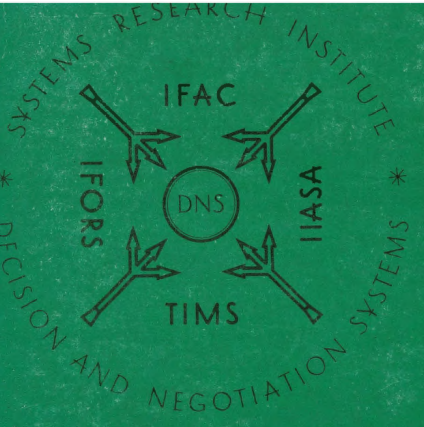

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SUPPORT SYSTEMS FOR DECISION AND NEGOTIATION PROCESSES

Preprints of the IFAC/IFORS/IIASA/TIMS Workshop
Warsaw, Poland
June 24-26, 1992

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VOLUME 2:

Names of first authors: **L-Z**

SYSTEMS RESEARCH INSTITUTE, POLISH ACADEMY OF SCIENCES

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INSPECTION IN ARMS CONTROL

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Abstract: This paper is an analysis of inspection in arms control. Two nations, roughly equal in power, negotiate an inspection agreement as part of an arms control treaty. There are several decision makers on both sides, each of whom have dissimilar goals for the inspection arrangement. We consider the interaction of the decision makers and their respective sides during the negotiation and implementation of the inspection agreement. We examine the quantitative problems which arise in connection with the agreement and how the decision makers react to them.

Keywords: inspection, negotiation, arms control, 2-person game, n-person game, multi-criteria decision making.

1. Introduction

Current arms control activity includes many treaties and proposals which involve inspections. The construction of an inspection agreement leads to problems in areas such as probability theory, geography, physics and economics. This paper considers inspections from the point of view of n-person game theory and the theory of multi-criteria decision making. The treatment is realistic rather than theoretic. This means we shall try to construct an accurate model rather than derive ingenious results.

Previous game theoretic work on inspection in arms control appears in Brams, Davis, Kilgour (1989), Fichtner (1986), Kilgour (1989), Maschler (1966, 1967). Generally speaking, the purpose of each of these papers is to construct a two person game theoretic model which is supposed to apply to a concrete inspection situation and then solve the game. The effort continues in Ruckle (1990), but this paper asserts that the two person games encountered are only a part of the total modeling process. The purpose of the present work is not to augment or supersede this literature, but to construct a more general model of inspection into which these results can be placed.

In Section 2, we shall describe our negotiation model as two sides each of which consists of a team of decision makers. The decision makers receive advice and help from personnel such as analysts and inspectors.

Inspections in arms control proposals vary from a single checkpoint at a plant entrance to numerous mobile teams poised to conduct almost simultaneous inspections of numerous sites with minimal advanced notice. Objects inspected vary from counting tanks to controlling biological weapons. Thus a basic problem is to classify inspection, which we take up in the third section.

In Section 4 we discuss how diverse elements in an inspection negotiation coalesce. Section 5 examines how competition continues during the implementation of the inspection process.

I conceived this study while serving as William C. Foster Fellow at the United States Arms Control Agency (ACDA.) However, I did all of the work after the fellowship's completion, and the opinions expressed here are not necessarily those of ACDA. I benefited from conversations with Mr. Al Lieberman of the Operations Analysis at ACDA and with his colleagues Mr. Robert Berg, Mr. Glen Johnson and CDR Robert Larkin (USN.)

2. The Negotiation Model

Two nations, neither of which totally dominate the other, negotiate an arms control treaty which includes inspection agreements. We identify these two nations as the two sides, SIDE1 and SIDE2. A team of decision makers, who answer to their political leadership, establish negotiating positions and implementation strategies for each side. We will sometimes refer to these decision makers as players. The players are abstract goals rather than real persons. A real decision maker strives, to some extent, toward all of these goals. The five players on each side are INSPECTOR, EVADER, DIPLOMAT, SPY and COUNTERSPY.

The INSPECTOR wants to assert the treaty's limitations. More precisely, he wants to demonstrate to higher authority or to an electorate that the inspection process does not permit the other side to enjoy the treaty's benefits while cheating excessively. The INSPECTOR's adversary is the EVADER who wants to defraud the inspection process, now or in the future, to achieve some objective, which the treaty prohibits.

The DIPLOMAT considers every agreement as a stepping stone to further agreements. The mechanics of inspection do not concern him, but in the inspection process he sees the opportunity for travel between the two sides, meetings between inspectors and personnel at the inspection site and building mutual trust. His main concern is that the inspection involve a large number of inspectors, spending relatively long periods at the site, and that the inspectors behave in a congenial manner.

The name SPY says it all. The SPY wants to use the inspection as a source of intelligence, not only about treaty items, but about all possible targets. The SPY argues for the inspectors' freedom of movement and for measurements detail greater than necessary to verify the treaty requirements. The antagonist of the SPY is the COUNTERSPY. Having a passion for secrecy, the COUNTERSPY agitates to restrict the freedom of movement for the inspection personnel and to limit the accuracy of the measurements they can take. His concern is not only for items targeted by the treaty for inspection, but for all objects of state security.

Other personnel, who are not part of the decision process, assist the decision makers. Analysts provided advice based on all sorts of information from probability theory to current events in local politics. In this paper our main interest is when the advise has mathematical content. Inspectors (not capitalized) perform the actual inspections according to policies, which the players construct.

Since neither side dominates the other, each side will probably both inspect and evade so there is occasion for two inspection games. If an inspection involves low level operations such as shipments through a portal these games may actually be realized. But when stakes are higher the EVADER will never allow a clear cut

detection of a violation. In the first place, the EVADER will prevent the INSPECTOR from examining evidence of a violation: airports will be closed, epidemics will break out, etc. In the second place, if the INSPECTOR uncovers evidence of a violation the EVADER will muddy the waters by claiming: the INSPECTOR is in error, the INSPECTOR fabricated the evidence, the treaty allows this activity etc. The advanced radar complex at Krasnoyarsk furnishes a striking example of this obfuscation. For years U. S. officials insisted that this installation violated the Anti-Ballistic Missile (ABM) treaty despite repeated denials of the Soviet Union and bitter criticism from American legislators and journalists. Finally, Soviet Foreign Minister Shevardnadze admitted that the site, indeed, violated the ABM treaty and would be dismantled.

From the difficulties encountered above you might conclude inspection serves no purpose in the case of equal sides so arms control should proceed solely on the basis of mutual trust. However, this conclusion is unacceptable politically. The public and their representatives demand arms controls with guarantees, i. e. inspections. A way around the difficulty is to assume that a blocked inspection is tantamount to a violation by the EVADER. If you do this, you exit the world created by the treaty, because the treaty generally speaks of "violations," "detection," and "sanctions." This solution defines inspection games which are probably non-zero sum, because the main threat, which the INSPECTOR has against a blocked inspection, is abrogation of the treaty; and this will also harm the inspecting side. Maschler (1966, 1967) treats sequential inspection in this context, although he assumes the INSPECTOR can detect violations.

3. Type and Nature of Inspection

In Ruckle (1990) I classified inspection as parallel or sequential. An example of parallel inspection is the simultaneous inspection of military installations as envisioned in some versions of the agreement on limiting conventional forces. Parallel inspection is characterized by simultaneous sampling. An example of sequential inspection is a guard checking the contents of trucks at a gate. Parallel inspection has a large scale nature while sequential inspection can have large or small scale. For example, the installation may have many gates and each guard post may use sophisticated high tech equipment.

Inspection may be limited or unlimited. Unlimited inspection means the inspectors have the right and the ability to inspect all targets. Limits on parallel inspection are the number of sites which the inspectors can visit, and the amount of warning required before inspections begin. Restrictions on sequential inspection are bounds on the number of searches and limits on the the guard's equipment. Limited inspection leads to a two person game between the INSPECTOR and the EVADER. We describe an example of the game arising from a sequential inspection.

3.1. Example. The EVADER ships sealed rail cars through a given portal, and the EVADER may inspect a certain number of them. Suppose the function v(n,k,r,s) denotes the benefit to the EVADER for the situation in which the EVADER has n remaining activities; the INSPECTOR has k remaining inspections; there have been r previous violations; s of these violations have been detected. The function v(n,k,r,s) should be increasing

in n, decreasing in k, increasing in r and decreasing in s. Ordinarily we do not expect that the INSPECTOR knows the value of r. We can bypass this obstacle by (a) assuming the INSPECTOR knows r by some collateral means of intelligence; (b) considering models in which u and v do not depend on r. If we assume that the interests of the INSPECTOR directly oppose those of the EVADER we conclude that v(n,k,r,s) is the value of the two person zero sum game described by the following game matrix.

		INSPECTOR	
		Inspect	Pass
EVADER	Don't Cheat	v(n-1,k-1,r,s)	v(n-1,k,r,s)
	Cheat	v(n-1,k-1,r+1,s+1)	v(n-1,k,r+1,s)

4. Negotiation

During treaty negotiation the five players attempt to influence their side's final positions on inspection. However, as with everything else under discussion, negotiators may modify inspection proposals for concessions elsewhere in the treaty. The INSPECTOR on one side will always oppose the EVADER on the other side, but at the same time oppose the EVADER on the same side because the final agreement will contain inspection arrangements which are almost symmetric. The nature of the opposition will be different, however, because the EVADER will accept a decision which helps the opposing INSPECTOR a little but helps the allied INSPECTOR a lot. Table 1 lists broad issues which arise in inspection negotiations and the disposition of the personalities toward these issues.

Table 1

Issue	Favor	Oppose
Numerous inspection personnel	I, D, S	E, C
Frequent inspections	I, S	E, C
Massive inspection technology	I, S	E, C
Freedom of action for inspectors	I, D, S	E, C
Precise definition of inspection targets	I, C	E, S
Heavy sanction for violation	I	E, D
Permanent fixtures at inspection site	I, D	E,

C: COUNTERSPY, D: DIPLOMAT, E: EVADER, I: INSPECTOR, S: SPY

The reasons for advocacy or opposition are usually evident. The DIPLOMAT weakly opposes massive inspection technology since he considers every agreement as a prelude to further agreement so the cost of the technology is not justified. Moreover, he may feel the technology indicates lack of trust. SPY and COUNTERSPY are ambivalent about permanent fixtures the inspecting side builds at the site. The COUNTERSPY on the opposing side sees the opportunity to restrict inspection personnel to the area around these fixtures while the SPY sees an opportunity to bug them. Their adversaries on the inspecting side see these considerations reason to oppose the fixtures.

To evaluate the a proposal, the INSPECTOR (or EVADER) could use a two person inspection game model as described in Example 3.1. In practice, however, analysts usually brief decision makers on estimated probability of detecting violations under various hypotheses about frequency of cheating. Decision makers then use intuition to decide which of several competing proposals to advocate. The reason for avoiding game theory is that it requires calculation of the utility of a successful evasion or disutility of being caught while trying to cheat. If these calculations are not entirely hypothetical then they demand extensive analysis. Moreover, the utilities may change frequently with the political and military situations of the two sides.

At the beginning of negotiations players on the same side don't want to quantify their positions. If they did a feasible position would hardly ever appear. The players hammer out a final position for their side by trading among themselves, by anticipating the position of the other side and by reacting to offers by the other side.

5. Implementation

In the final version of the treaty every opportunity of SIDE1 to inspect will correspond to an opportunity for SIDE2 to inspect. Corresponding inspections may allow for differences of geography, transportation networks and social structure of the two sides. However, there probably will be more symmetry than there should be for real fairness. Inevitably one side will receive a more advantageous arrangement.

Decision makers on each side design inspection procedures within the treaty framework paying more attention to technology and to probability theory than to game or decision theories. Just as with negotiations these decision makers would rather interpret detection probabilities intuitively than estimate utilities to fit a game matrix. Political and military change necessitate ceaseless modification of procedures. The five players incessantly maneuver to advance their goals. One constant is that each side will take advantage of all privileges granted by the treaty.

The INSPECTOR must not only maintain the inspection program but also convince the political authorities that the program remains effective. The arguments which the INSPECTOR can employ for this purpose are limited by the laws of politics rather than the laws of logic. As a hypothetical example, suppose a political authority questions the accuracy of a certain technical device used in an inspection. The INSPECTOR

is obliged to defend the accuracy of the device even though the device itself may not be very useful for inspection process.

6. Conclusion

In this paper we have tried to describe inspection in arms control, not as it should be but as it is. We have noted how decision makers prefer intuition to analysis and some of the reasons for this. Various players have goals for inspection different from the supposed purpose to prevent treaty violation. Real world impediments prevent inspection from being the clear cut objective process defined in the treaty. Politics sometimes requires argument to be formal rather than realistic. Moreover, during the negotiation process, diplomats can barter portions of an inspection agreement for other concessions.

Game and decision theorists should represent their models as advice about a situation instead of a complete solution. Decision makers see clearly when an inspection model does not contain all the ingredients, and so they reject it out of hand. This is unfortunate because the model may apply some aspect of the situation a lot better than the decision maker's intuition.

The introduction of a utility function presents difficulties in the analysis of an inspection proposal. Part of the trouble is that the players do no want to tie themselves down to a fixed quantity. Another obstacle is that determination of realistic utilities is a difficult task. Finally criticizing values of a utility is one of the easiest ways to attack a position. Model builders should employ utility functions sparingly and should study the model for a range of utilities rather than a single function.

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