Chapter 10

Introduction

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Cooperation is central to the success of the non-proliferation regime, but we cannot simply assume that parties are cooperating. Monitoring helps confirm that countries are fulfilling their positive obligations to report stocks, technologies, and operations and their negative obligations to forego prohibited activities. Science and technology have long played important roles in monitoring treaty obligations, and as new technologies and analytical methods emerge and mature their roles can increase. However, neither development nor adoption is guaranteed. Technical developments require continued efforts by scientific and technical experts, informed by implementers and supported by adequate resources. Adoption and implementation of new technologies also require adequate resources and the shared will to enhance capabilities.

The international community relies on the International Atomic Energy Agency (IAEA), and particularly its Safeguards program, to confirm each country's compliance with its obligations under its comprehensive safeguards agreement and any additional agreements (such as an Additional Protocol) that expand the range of permitted inspections. As of 2019, 175 states have entered into comprehensive safeguards agreements with the IAEA, including all non-nuclear-weapon states party to the Nuclear Non-Proliferation Treaty (NPT) and all states party to regional nuclear-weapon-free-zone treaties. Under these agreements, the IAEA monitors activities to ensure that nuclear material is not diverted to a program for nuclear explosives. The IAEA also has voluntary agreements with the five NPT nuclear-weapon states and with India, Pakistan, and Israel, which are not parties to the NPT. The IAEA's most extensive safeguards efforts are currently in Iran, largely driven by requirements under the Joint Comprehensive Plan of Action (JCPOA). After operating for many

¹Rotblat et al. [1].

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years with the same technologies and approaches, the IAEA is now employing a variety of new technologies and using other extant technologies that have become feasible for the IAEA to use in conjunction with their traditional observations and analyses.

The ban on nuclear explosion testing, not yet in force but observed by all except North Korea, is a key element of the non-proliferation regime. The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) embodies both cooperation and monitoring and supports the non-proliferation regime. The CTBTO has a plenary body for deliberation and decision making and the Provisional Technical Secretariat, which conducts monitoring, processing and dissemination of data, and prepares for possible future on-site inspections. The CTBTO's capabilities have surpassed expectations, providing high-quality data and analyses of seismic events around the world, complemented by radionuclide detectors, and infrasound and hydroacoustic sensors. North Korea's violations of UN Security Council resolutions and international norms through nuclear explosion testing, as well as on-going production of fissile material and missile tests, have provided unfortunate opportunities for the CTBTO to demonstrate its capabilities, and it has performed well.

Detectors themselves have improved, but it is really the analysis of combinations of signals from detectors and sensors that has substantially improved monitoring capabilities. Artificial intelligence can help with these analyses. Multispectrum satellite imagery powerfully augments analysis using ground-based detection to compare to declarations. Technical advances for traditional monitoring can be complemented by nontraditional monitoring, which could include what Rotblatt called societal verification¹ and by what Stubbs and Drell called public technical means.² In the former, citizens of a treaty-bound country see it as their obligation to report publicly or to international bodies any potential violation of their nation's treaty obligations. The latter involves non-government analysis of open-source information. In both cases, technological innovation enables major improvements in the public's ability to assist the non-proliferation regime. But none of these advances comes without controversy.

The greatest recent advances in capabilities have come from integration of multiple sources of data. The CTBTO operates the International Monitoring System (IMS), data from which can be merged with data from national resources outside of the IMS. The IAEA now uses commercial satellite imagery extensively to analyze consistency. Together, these and other technologies make the non-proliferation monitoring regime more capable than ever before, and there are opportunities for further improvement.

²Stubbs and Drell [2].

References

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2. C. Stubbs, S. Drell, Public domain treaty compliance verification in the digital age. *IEEE Technol. Soc. Mag.* **32**, 57–64 (2013)

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