Strategies of Arms Control: A History and Typology* (Manchester: Manchester University Press, 1996), 118.

[75] Paul Gallis, "Arms Control: Negotiations to Reduce INF Weapons," (Washington, D.C.: Congressional Research Service, 1988), 4.

[76] Ibid.

[77] Ibid.

[78] Interview with John Woodworth, July 26, 2017.

It is important to note, however, that there is more nuance to this argument. Whether or not verifying the absence of treaty-accountable items is easier depends on the context and the scenario; in some cases, it may not be. Detecting, identifying, and proving a violation is oftentimes complex and depends on the level of access and cooperation between the two states. Negotiations over cruise missile limits, for example, have brought up the complexity of verifying 'zero' proposals and how there is still inherent risks associated with verifying 'zero'. Comment by Dr. Ron Lehman, August 20, 2017.

Senator Wallop, speaking on the INF Treaty's Verification Provisions, on April 12, 1988, 100th Cong., 2nd sess., *Congressional Record* 134, pt. 5:6386, available at https://www.govinfo.gov/content/pkg/GPO-CRECB-1988-pt5/pdf/GPO-CRECB-1988-pt5-3.pdf.

After gaining Soviet acceptance of the use of on-site inspections at the Reykjavik Summit, the United States tabled a draft treaty in March 1987 that detailed the previously discussed verification methods. Next, to shift the Soviet position more formally, these verification demands were detailed in the draft treaty that the United States tabled in March 1987. The proposal involved extensive data exchanges on the specific locations of the remaining deployed missiles; detailed and regularly updated information about their launchers and support equipment; noninterference with telemetry on missile tests; and challenge inspections at the production, assembly, storage, repair, and deployment sites.[79]

The U.S. interagency process incorporated the inspection techniques that had been developed by the U.S. national laboratories and others over the preceding years. The resulting inspections and other associated procedures were incorporated into the U.S. draft treaty language, expanding the scope of the originally planned verification provisions. Ultimately, the draft documents were sent to the U.S. negotiating team in Geneva and introduced to the Soviet counterparts.[80]

The Soviet Union finally agreed on the elimination of INF systems during the summer of 1987, as outlined in Gorbachev's 'double zero' proposal in July. However, the Soviet Union wanted to continue to retain 33 SS-20 missiles in Asia, arguing that it would be protection against China and not part of the European theater.[81] The same number of warheads (one hundred, because each SS-20 carried three warheads) would be allowed in the continental United States. As American negotiators were determined to get to 'true zero,' verification became a critical argument for closing this final gap in the two states' positions. The United States maintained that a true zero would be easier and simpler to verify and would allow the United States to drop some of the most intrusive verification demands from the draft treaty.[82] Ultimately, this strategy worked, leading to the Soviet side to eliminate its demand of residual forces and the United States to reduce its verification requirements.[83]

Verification technologies were used again as a strategic tool only a few weeks prior to the conclusion of the negotiations and the signature of the treaty.[84] One of the priorities for the Soviet Union had been to prohibit the production and flight-testing of the stages and launchers of the treaty-limited systems. This provision targeted the U.S. Pershing II missiles, the key system that the Soviet Union was determined to remove. There were proposals by some in the United States to use the final stage of the Pershing missile as a stand-alone system, which the Soviet side opposed and was ultimately able to prohibit in Article VI of the treaty.[85]

In mid-November 1987, the Soviet negotiators approached their American counterparts with a problem – the first stage of the treaty-limited SS-20 missile was the same as that of the non-treaty-

---

[79] Gallis, "Arms Control: Negotiations to Reduce INF Weapons," 4.

[80] Interview with Dr. Stan Fraley, July 26, 2017.

[81] This was the Soviet Union's proposal from Reykjavík Summit in October 1986.

[82] Kenneth Adelman, "For True Security, 'True Zero,' Not 'Near Zero,'" *New York Times*, July 9, 1987, http://www.nytimes.com/1987/07/09/opinion/for-true-security-true-zero-not-near-zero.html?mcubz=1.

[83] The verification argument became even more attractive both to the United States and the Soviet Union because of the backlash that the United States was experiencing from its Asian allies, relating to the potential residual forces that the Soviet Union would be allowed to maintain in Asia. Comment by Dr. Ron Lehman, August 20, 2017.

[84] Interview with Dr. Stan Fraley, July 26, 2017.

[85] Ibid.

accountable, longer-range SS-25.[86] Maintaining the SS-25, however, would be a violation of the treaty article that was critical for the Soviet side. To save the SS-25 missiles, an exception was carved out that allowed the Soviet Union to continue to deploy the SS-25 missiles, if the United States was able to effectively verify it was not possible to clandestinely deploy SS-20s. Since the issue had only become known at the end of the treaty negotiations, there was intense pressure to reach a mutually acceptable verification solution.

In a short period of time, the inspection protocol negotiators agreed on distinguishing the two missiles based on their internal and external characteristics. [87] The second stages had different dimensions and different numbers of warheads, which could be used as the distinguishing features. The Soviet side was deeply opposed to any visual or physical inspections of the missiles inside the canisters and would only accept external inspection. Ultimately, it was agreed that two types of radiation systems could be used for the external inspection of the two missiles at the Votkinsk final assembly facility and at the previously-agreed missile deployment sites, which would be converted to SS-25 bases.

The two sides agreed on a portal perimeter monitoring protocol for the canisterized missiles leaving the Votkinsk facility to confirm the missile dimensions through x-ray measurements. The SS-20 missile had two stages in total, compared to the three stages of the SS-25. Whereas the first stages of the two missiles were identical, the second stages were distinguishably different in their dimensions. The x-ray measurements could confirm the diameter of the second stage. It was agreed that in this way the U.S. inspectors could independently verify the information provided by the Soviet side.[88] The details were discussed further in May 1988, after the United States learned more about the structure of the SS-25 missiles that came out of Votkinsk.[89]

The key U.S. verification concern – that Soviet SS-20s could be clandestinely deployed at the converted SS-25 bases – was addressed by allowing confirmation of the deployed missiles by verifying the number of warheads, which was the second distinguishing characteristic between SS-20s and SS-25s. Since visual and physical inspections of the missiles were not allowed, the two sides agreed during the negotiations on using radiation measurements.

During the implementation discussions, understanding of the technical capabilities of the various verification systems being considered was critical, because the Soviet negotiators were

---

[86] Ibid.

[87] Ibid.

[88] Ibid.

[89] The United States had learned that the missiles that came out of Votkinsk were not the full version of the missile, and that there were also other canisterized items that could be confused for treaty-accountable items. These new details complicated the previously agreed verification provisions, with the further difficulty that the dimensions listed in the signed Memorandum of Understanding could not be changed. The two sides eventually reached a compromise: no items could exit a continuous monitoring facility on the territory of the Soviet Union whose dimensions are equal to or greater than the dimensions of the SS-20 missile without its front section, but less than the dimensions of an SS-20 launch canister, as those dimensions are listed in the Memorandum of Understanding. For the purposes of this assurance, the length of the SS-20 missile without its front section would be considered to be 14.00 meters. In the context of this assurance, the United States side would not be inspecting any shipment whose dimensions are less than those of an SS-20 launch canister, as listed in the Memorandum of Understanding. This shows how cooperation on intrusive measures continued to grow at that time. Comment by Dr. Ron Lehman, August 20, 2017.

concerned about what the measurements could reveal about the warheads. Gamma measurements were considered too intrusive because of the detailed information about the warheads that would be revealed. The sensitivity and resolution of neutron detector measurements are less sensitive and the resolution could be limited further, depending on the detectors used. The U.S. negotiators in Geneva, particularly the technical experts, understood the capabilities of these measurement systems and thus were able to negotiate the verification provisions needed to meet U.S. demands. As with the x-ray measurements, the United States could confirm the effectiveness of this approach by using baseline measurements done prior to the start of the inspections and allow the United States to independently distinguish between the radiation pattern of the two missiles and establish reasonable confidence that the signals could not be spoofed.

The mobility between the technical and policy communities through interagency personnel exchange aided in the ability to react as needed. An illustrative example of this process is Dr. Stan Fraley, who was a member of the staff of Sandia National Laboratories, but supported the Office of Verification Policy within the Office of the Secretary of Defense on an Intergovernmental Personnel Act (IPA) assignment.[90] At the Office of Verification Policy, Fraley was assigned with creating the first draft inspection protocol for the draft treaty that the United States would later table in the negotiations in March 1987. The protocol included the five types of inspections that had been considered in the Sandia study that the OSD had initially contracted several years earlier.[91] As the negotiations progressed, Fraley was deployed to Geneva as an Advisor to the Office of the Secretary of Defense member on the INF delegation. In Geneva, Fraley became the U.S. chair of the U.S./Soviet Working Group for the Inspection Protocol of the INF Treaty, serving in the position until the treaty was signed. He then returned to Sandia National Laboratories to become the program manager of the effort to develop the portal-perimeter monitoring system, including Cargoscan, which was deployed at Votkinsk.[92]

Fraley's involvement in the process highlights how knowledge from the technical communities flowed to the policy level. During the formulation of the draft inspection protocol at OSD, it expanded some of the verification provisions that had not been included in the draft treaty text at that time. The Interagency Group considering the inspection protocol of the draft treaty expanded the provisions in the draft treaty to incorporate these concepts.[93] In Geneva, Fraley's involvement in developing the verification approaches ultimately assisted in the creation of a solution to the Votkinsk monitoring challenge with his Soviet counterpart.[94] The connections through Fraley and other involved scientists at Sandia established the link between the technical and diplomatic levels, and between Sandia, Washington, and Geneva.[95]

More generally, the connections that OSD had developed with Sandia during the early studies on verification became important during the negotiation stage.[96] For example, prior to the Reykjavík

[90] Interview with Dr. Stan Fraley, July 26, 2017.

[91] Ibid.

[92] Ibid.

[93] Ibid.

[94] Ibid.

[95] Interview with Carolyn Pura, July 14, 2017.

[96] Interview with Dr. Stan Fraley, July 26, 2017.

Summit in 1986, Sandia was asked to build a table-top model for portal-perimeter monitoring at a generic facility that was subsequently brought in for consideration at the White House and other government agencies for visualizing inspection challenges and understanding the limitations of verification.[97] Later, this same model was displayed in Geneva to the START Delegation, where portal-perimeter monitoring was still being considered for monitoring under START. This was during the time that the concept had been dropped for the INF Treaty.[98]

The INF Treaty negotiations illustrate a special instance where U.S. negotiators had a relatively high level of freedom to experiment with negotiating more intrusive inspections in a low-risk environment. Contrary to SALT negotiations, where the risks associated with highly intrusive cooperative measures eventually outweighed the potential benefits, the U.S. INF negotiators knew that the verification circumstances between U.S. and Soviet weapons systems were asymmetric. The verification provisions would not apply to U.S. systems, because only the Soviet side was utilizing the exception to Article VI in the treaty and would face the intrusive inspections related to certifying that no SS-20s would be deployed. This benefit was accentuated by the intense time pressure of the negotiations, and the fact that the Soviet side placed significant importance to Article VI. Additionally, the costs associated with deploying the heavy x-ray machinery to Votkinsk provided U.S. negotiators a legitimate rationale to request the maximum use of the equipment, which became to be authorized for all outgoing rail cars containing SS-25 missiles.[99] These political, practical, and economic factors contributed to the U.S. negotiators' ability to successfully pursue an intrusive inspection protocol, sustained by the important technical capabilities and knowledge base that provided credibility and confidence to U.S. negotiators.

Ratification Process

During the ratification of the INF Treaty, technical verification capabilities served as an important assurance both at the international and domestic levels. The Reagan administration was able to alleviate concerns about Soviet cheating among skeptical factions both in the United States as part of the Senate's ratification process, as well as abroad among NATO allies, in the context of the verification standards established at the 1979 NATO meeting.

The U.S. strict position on verification was motivated by the considerable domestic challenge of reassuring the Senate of the verifiability of the INF Treaty. In late 1987, the Senate leadership had already requested that the Select Committee on Intelligence provide a report on the capabilities available for monitoring and verifying Soviet compliance in arms control.[100] The review process included on-the-record staff briefings with a wide range of stakeholders in the intelligence community

---

[97] John Adam, "Verification Keeps Ivan Honest," *Washington Post*, January 24, 1988, https://www.washingtonpost.com/archive/opinions/1988/01/24/verification-keeping-ivan-honest/fe46afaf-a503-4eca-9c72-14297e864993/?utm_term=.1786405031aa.

[98] Interview with Dr. Stan Fraley, July 26, 2017.

[99] Ibid.

[100] U.S. Senate, Select Committee on Intelligence, *Report of the Select Committee on Intelligence, United States Senate, January 1, 1987 to December 31, 1988* (Washington, D.C.: U.S. Government Printing Office, 1990), 9, available at https://www.intelligence.senate.gov/sites/default/files/publications/101219.pdf.

(coordinated with the CIA's Arms Control Intelligence staff) involving representatives from relevant agencies of the U.S. intelligence and defense community, including from the CIA, DIA, NSA, the State Department's Bureau of Intelligence and Research, the Department of Defense, and the Arms Control and Disarmament Agency.[101] In February 1988, formal ratification hearings began and focused on the risk of Soviet cheating. The key concern was that covert deployment of SS-20 missiles would be very difficult to verify, and after the conclusion of the START Treaty there would be greater incentive to cheat.[102]

The Reagan administration knew how important verification considerations would be for the ratification of the INF Treaty in the Senate, which is why these concerns ultimately led to renegotiating and clarifying some of the verification provisions of the INF Treaty.[103] The Senate delayed its ratification of the treaty until it received these assurances and the most controversial verification issues were resolved. Ultimately, the Senate resolution on ratification required the President to obtain confirmation from the Soviet Union that the agreed verification and compliance details outlined in the inspections "are of the same force and effect as the provisions of the Treaty."[104] This was confirmed in the exchange of notes in May 1988, allowing the U.S. and Soviet leaders to exchange instruments of ratification on June 1, 1988, officially entering the treaty into force.

Verification had an important role in assuring American NATO partners of the security consequences of the INF Treaty. In the December 1979 NATO meeting, verification was discussed as one key characteristic of a potential arms control agreement with the Soviet Union.[105] Thus, verification had been a driving rationale for U.S. negotiators, but the signature of the treaty established new necessity to assure the alliance partners. From the perspective of European NATO partners, the INF Treaty was an effort by the Soviet Union to decouple the United States from Europe. Removing U.S. nuclear capabilities from the European theater would reduce its commitment to European security, and thus diminish the credibility of U.S. extended deterrence.[106] To counter this, the United States made maximum verifiability to ensure and enforce the elimination of INF forces from the region the cornerstone of the INF Treaty so it would be acceptable to its European NATO partners.[107] This was paralleled by demonstrating the continued U.S. commitment to European security through the strategic forces in the United States and at sea.[108]

---

[101] U.S. Senate, Select Committee on Intelligence, *Report of the Select Committee on Intelligence,* 9.

[102] Senator Wallop, speaking on the INF Treaty's Verification Provisions, on April 12, 1988, 100th Cong., 2nd sess., *Congressional Record* 134, pt. 5:6386.

[103] U.S. Senate, Select Committee on Intelligence, *Report of the Select Committee on Intelligence*, 2-3.

[104] Graham, Jr. and LaVera, *Cornerstones of Security: Arms Control Treaties in the Nuclear Era*, 515.

[105] Maynard Glitman and William Burns, *The Last Battle of the Cold War: An Inside Account of Negotiating the Intermediate Range Nuclear Forces Treaty* (New York: Palgrave Macmillan, 2006), 209.

[106] Interview with Dr. Ron Lehman, July 12, 2017.

[107] Ibid.

[108] Stanley Sloan, *NATO Nuclear Strategy, Forces, and Arms Control* (Washington, D.C.: Congressional Research Service, 1992), 4.

Implementation Process

The verification of the implementation process can be considered to consist of two phases: first, verifying the declared treaty-accountable items and verifiably destroying them; and second, the long-term verification of treaty compliance. The INF treaty negotiators had emphasized significantly the first phase, and the verification mechanisms that have been discussed in this paper mainly target this period. As will be analyzed in this section, verification technologies served as a moderating force during the elimination period for both arguments about the insufficiency of the verification protocol, as well as about the unbearable intrusiveness of the inspections. These technologies, however, are not applicable to verifying longer-term compliance with the treaty's provisions. As new concerns have been raised after 2014 about Russian violations to the treaty, the verification provisions included in the treaty have not been able to resolve the compliance concerns or alleviate the political tensions.[109]

During the elimination process, verification technologies served in an important role in providing flexibility to carrying out the inspection provisions, which reduced the political tensions between the two states. An initial challenge was the practice of having different organizations and officials implement the technical provisions that had been agreed upon by diplomats. Both sides were internally divided, and some of the factions within both states were deeply opposed to the negotiated treaty. Nevertheless, cooperation at the technical level was ultimately also filtered to the political level and the implementation of the elimination process was completed in 1991.

Not all provisions were agreed before signature, so after the treaty was signed, several details still needed to be agreed upon. The calculations at this stage, after both sides had committed to the treaty politically, focused on making legitimate and credible assessments of the verification needs for the treaty to finalize the implementation details. This required establishing a degree of isolation from the prior negotiation process, where verification arguments had also been employed for political and strategic purposes. On these grounds, Article XII of the treaty had established the Special Verification Commission and the Nuclear Risk Reduction Centers as the mechanisms for facilitating the cooperative verification measures after the treaty had entered into force.[110] Before these bodies would take on the verification mission, bilateral technical talks would be used to establish the specific inspection procedures that would translate the treaty's verification authorities into practice. To do this, three joint U.S.-Soviet technical talks were held between March and May 1988 in Moscow, Washington, and Vienna.[111] The week-long meetings were meant to establish standardized inspection and escort procedures, including determining the allowable cameras, measurement equipment, and other tools that the inspectors could use.[112]

The challenge was finding trusted and validated technologies that adhered to the legal and practical standards of both sides. For example, U.S. export controls restricted certain technologies for foreign use, which limited implementation options to commercially available equipment.[113] It was

---

[110] U.S. Department of State, "INF Treaty."

[111] U.S. Department of Defense, Defense Threat Reduction Agency, "On-Site Inspections Under the INF Treaty," 23.

[112] Ibid., 24.

[113] Smith, "Missile Inspection Technicality Provokes Top-Level Protest to Soviets."

advantageous to use cheaper, less intrusive technologies, but at the same time they would need to address concerns about spoofing.[114] Balancing these competing values became very difficult, especially as the Soviet side tried to propose alternative, less intrusive verification scenarios for the special verification provisions that they would face. While the Soviet chair of the inspection protocol negotiations in Geneva had yielded to using radiation detection equipment, it became evident that Moscow was not as comfortable with this and some of the other verification provisions.[115]

Even as the debate about the implementation details risked becoming a political confrontation, the Reagan administration's ability to concede to changes in the verification provisions was limited. As has been discussed earlier, President Reagan had made a personal commitment to the verifiability of the treaty and had put his political credibility on the line. In the Senate hearings, verification had been front and center on both sides' arguments. The challenges that now arose in the implementation could be used as political tools by the American opponents of the treaty to illuminate the failures of engaging with the Soviet Union. Skeptical Senators kept a close eye on the strict adherence to the verification provisions, which pressured the administration to ensure that all verification authorities were fully utilized, even if the White House had few genuine concerns about Soviet noncompliance.[116]

Under these conditions, the technical community assumed a role in finding acceptable solutions that could be proposed at the technical talks, thus mitigating the domestic and international political tensions that had emerged as a result of the high political significance verification had in the domestic political sphere of the countries. Technical negotiations were ultimately able to resolve the debate in a way that saved face for both sides by bringing objectivity and neutrality to the treacherous political environment even though there were no cut-and-dry solutions.

Lawrence Livermore and Los Alamos National Laboratories had studied the possibilities of taking external radiation measurements of missiles after the previously discussed Defense Science Board study. The initial idea of confirming the contents of canisterized items had come from Qatar, where border security officials had proposed using x-ray measurements in anti-smuggling efforts to inspect rail cars for small arms and light weapons, alcohol, and other contraband items.[117] After the national laboratories had become aware of research in this area, they had made initial efforts to develop approaches and systems that could be applied to arms control treaty verification.

After the INF Treaty was signed, the Department of Energy created a more deliberate research agenda to fulfill the specific verification provisions that the INF Treaty contained.[118] DOE created a separate program that would develop the systems that could be proposed for the INF inspections in the bilateral technical talks. Los Alamos National Laboratory led the effort to develop gamma radiation systems for the purpose, whereas Sandia National Laboratories was focused on the development of

---

[114] Interview with Dr. Ron Lehman, July 12, 2017.

[115] Interview with Dr. Stan Fraley, July 27, 2017. Some of the details had been agreed on separate sessions by different sub-groups.

[116] R. Jeffrey Smith, "Missile Inspection Technicality Provokes Top-Level Protest to Soviets," *Washington Post,* March 19, 1990, https://www.washingtonpost.com/archive/politics/1990/03/19/missile-inspection-technicality-provokes-top-level-protest-to-soviets/beec1736-9b6b-4ec2-ad2d-85c78d319f2c/?utm_term=.3f8443399a64.

[117] Interview with Dr. Stan Fraley, July 26, 2017.

[118] Ibid.

neutron-based systems.[119] As discussed earlier, because of the asymmetry between the sides, the United States was not concerned about measurements on U.S. systems and thus was more unconstrained in proposing detector options, without going through a much more detailed analysis of the risks and costs associated with including these methods in the verification provisions. This was not the case for START, where radiation detection measurements were used in a much more limited way, partially because the provisions would be symmetrically applied to both U.S. and Soviet weapons systems.[120]

The key challenge at this stage was introducing a system that would harness the U.S. technical capabilities, but that would also address the Soviet concerns about sensitivity. The system that was ultimately adopted for monitoring the deployment bases measured the neutron intensity flux from the missile launch canister.[121] Determining the technical specifications of the equipment required in-depth understanding of the classification concerns of using active interrogation in monitoring warheads and the risks of various evasion scenarios. The assessment needed to be sufficiently general, so that its usefulness would not depend on any specific or unique features of a missile or warhead design.[122] Generally known geometric features of a MIRV layout, such as that the warheads' fissile material bodies will be separated from each other by the high explosives surrounding them and the electronic controls in the re-entry cone, were used to provide confidence that the detectors would be appropriate and accurate for the monitoring mission.[123] Safety and security was needed to ensure that the detection methods would not damage the inspected items, such as the electronic components in the missiles. Training on the proper use of the detectors would also need to be communicated to the inspectors.[124]

To monitor the cargo leaving Votkinsk and ensuring that no SS-20 missiles left the facility, x-ray sensors were chosen as the most appropriate system. The sensors could distinguish material composition at varying resolutions, depending on radiation intensity, and are resistant to deception.[125] The use of the Cargoscan x-ray system remained a highly contentious issue until the implementation stage. The two sides continued to debate the resolution of the images, because Soviet officials maintained that the recorded images were too detailed and could risk revealing details about missile design details.[126] Thus, initial portal monitoring at Votkinsk involved only visual inspection and exterior measurements, which was deemed sufficient by U.S. administration officials.[127]

Another way to isolate the political tensions from the inspections was to establish a new agency for the verification mission. This process had been started shortly before the INF Treaty was signed and after the details of the verification provisions became clear in late 1987. At that time, a small task force was set up by Admiral William J. Crowe, Jr., the Chairman of the Joint Chiefs of Staff, to "develop a concept of operations and recommend an organizational structure for implementing the

---

119 Ibid.

120 Ibid.

121 Alexander DeVolpi, "Expectations from SALT," *Bulletin of the Atomic Scientists* 26, Issue 4 1970), 32.

122 Ibid.

123 Ibid.

124 Ibid., 34.

125 Adam, "Verification Keeps Ivan Honest."

126 Smith, "Missile Inspection Technicality Provokes Top-Level Protest to Soviets."

127 Ibid.

INF Treaty."[128] Under more specific guidelines from the National Security Council, the work of the task force led to the establishment of the On-Site Inspection Agency (OSIA) within the Department of Defense, which would have the responsibility of coordinating and implementing the on-site inspection process.[129] Throughout the spring of 1988, during the ratification hearings and on-going technical talks, OSIA conducted mock inspections in all the 31 U.S. INF sites and took on the responsibility for finding a way to make the Cargoscan system operational for the inspections.[130]

As inspections began, the organization and coordination of the technical communities shifted from developing and testing the verification technologies to employing them in the field. During the later stage of the implementation process, the most important role for U.S. experts and officials was to create relationships with their Soviet counterparts and find a way to implement the treaty in practice, despite higher-level political tensions.

Contacts at the diplomatic level continued to play an important part throughout the implementation period. Beginning in early 1988, the U.S. Embassy in Moscow took a central role in coordinating preparations for the verification mission, with the inspections to start in July 1988.[131] The Port of Entry designated in the treaty for the inspections at Votkinsk was Moscow, requiring the inspectors take a 1,200 km journey through the Urals. Whereas the Soviet Union was responsible for most of the arrangements in-country, the U.S. Embassy in Moscow was responsible for having the Cargoscan equipment to be transported to the inspection site.[132] The cooperation between the U.S. Embassy and the Soviet Foreign Ministry strengthened as the countries' more general relations evolved. This was essential for resolving the numerous details needed to successfully transport the equipment via complicated air and ground routes to Votkinsk.[133]

The portal monitoring started in July 1988, at the same time as the other inspection types. As was discussed, the two sides had not reached an agreement about the specifications of the Cargoscan system, forcing the initial monitoring to conduct the inspections without this capability. Before the Cargoscan could be used, Soviet officials needed to approve the technical documentation provided by the United States and construct the facilities where the equipment would be fielded. After American presence was established at Votkinsk, the U.S. inspectors were able to convey the technical issues back to the U.S. Embassy in Moscow and ultimately to Washington. The issues would then be raised at the Special Verification Commission in Geneva.[134] Both sides' increasing practical experience in inspections informed the discussions at the diplomatic level, and the final Memorandum of Agreement on the inspection protocol was signed in December 1989 by U.S. Ambassador Steven Steiner and Soviet Ambassador Mikhail Strel'tsov.[135]

---

[128] U.S. Department of Defense, Defense Threat Reduction Agency, "On-Site Inspections Under the INF Treaty," 14.

[129] Menzel, "Experience with Implementation of the INF Treaty," 77.

[130] U.S. Department of Defense, Defense Threat Reduction Agency, "On-Site Inspections Under the INF Treaty," 27 and 75.

[131] Interview with Steven Pifer, July 20, 2017.

[133] Ibid.

[134] Ibid., 86.

[135] Ibid., 90.

The memorandum contained the technical details for the Cargoscan system, which was a linatron x-ray machine.[136] It was installed and tested in January 1990, and declared operational by the United States. The Soviet experts at Votkinsk, however, raised concerns about the characteristics, operations, and safety of the Cargoscan system, which continued to delay the system from becoming operational.[137] Americans were able to point to their authority to use the system based on the INF Treaty text, its inspection protocol, and the Memorandum of Agreement, and also addressed the concerns raised by the Soviet side. In March 1990, as the confrontation continued and the Soviet side would not certify the system for use, the situation developed into a substantive confrontation at Votkinsk.[138] As Americans were denied the right to use Cargoscan on a departing rail car, the U.S. inspections declared that this was a violation to their inspection authorities. After the missiles left without having been inspected with Cargoscan, the issue was elevated to a ministerial level and the U.S. Secretary of State James Baker intervened through an official protest.

A U.S. delegation, led by the Secretary of Defense's representative to the Special Verification Commission, was sent to Votkinsk to find solutions to the issues that had no cut-and-dry technical solutions. U.S. experts' role was ensuring the fidelity of the system to the maximum level possible and providing confidence to the Soviet technical experts on its operations. After the U.S. and Soviet delegates had addressed the Soviet concerns to the extent that they could, the Cargoscan system was finally certified for use and started operating by the end of March 1990.[139]

The technical credibility of the concerns raised by the Soviets can be debated but it is certain that they reflected the political and ideological tensions that the new level of engagement and access had created.[140] In many ways, inspections and verification were mirrors of greater societal questions. The U.S. position on verification reflected the values of transparency and openness, which U.S. diplomats knew would be perceived differently by the Soviet side. Opening up the Soviet society through inspector access and allowing the Americans to interact with their Soviet counterparts could be a genuine risk, as would be bringing Soviet inspectors to the United States and allowing them to experience very different kind of societal and economic conditions.[141] In addition, the negotiators had to resolve entry and access rights with third countries, where INF systems were based.[142] These aspects of the INF Treaty verification had an important impact on Cold War dynamics and also explain why certain technical issues became so contested politically.

The continued involvement of the scientists in the technical talks regarding verification procedures provided important continuity to the treaty process. The scientists understood Soviet perceptions and sensitivities regarding verification and were able to guide research in a direction that could result in acceptable solutions. Some of the same scientists continued to be involved when the systems were prepared to be used in the inspections.[143] These types of connections provided other

---

136 Ibid., 92.

137 Ibid.

138 Ibid.

139 Ibid., 93.

140 Interview with Dr. Ron Lehman, July 12, 2017.

141 Ibid.

142 Comment by John Woodworth, August 18, 2017.

143 Interview with Carolyn Pura, July 14, 2017.

important technical resources, including developing data validation methods. The Sandia cryptographer Gustavus Simmons had conducted research on subliminal channels and other methods of data validation, for example, which were ultimately not used in the INF Treaty, but supported other parallel and subsequent arms control efforts.[144]

While the lack of precise technical details for the verification equipment became a source of political tensions during the implementation period, it also provided an opportunity for the U.S. and Soviet technical communities to continue to interact while solving them. Preparedness within U.S. technical communities allowed the United States to control the spectrum of options for the technical equipment while providing the Soviet officials with alternatives that could address theirconcerns about intrusiveness. There was a good faith effort to understand the genuine concerns of the other side, and make a serious effort to accommodate the needs and avoid obstructionism. At the end, both sides' concerns were similarly focused on security risks and becoming vulnerable for the other side's intelligence.[145]

[144] Gustavus Simmons, "How to Insure that Data Acquired to Verify Treaty Compliance are Trustworthy," *Proceedings of the IEEE*, Vol. 76, No. 5 (1988).

[145] Interview with John Woodworth, July 26, 2017.

IV. Precedents for Arms Control

A confluence of factors contributed to making the INF Treaty possible and verification technologies are only one dimension of the story. It is evident, however, that technology and technical expertise played a significant role in the negotiation, ratification, and implementation of the INF Treaty and shaping the outcomes during each of these three stages. The deployment of innovative technical approaches helped to achieve political ends and provide insights on how similar strategies could be used in the future. This paper has focused on this variable in the treaty process and explored how scientific and technical expertise was harnessed to promote state-to-state cooperation. Arguments about the verifiability of arms control treaties, particularly the lack of sufficient verification capabilities, have often been employed as blocking strategies to oppose and obstruct diplomatic efforts – but the story of the INF Treaty highlights how technical preparedness and capabilities can also be used as a constructive tool in international diplomacy. This paper demonstrates that verification capabilities can be operationalized to shift negotiating positions, create flexibility in treaty architecture, provide confidence to alliance partners and to the ratification process, and manage the tensions in the implementation process. These dynamics are often obscured by the higher politics of treaty negotiations, and are oftentimes purposefully managed in the background. Nevertheless, they should be considered an impactful tool for diplomats and policymakers in future engagement efforts on arms control and other international security issues.

With respect to the first question that this paper addressed, on the role that verification technologies played in facilitating the INF Treaty process, the critical insight is that verification technologies are not only technical tools that provide detection capabilities and deter cheating. Throughout the treaty process, these capabilities can be operationalized as strategic tools to shape the outcomes of the different stages. The United States was able to propose certain arms limitations during negotiations, because technical verification options had already been identified and developed. Technical verification options were also the solution when a last-minute impasse was reached.

Technical verification discussions were also a useful strategy to keep the momentum going during difficult or slow times in the negotiations, even if they ultimately had little impact on the final treaty outcome.[146] When the discussions on limitations on numbers of weapons and systems were stalled or made only slow progress, verification approaches and technologies were always something that could be discussed. To facilitate this, the scientific community was encouraged to develop and present on innovative technologies, even if they rarely were included in the final verification protocol.

The question of the organization and coordination of the technical communities directly relates to the role that verification technologies can play. A key lesson is that it is very difficult to predict what circumstances and verification needs will arise and how a treaty partner's willingness to accept intrusive verification methods may shift during the process. In the very early years of the INF negotiation process, the expectation was that the Soviet Union would never accept on-site inspections, which led some to argue that putting resources into this verification research would be fruitless. The Soviet side, however, ultimately shifted its position. Overall, the verification measures that were included in the INF Treaty surprised both American and Soviet negotiators. Even though U.S.

[146] Interview with Dr. William Dunlop, August 4, 2017.

negotiators had demanded these measures, the purpose was initially political, and the negotiators did not anticipate the results.

Unquestionably, technology has contributed to other arms control agreements in important ways, but the INF Treaty was a turning point in its employment of intrusive verification methods. One of the core lessons for future arms control negotiations from the INF Treaty is that technical foresight and preparedness are essential components of arms control negotiations. There was a conscious and directed research effort to develop these capabilities prior to the negotiations, which paid off in several different instances when the talks proceeded. The first steps to develop the technical verification capabilities for the INF Treaty were taken years before the idea of the treaty was raised with the Soviet Union, and before the parameters of the treaty became clear. If these steps had not been taken, however, the negotiators' set of technical tools and proposals would have been much more limited. The willingness of the right people to ask the 'what if' questions, even those that were against the prevailing U.S. policies or negotiating position, became essential at a later stage. Ideas about verification technologies or treaty architecture should not be rejected only because they are unlikely at the time. Conditions shift rapidly at the diplomatic level, and only options that have been researched previously can be proposed by the negotiators. While research on arms control verification has continued during the past decades, it is clear that gaps remain in the technical preparedness to verify future agreements.

In any arms control process, there are going to be unanticipated conditions and details that only arise at the implementations stage, and which were not considered by the treaty negotiators. Technical expert communities can try to address these verification disagreements and confrontations by providing credibility and validity to the scientific and technical assessments, but this capacity has its limits. Technical disagreements are often about differences in interpretation, and these differences are shaped by political, ideological, and strategic calculations. Under these conditions, no amount of technical preparedness and research could help solve the issues; they need to be addressed at the diplomatic and strategic levels. The implementation stage of the INF Treaty manifests these limitations clearly. While technical experts were able to contribute to the negotiation and ratification stages of the treaty process in many ways, their capacity to solve the technical implementation challenges were more limited precisely because the issues had political underpinnings, in addition to technical ones.

To make this interplay between the technological and policy communities possible, institutional investments need to be made to develop and sustain expertise at all the relevant levels. As was shown in the case of the INF Treaty, the connections between the technical and policy experts developed over time. Similarly, developing the next generation of experts requires sustained investments over the next years and decades. Despite the uncertainty of future prospects for arms control, or precisely because of it, this commitment needs to be formulated into a deliberate strategy that accepts that the benefits may not be immediately evident, but that these investments may be the critical enabling factor for future efforts. Even though many of the ideas and technologies that were conceptualized for use in INF verification were ultimately not included in the treaty's verification provisions, they contributed to a more general technological progress and are applicable to many other fields as well. As was the case with Cargoscan, the original idea emerged from the context of border security and law enforcement, and the development of these systems furthered technical capabilities

for these application areas as well.[147] Vice versa, the resources that have been invested after 9/11 into developing border detection and monitoring capabilities for homeland security applications have also benefited the arms control verification community.[148]

The ratification of the INF Treaty also demonstrates how the organization and coordination of the technical communities had an impact. As with many arms control agreements that require ratification from the Senate, it is not only the message, but the messenger, that matters. The close involvement of the technical experts who were part of the Geneva negotiations was critical for gaining the Senate's advice and consent for ratification of the INF treaty. Allowing experts to testify authoritatively on the negotiated verification provisions helps explain the negotiation team's case that the treaty was effectively verifiable, and objectively counter opposition. By anticipating the potential concerns raised regarding the verifiability of arms control treaties, technical experts can help alleviate some aspects of politically contentious ratification processes.

Implementation of the INF Treaty verification regime demonstrated that cooperative verification measures could continue even if political tensions became elevated in more general U.S.-Soviet relations, and that the increasing collaborative attitude could also alleviate the tensions. It is very difficult to anticipate all challenges that arise in field conditions, particularly in sensitive military facilities, or those that emerge due to political factors. When this happens, previously established relationships can become critical for preventing a break-down of an agreement. By establishing an On-Site Inspection Agency, the technical inspections could be isolated from other geopolitical events, and collaboration could continue without being impacted by political tensions.

Overall, the verification provisions in the INF Treaty represented a new level of engagement and openness between the United States and the Soviet Union. The treaty came to symbolize a new era of U.S.-Soviet relations, reflecting a shift within both states. In particular, Gorbachev's approach represented a new era of Soviet leadership, including his views on foreign and security policy that departed in many ways from those of his predecessors.[149] It could be viewed that engagement on the INF Treaty ultimately paved the way for the end of the Cold War, and that "[o]nly by placing the INF process against the backdrop of evolution in Soviet strategy can one appreciate its political and strategic importance, which transcends the numbers of weapons involved."[150]

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-TR-738786

[147] Interview with Dr. William Dunlop, August 4, 2017.

[148] Interview with Carolyn Pura, July 14, 2017.

[149] Goldberg, "Moscow's INF Experience," 89.

[150] Ibid.