Appendix A: Formal Models of Verification Synergy

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Introduction

Arms-control verification, the process of collecting information and using it to make policy judgements about whether a country is complying with an arms-control regime, can be conceived as an array of decisions about specific observed behaviour, events, facilities, or equipment. Are the observations consistent with, or contrary to, the rules governing types and locations of equipment, strengths and locations of forces, etc., laid down under the arms-control regime in question? Although these specific decisions are of great importance to national security, available relevant information is often quite limited. It is therefore desirable to expand the information base insofar as possible, and to use available information as much, and as efficiently, as possible.

Verification synergies make valuable contributions to both gathering and processing information. Synergy can occur

- **across decisions**, when a single piece of information provides useful input to many specific verification decisions;
- **across data**, when information from several sources is combined effectively to reach a specific verification decision.

In this Appendix, a formal model is developed for the process of using information effectively and efficiently in arriving at a specific decision. No attempt will be made to model how an individual item of information, originating, for example, in an information exchange and/or a declaration, can improve many subsequent verification decisions. Rather, the purpose of this model is to explore the underlying logic of across-data synergy and to explain which aspects of inputs are most important in shaping outputs.

Like most formal models, the one presented here is quite abstract, including general or stylized representations, and excluding details that distinguish particular real-world instances of across-data synergy. The objective of such simplification is to provide insight into the costs and benefits of additional relevant information and its integration into the decision-making process — to offer general guidance to those who must face these problems.

Thus, attention is here focused on questions of when, why, and how many sources of information can synergistically contribute to verification goals, in the context of a specific decision problem. To model a specific verification decision, it is assumed that a "suspect event," an abnormal occurrence or observation, has been identified. The analysis addresses the question of which, if any, sources of information should be tapped prior to assessing whether this event constitutes compliance or violation. The formulation takes account of the costs of information, including not only the direct costs of collecting and interpreting it, but also the possible costs of delay during collection and interpretation.

The analysis applies to sources of information relevant to the suspect event. In general, these sources are monitoring and inspection activities, typically including NTM/ITM/MTM, intelligence sources, overflights and on-site inspections. General information, such as from preliminary data exchanges, would not normally be counted as an information source in this sense, for it usually does not bear directly on a specific verification decision. Instead, general information ordinarily serves to expand specific information and to make it more precise and accurate.

The aim of the analysis below is to develop a means of identifying which new source of information should be accessed and to explore how the information should be integrated into the decision-making process. Nonetheless, the methodology is quite general and can be used to address questions related to additional independent information in many enforcement processes.

Problem Description

The operation of information synergy in verification is best understood in the context of decision problems under uncertainty. In the most fundamental model of a specific