Game Theory and Verification

With the negotiation of new arms control treaties covering a broader range of military equipment and activity, new forms of verification of compliance with treaties have been suggested and, in some cases, accepted. Potter's (1985) claim that verification systems are an overriding prerequisite for arms control treaties is just as true now, and will remain so in the future. The development of arms control depends, in large measure, on the development of verification.

The improvement of existing verification systems, and the development of verification systems covering new areas, present problems that are both technological and decision-theoretic. Technological advances in verification increase the amount or reliability of data which can be gathered, enabling the inspecting party to learn more, or in some cases to prove more, about the activity in question.

Decision-theoretic advances in verification have a different function, however. By understanding how decision makers would rationally select actions--such as to cheat, to inspect, or to accuse -- decision theory makes a different, but equally important contribution to the improvement of a verification system. Using decision theory, the effectiveness of proposed provisions of treaties can be evaluated before they are put in place; decisions about when, where, and how to inspect can be optimized so as to maximize the probability of detecting violations which have already occurred, and deterring them in the future; and advances in verification technology can be evaluated.

The branch of decision theory that must be used in the analysis of verification problems is *game theory*, a collection of models and principles dealing with decisions in situations of (at least partial) conflict. Non-cooperative game theory is most appropriate because it emphasizes decision problems in multi-decision maker, multi-objective situations. The central objective of this research project is to contribute to the overall development of game theory models and analysis of the verification problem.

In the last few years, there have been a number of attempts to apply game theory models to verification problems. Among the important early meetings on this subject were the Workshop on the Application of Game Theory to the Arms Control and Disarmament Process, held in Ottawa in April, 1986, and the Workshop on the Application of Game Theory to Arms Control Verification, held at the University of Waterloo in March, 1987. The results of the Waterloo workshop were published as a report (Fraser and Kilgour, 1987).

The recent uses of game theory to model, analyze and understand the verification process are exemplified in these recent works:

(1) Brams and Kilgour (1986, 1987, 1988) indicate that there are minimum quality standards for detection systems, below which verification is incapable of deterring cheating.

(2) Avenhaus (1986) and O'Neill (1988) focus on uncertainty ("ambiguity") as an inevitable feature of verification systems, and on how it affects decision making.

(3) Brams, Davis and Kilgour (1988) develop a simple model of the optimal allocation of cheating and inspection effort under the I.N.F. Treaty.