discourage their use. The most important problems with data are

- **Inaccuracy:** Many inspection procedures typically either miss large quantities of useful information (e.g. satellites with limited swath-width and/or making relatively few passes), or provide data that can be very difficult to interpret (e.g. aerial photographs).
- **Cost:** Some inspection procedures either require large direct and indirect expenses (e.g. training, equipping and operating on-site inspection teams) or impose high time costs (e.g. waiting for satellite passes).

Were it not for these and related problems, every verification decision would benefit from a large amount of information. Ideally, decision-makers interested in making the best possible decision would supplement prior information with accurate data from free inspections. In other words, decision-makers face the problem of deciding what information to seek out and how to use it effectively precisely because data rarely lead to certainty and are almost never free.

When is it to a decision-maker's advantage to access additional information — to pay the cost, and accept the possible inaccuracies, in hopes of making synergistic use of the new information and thereby arriving at a better decision? The formal model that follows determines criteria for when and how a decision-maker faced with the Basic Enforcement Problem of Figure 1 should supplement existing information. As well, the model provides a means of assessing the level of costs the decision-maker should be willing to bear to obtain this extra information, and a method for incorporating the new information into the decision process.

Methodology

A convenient and natural tool for representing and analyzing the Basic Verification Decision Problem of Figure 1, and others like it, is Bayesian Decision Analysis. The purpose of Bayesian Decision Analysis has been defined as the logical analysis of choice among courses of action when

- the consequence of any course of action will depend upon the "state of the world," and
- the true state is as yet unknown, but
- it is possible at a cost to obtain additional information about the state.*

Bayesian Decision Analysis has previously been used to explore how, and to what advantage, information from different sources ("tests") can be combined in a verification context.**

Bayesian Decision Analysis is founded on Bayesian Statistics. The latter is essentially a model of how a "rational" individual, who holds a personal ("subjective") probability distribution over the states of the world, should update this prior distribution after evidence about the state of the world has been received. For example, in the Basic Enforcement Problem, the decision-maker is assumed to have a **prior** belief about the likelihood of state Red. When new information becomes available, the decision-maker should rationally revise this probability belief. Bayesian Statistics defines a **posterior** distribution, which in this case represents the decision-maker's revised belief that the state is Red. Appendix B presents an illustration of how Bayesian Statistics can be applied in arms control.

To Bayesian Statistics, Bayesian Decision Analysis adds a simple decision analysis procedure, which begins with a value for each possible outcome, i.e., each possible combination of action and state of the world. The decision-maker can then evaluate each action according to its expected ("average") value under the decision-maker's current beliefs about the true state. The rational decision-maker then selects the action with the greatest expected value according to his/her own beliefs.

* Howard Raiffa and Robert Schlaifer, Applied Statistical Decision Theory, MIT Press, Cambridge, MA, USA, 1961, p. 3.

** "New Research in Arms Control Verification using Decision Theory: Site Selection for On-Site Inspection under CFE I and Interactions among Verification Methodologies," External Affairs and International Trade Canada, March 1991.