STRUCTURAL MODELS OF INTERNATIONAL CRISES

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INTRODUCTION

We construct basic models of *binary crises*, i.e. crises between two groups of nearly equal strength, and without intermediating forces. The claim associated with our models is that they capture the global, systemic structure of all such crises met in reality. The models are formulated in rather abstract terms, comprising and integrating both 'dimensions' or 'levels of analysis' discussed in the literature: the systemic[2] level, and the individual level of the decision maker. They are *basic* models covering the essentials of *all* binary crises, as contrasted to *special* models which apply only to particular kinds of such crises, describing them in greater detail. Our second claim is that a large array of interesting special models may be obtained by refining the basic models. In particular, most of the characteristic features of crises discussed in the literature can be expressed or defined in specializations of the present models (see Sec.8).

The models are intended as a basis for future application in computer assisted crisis management. For this reason they are designed in a 'structural' way, i.e. they are completely formalized fitting the standards of model theory.[3] This means, first, that it is easy to transform them into computer programs.

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[2] We use this term in the usual, more general meaning in which a system does not necessarily have to comprise the *whole* international system. Systemic analysis thus also applies to more local phenomena, as long as they may be seen as proper systems possessing an identity of their own. A full discussion of whether crises have such an identity is beyond the scope of this paper. A theoretical argument against the necessary inclusion of the full international system into any analysis of crises is provided by general methodology which recommends to concentrate on the 'positive' cases (crises proper), and to give less weight to 'negative' ones ('equilibrium' states of the international system) in theory construction. See Balzer et al. (1987) for an exposition of this methodology. Besides, we think our models show to a sufficient degree that crises may be identified without reference to the international system.

[3] See for instance Shoenfield (1967), Chap.5. However, no familiarity with the formal notion of a model is presupposed here.

Second, and more intuitively, in our context this roughly means that the models provide closed, coherent pictures of the phenomena which do not rely on items or meanings external to them.

Our models do not refer to concrete classifications of dimensions, types of actions or propositions relevant for crises, like for example that of Brecher (1977) or McClelland (1964). Such classifications certainly are relevant in application to concrete cases but are left out here for reasons of simplicity. In this paper we want to concentrate on the purely structural features of crises, and on the presentation of our own models. As these are complicated enough comparison to other approaches will be rather brief (Sec.8).

We concentrate on the most basic, binary case. The typical application will be to crises involving two states of nearly the some status. More complex situations involving international organizations as mediators will have to be treated differently. We think, however, that our models can profitably be used in the analysis of those more complex cases.

The precise definitions underlying the present exposition are summarized in the appendix.

1 PRELIMINARY REMARKS

The literature on crisis research may be classified as falling roughly under three (overlapping) headings. First, there are attempts at formulating empirically tested hypotheses about crisis behavior and decision making using established statistical techniques, like McClelland (1968) or Holsti et al. (1968). Second, there are empirical investigations of large numbers of crises from a systemic point of view in which dimensions, and characteristics of crises are classified. Examples are Bloomfield and Moulton (1989), Gantzel and Meyer-Stamer (1986), Pfetsch (1991), and, in the beginning, McClelland (1964). Third, there are approaches of a more narrative and historical methodology, like Lebow (1981). Recently, some attempts are made to brigde the gap between the decision-oriented and the systemic approach, like Brecher et al. (1988). All approaches use some working hypotheses about what is meant by a crisis, most of which are formulated and discussed in Hermann (1972) and Brecher et al. (1988). For example, crises are seen as events in which there is a high level of stress[4], of pressure of time for decisions[5] or in which the group's basic values are threatened, in which there is a high probability of military conflict or use of force, and a challenge to the structure of an international system.[6]

In contrast to these approaches we aim at *structural* models. These are closed

[4]Holsti (1972)
[5]Hermann (1972), p.13.
[6]Brecher et al. (1988), Vol.I, p.3.

models with two properties. First, all objects occurring in the system modelled are made explicit, and second, the terms used to describe the system are characterized in a completely internal way, namely by means of how they are related among each other. These two features of models in the technical sense are best appreciated when confronted with the ususal way of describing crises.

For instance, Brecher (1979) characterizes a crisis as an event in which, among other things, there is a high probability of the use of force. It is tacitly understood that the entities to which 'use of force' may be attributed (military, or other groups) are present. A structural model in this situation will explicitly introduce a set of corresponding groups such that statements about the use of force may be explicitly formulated by referring to the groups (the grammatical subjects) using it. To illustrate the second feature let us consider a form of hypothesis used frequently in the literature. In Paige (1972), p.51 one hypothesis is that the greater the reliance on group problem-solving processes, the greater the consideration of alternatives. In a structural model the statement of this hypothesis presupposes the presence of entities of the kind 'group problem-solving processes' and 'consideration of alternatives'. In order to state the hypothesis relational terms have to be specified, namely 'to rely on' and 'to be greater than' (applied to 'considerations'). These items might naturally be made explicit by talking about a group, about problem-solving processes, alternatives considered by the group, and by using 'reliance' and 'greater' as relational primitives of the model.

Roughly, a structural model contains all the stuff to which it's hypotheses refer, and it specifies the meaning of its primitive terms by nothing else than its hypotheses. All extra meaning those terms have in natural language is – strictly speaking – irrelevant to a structural model. This does not rule out that in a concrete situation the meaning of the model's terms may be further determined by means of interpreting the terms in that situation. The point is that such interpretation – which may be as specific as we want – does not change the general meaning of the model's terms as fixed by the hypotheses governing the model. In the above example 'reliance on group problem-solving processes' in a concrete situation, like the Cuban Missile Crisis, may have a very specific meaning, implying trust, self-consciousness, and stability of the own system. In a structural model, however, the meaning of such reliance will shrink to a relation between the group and problem-solving processes which satisfies several hypotheses (among them that mentioned above).

2 PRIMITIVE TERMS

Our primitive terms used in describing the model are somewhat different from those found in the literature.

The most important basic stuff we use are propositions. In the present context a proposition may simply be regarded as a sentence formulated in the natural language of the group involved, typically a sentence formulated in the indicative, like 'we thread (blockade, attack ...) them', 'we want to prevent them from invasion (attack,...)'.[7] The propositions may be of any level of abstraction, and range from subordinate military orders ('set squadron XYZ into operation according to plan ABC') to global political statements ('our country's freedom is severely threatended').

The important role of propositions in crises should be obvious. People in crisis-management groups or leading groups on both sides talk with each other, they exchange information with their environment and with the opposing group by means of sentences. Their goals and plans are stated and stored in terms of sentences, their action alternatives are (finally) contemplated or computed in terms of sentences. Therefore, propositions play a major role in describing what is going on.

Propositions form a *space of propositions* containing, besides the propositions themselves, some basic connectives among propositions. These are of the nature of the logical connectives 'and', 'or', 'if then', 'not' but also of a weaker kind of 'meaning-implication'. Thus 'to launch a military attack' implies (by meaning, not logically) 'to put some military units into operation', or 'to sign a treaty' in this sense implies 'to have written versions of the treaty at hand'. We require that the set of propositions together with the 'logical' connectives form a *Boolean algebra*[8]. Supressing the 'logical' connectives, a *space of propositions* thus consists of two items: ($\mathcal{A}$,$\preceq$), a set $\mathcal{A}$ of propositions, and a relation $\preceq$ of meaning implication for propositions.

In applications the space of propositions may easily be structured in more sophisticated ways. For instance, we may superimpose a classification of propositions according to any given schema like that of Brecher (1977) or McClelland (1968).

A second basic kind of objects in the model are plans. Taking the simplest possible approach, a plan consists of three items: a goal, a finite set of assumptions, presuppositions or actions which have to be satisfied, realized or performed in order to achieve the goal, and some ordering of these assumptions in time. A plan P thus may be written as

$$P = (z, A, \tau, \theta)$$

where z is a goal (described by some proposition), A is a set of assumptions (each assumption also being described by some proposition), τ is a set of instants[9] ordered in some suitable way, and θ 'classifies' the assumptions according to their time of occurrence. To each instant, θ assigns the set of assumptions which have

[7] More formally, a *proposition* is a set of sentences (perhaps from different languages) all of which have the same meaning. Though philosophically contested (see Schiffer (1987)) this notion has proved rather useful in the social sciences.

[8] See Graetzer (1978) for details.

[9] We assume that there are only finitely many instants. Representing points of time by real numbers, the order of time may be taken to be that of the representing numbers.

to be satisfied at that instant in order to achieve the goal. A plan with four points of time – four ‘phases’ – is depicted in Figure 1.

Fig.1

τ	A	θ
t_4	z	$\in \theta(t_4)$
t_3	a_4, a_5	$\in \theta(t_3)$
t_2	a_3	$\in \theta(t_2)$
t_1	a_1, a_2	$\in \theta(t_1)$

The assumptions occurring in a plan at it’s ‘first’ point of time we call the plan’s *initial assumptions.*

This notion of a plan may be filled with further content by inserting more details about the structure of plans, namely plans being composed of ‘planning-elements’ (each such element including presuppositions, actions, and corresponding effects) and some fine structure of how planning-elements have to be fitted together in time to become operative.[10]

Besides propositions and plans the only entities occurring in the model are groups and points of time. Time is represented by a bounded, countably infinite set T of real numbers with a minimal but no maximal element, the order of time is represented by the mathematical order of these numbers. This special form leads to considerable simplification.[11] The notion of a group is treated as primitive, and not further analyzed. We assume that there are just two groups which may be interpreted as the groups of decision makers or of crisis-managers on both sides. These groups are the ‘carriers’ of plans. Groups at each time choose different plans which they want to execute, and they have opinions or beliefs of what is the case at each time.

We use a function, *choice*, to express which plans a group has chosen at each given time. We write $choice(G, t) = \{P_1, ..., P_n\}$ as an abbreviation for ‘at time t, group G has chosen plans $P_1, ..., P_n$’, and we assume that the set of plans chosen at each instant is finite. In order to treat differences of perception the choice-function will be relativized to the other group G'. So we write

$$choice_{G'}(G, t) = \{P_1, ..., P_n\}$$

to express that from the point of view of group G', group G at time t has chosen

[10] These details will be presented in another paper.

[11] One feature – not discussed in this paper – is that it allows to model pressure of time in a straightforward way.

plans $P_1, ..., P_n$, and similarly for G and G' exchanged: $choice_G(G', t)$. In this notation unrelativized choice of group G may be expressed by $choice_G(G, t)$, i.e. by those plans group G chooses from its own point of view (and similarly for G').

We use a function, *real*, to describe what each group at each time believes to be the case: the 'real' state of affairs at time t as seen by group G. This state of affairs we will call the group's *reality* at time t.[12] For a group's reality at time t we write: $real(G, t)$. Such a reality is modelled by a finite set of propositions, namely those propositions which members of group G believe to be realized, or true, at t. This description also is relativized to the other group so that we may express what one group thinks the other group believes to be the case. In general, we write

$$real_{G'}(G, t) = \{a_1, ..., a_m\}$$

to express that, at time t, from the point of view of group G', group G believes that propositions $a_1, ..., a_m$ are realized, or true, or correctly describe the state of affairs at t. Here, too, G and G' may be exchanged, and we obtain unrelativized expressions by setting G equal to G' or G' equal to G.

Finally, we use the notion of *crash plans* as distinguished plans which, depending on the application, either involve the execution of force on a non-marginal scale or the implementation of measures with considerable negative effect on the other group.[13] Formally, crash plans are represented by a distinguished subset C of the set of plans. We write C_G to denote the crash plans of group G, and $P \epsilon C_G$ to express that P is a crash plan of group G.

This concludes the list of terms we need in order to describe our model. By throwing together all the propositions and plans occurring in a model, respective, in the set $\mathcal{A}$ and in the set $PLAN$ our primitives may be summarized in the following list:

$$(\mathcal{A}, \preceq, PLAN, T, \Gamma, C, choice, real)$$

where

- $(\mathcal{A}, \preceq)$ is a space of propositions
- $PLAN$ is a set of plans (with all propositions being taken from $\mathcal{A}$)
- T is a set of real numbers (points of time)
- Γ is a set consisting of two groups G, G'
- C maps groups into sets of plans
- *choice* maps any two groups and any instant into a set of plans, and
- *real* maps any two groups and any instant into a set of propositions.

[12] We don't think that this label will be misunderstood as indicating that we believe in some 'absolute, objective reality' (whatever that may mean).

[13] In most cases crash plans involve military fight. However, we want our formalism to capture non-violent crises – like 'commercial wars' – as well.

3 SOME DEFINED CONCEPTS

The crucial unit of reference in the formulation of our hypotheses is, at a given time t, what we call the *state*, $s_t(G)$, of a group G at t. A state consists of two items: the set of plans feasible for the group at time t, $feasible_G(G,t)$, and the reality $real_G(G,t)$ of G at t. Thus we may write the state of group G at time t (as perceived by group G) in the form

$$s_t(G) = (feasible_G(G,t), real_G(G,t)).$$

The plans feasible for G can be defined as those chosen plans whose assumptions are in accordance with what is believed true by G. More precisely, we say that a proposition a is *consistent* with a set B of propositions if the negation of a, $\neg a$, is not a member of B or, more generally, if $\neg a$ is not implied[14] by members of B. Now a plan P is $feasible$ for group G at time t if 1) P is chosen by G at t and 2) all assumptions of P are consistent with the reality for G at time t. We write

$$feasible_G(G,t) = \{P_1, ..., P_n\}$$

to state that plans $P_1, ..., P_n$ at time t are feasible for group G (from the point of view of group G).

We distinguish between chosen plans and feasible plans because a plan, at some time t, may be chosen without being feasible. A plan chosen may be contingent on assumptions which are *not* satisfied, but the mere existence of the plan can have important political implications. Think of a plan for military mobilization which may be said to be permanently chosen in the sense that it will be immediately executed in case its preconditions should get realized. Feasible plans are needed to trace the actual path of crisis performance; chosen plans provide a frame for these paths.[15]

A state comprises information about what plans have been chosen by group G at t for execution and are held feasible by G (the elements of $feasible_G(G,t)$), and the relevant propositions which members of G believe to be true at t (the elements of $real_G(G,t)$). Note that the lower index 'G' is identical with the first argument in both expressions, that is, we are talking about the feasible plans of G and the propositions believed in by G, both *as perceived by* the same group G. Our notation also allows to consider states of the form $(feasible_{G'}(G,t), real_{G'}(G,t))$, i.e. states of group G as perceived by the other group G'. Such expressions will be needed below in defining conflicting goals. Note that the above definition of feasibility is consistent with that of relativization.

[14] 'Implied' in the sense of the meaning implication given by $\preceq$.

[15] The real importance of chosen plans in contrast to feasible ones is realized in the analysis of the causal mechanisms of the development and avoidance of crises (which will not extensively be performed in this paper).

In a state of group G there is a close connection between the propositions believed true and the assumptions occurring in the feasible plans. If a feasible plan P requires that some assumption a must be satisfied at t then the group's reality at t is of course relevant to the execution of that plan. If reality is such that the negation of a holds true then the plan by definition is not feasible, and will not be carried out. On the other hand, if all the assumptions of plan P required at time t are (believed to be) realized then the execution of the plan may continue. That proposition a is realized in a state here means that it is believed true in that state, i.e. it is an element of the set of propositions $real_G(G,t)$. a is *not* realized in a state if a does not occur among the propositions making up the reality of that state. If all the assumptions of a plan are realized in a given state we say that the plan is *realistic* (at the time considered). Note that a plan may be feasible without being realistic. Feasibility only means that it's assumptions are compatible with what is believed to be the case. From mere consistency we cannot infer that the assumptions really are satisfied. It is a natural assumption about the groups' behavior that each group having chosen some goal tries to change its reality such that most of the assumptions of a plan achieving that goal become true, i.e. the plan becomes as realistic as possible, and that it will abandon a plan for that goal if some crucial assumptions of the plan are not satisfied and are not likely to be satisfied in the future (i.e. if the plan is unrealistic). This assumption does *not* belong to our hypotheses, but is highly relevant in specializations of the model which focus on the causal mechanisms of crises.

As a third notion we define that of two plans held by the two groups being *in conflict*. The motivation for this notion is that conflict is 'caused' by conflicting plans. Conflict of plans is defined with respect to their goals. By the previous definitions the goal of a plan is a proposition, and for propositions it makes perfect sense to say that they contradict each other. Two propositions (or two goals) g, g' contradict each other just in case g implies $\neg g'$ or g' implies $\neg g$. Now two plans P, P' are *in conflict*, if their goals contradict each other, and if, in addition, both plans are chosen, and are realistic. Chosen plans and real (true) propositions were introduced for one group G from the point of view of this group or from the point of view of the other group. It is necessary, therefore, to specify which versions of *choice* and *real* should be used in the definition of conflicting plans. To decide this question let us consider a plan P chosen by group G (at t) and a plan P' chosen by group G' such that both plans' goals contradict each other. We want to investigate the conditions of perception under which this situation is likely to give rise to a real conflict between the two groups. We have to consider the following four statements (at t):

(1) P is in $choice_G(G,t)$, (2) P' is in $choice_{G'}(G',t)$
(3) P is in $choice_{G'}(G,t)$, (4) P' is in $choice_G(G',t)$.

Suppose, that statement (1) would not hold, that is, that P were not chosen by G from the point of view of G. This simply means that group G has not chosen plan P and is aware of this. In such a case we cannot say that the goal of plan P is a goal of group G, and therefore we cannot say that the goal of P for group G contradicts some goal of the opposing group. So in G's view there is no cause for conflict. The same holds for statement (2) and group G'. Now suppose statement (3) were false, i.e. P were not chosen by G from the point of view of G'. In other words: from the point of view of the opposing group G' group G did not choose P. So G' has no reason to compare the goal of plan P with the goal of it's own plan P'. In G''s view no conflict is visible. The same holds for statement (4). These considerations show that certain *combinations* of (1) - (4) have to be satisfied in order to give rise to conflict. The minimal combinations here are (1) plus (4) and (2) plus (3). If (1) and (4) both are true then group G perceives a conflict because G' from G's point of view has chosen a plan P' which contradicts the plan P chosen by G. The same holds from the point of view of G' for the combination of (2) and (3). In each case it is likely the the group perceiving conflict starts some action which then will lead to recognition of the conflict also by the other group. Of course, if all four statements are true then conflict is even more likely. In order to avoid the distinction of cases in the following we will concentrate on the case of all four statements being satisfied. We stress, however, that the two weaker cases also are relevant and have to be studied.

Finally, for the plans to lead to conflict it is necessary that their assumptions are feasible, and their initial assumptions are realistic from the point of view of both groups. That is, each group must believe that it's plan's assumptions are realized, and that the initial assumptions of the respective other group's plan also are realized.

We thus arrive at the following definition. Let G and G' be the two groups of our model and let t be some point of time. Then plans P and P' are *in conflict* (for G and G' at t) if and only if

(1) P is in $choice_G(G, t)$ and P' is in $choice_{G'}(G', t)$
(2) P is in $choice_{G'}(G, t)$ and P' is in $choice_G(G', t)$
(3) the goals of P and P' contradict each other
(4) the assumptions of P all belong to $real_G(G, t)$ and to $real_{G'}(G, t)$
(5) the assumptions of P' all belong to $real_{G'}(G', t)$ and to $real_G(G', t)$.

Finally, we may express *conditional commitment* of a group to choose a plan P as a reaction to the other group's choosing a certain, contested plan. The other group's choice thus forms a condition which, when satisfied leads to a subsequent choice of P by the 'own' group.[16] Such commitment can be expressed either by means of a new primitive *commit*[17] or by means of suitable statements of the form described. A statement „If P' is chosen by G' at t_i, then G will choose P at t_{i+1} expresses a commitment of group G, conditional on G' choosing P'“.

[16] Most political commitments have this form: If you will do A (choose plan P') we will do B (choose plan P).
[17] See Sec.6.

4 HYPOTHESES

With the help of these definitions we now may state the hypotheses which govern our model. There are five basic hypotheses, which cannot be clearly separated from each other, however.

The first hypothesis says that the model contains some earliest[18] point of time t_0 at which both groups have chosen conflicting plans. In the formulation of the other hypotheses we will refer to these plans as the *initial plans*, and for each group the goal of it's initial plan will be called the group's *crisis-goal*. The earliest instant t_0 is called the *origin* of the crisis.

The second hypothesis is that the model contains, for each group, a crash plan with two properties. First, each group's crash plan is chosen by that group at each time after the origin. Second, the goal of each group's crash plan is linked to the crisis-goal of that group. This may be made precise in different ways. A strong kind of link obtains when the crash plan's goal implies the crisis-goal in the sense of the meaning implication: $\preceq$. A weaker kind of link is given by commitments of the group to choose the crash plan once the other group chooses a distinguished, contested plan. A third, still weaker link is given by the crash plan's being the final plan that will be reached in a sequence of commitments both groups have made.

In order to formulate the third hypothesis recall that our model contains an infinite, countable set of points of time. Moreover, the set of instants is bounded, has a smallest or 'first' element, and does not have a largest or 'final' element. As a matter of real analysis the numbers in this set – when ordered by the usual ordering of real numbers – form a sequence which 'looks like' a converging sequence.[19] For each point of time t and for each group G we may consider the state $s_t(G)$ of that group at t. By letting t run through the set of all points of time in the right direction, i.e. from the 'smallest' to ever larger numbers, the corresponding states of the group will form a sequence $(s_t(G))_{t\epsilon T}$.[20] This sequence of states for each group G we call the *planning cone* of G.

We now require that for each group it's planning cone $(s_{t_i}(G))$ converges to a distinguished limit denoted by $s_{\nearrow}(G)$, provided that at each time after the origin some chosen plan still has the crisis-goal as its goal. In other words: if both groups pursue there crisis-goal, their planning cones will converge. Convergence can only be avoided by at least one group giving up its crisis-goal.

The limit of a convergent planning cone is required to consist of two parts:

[18] Actually, the existence of an *earliest* such point of time follows from the mere existence of a point at which there are conflicting plans and our way of representing time.

[19] Technically, it is a *Cauchy*-sequence, a sequence the elements of which get arbitrarily close to each other with increasing index.

[20] The character of a sequence can be brought out more clearly by using the assumption about T and writing T in the form $T = \{t_1, t_2, ..., t_i, ...\}$, where $t_1 < t_2 < ... < t_i < ....$ With '$\mathbb{N}$' standing for the set of positive integers the sequence then takes the form $(s_{t_i}(G))_{i\epsilon\mathbb{N}}$.

a plan P, and a set A of propositions. It thus takes the form

$$s_{\nearrow}(G) = (\{P\}, A).$$

This limit has the same format as a state; the set $\{P\}$ containing plan P has the same format as a set of plans, $feasible_G(G,t)$, chosen by a group, and the set A of propositions has the same format as a set $real_G(G,t)$, the reality of a group. So the limit in fact may be regarded as a 'limit-state'. Informally, we may imagine the limit-state like an ordinary state consisting of a set of plans chosen be G 'in the limit' and a set A representing G's reality 'in the limit'. The two components of the limit-state we therefore call the *limit-plan* and the *limit-reality* respectively.

The limit-state of each group has to satisfy two more requirements. First, the limit-plan P of group G's limit-state is simply the crash plan chosen by that group according to the second hypothesis. Second, the limit-plan P is required to be realistic with respect to the limit-reality A. That is, all assumptions of P have to be in A. Convergence of the sequence of states implies that the sequence of the realities being part of each state also converges in a precise sense. So the propositions in the limit-reality are arbitrarlily close to propositions in realities of 'earlier' states and in this derived sense may be said to be believed true. The second requirement then expresses that all assumptions of the limit-plan are realistic or believed true by the group in the sense of being arbitrarily close to propositions that were believed to be true at some earlier stage.

By summary, a structure

$$(\mathcal{A}, \preceq, T, PLAN, \{G, G'\}, C, choice, real)$$

is a *model of a binary crisis* iff it satisfies the following hypotheses:

H1 At some earliest time $t_0 \in T$ both groups G, G' have chosen from $PLAN$ conflicting plans with conflicting crisis-goals.

H2 For each group G there is a crash plan P_c such that G has chosen P_c at t_0, and such that the goal of P_c is linked to the crisis-goal of G.

H3 There are limit-states $(\{P\}, A)$ and $(\{P'\}, A')$ such that if, for all t after t_0, both groups have chosen plans whose goals are the respective crisis-goals then

H3.1 P and P' are identical with the crash plans P_c and P'_c, respectively.

H3.2 All assumptions of P are in A, and all assumptions of P' in A'.

H3.3 Both groups' planning cones converge to their respective limit-states relative to suitable topologies:
$lim_{t\to\infty} s_t(G) = (\{P_c\}, A)$ and $lim_{t\to\infty} s_t(G') = (\{P'_c\}, A')$.

The choice of topologies relative to which convergence is defined is a formidable task in application, and is left open at the present, general level. In Sec.5 we will describe one possibility – out of many others – to introduce a suitable topology.

Intuitively, the dynamical picture emerging from these hypotheses is this. At some time t both groups choose plans with conflicting goals, their crisis-goals. Once the conflict is recognized they start interacting such as to further the achievement of their own crisis-goal and to prevent the achievement of the opposing group's crisis-goal. This ultimately leads to a convergence of both groups' planning cones towards a limit-plan with the two special features described in H3.1 and H3.2. On the assumption of convergence this means that each group successively chooses plans aiming at the realization of the crisis-goal. But this also has the effect of furthering the possible execution of crash plans held by both groups. These crash plans get ever more realistic because, by H3.2, their assumptions in the limit are realized, and by convergence, these limit-assumptions are approached by the realities $real_G(G,t)$. Furthermore, pursuing the crisis-goals leads to a successive narrowing down of the set of chosen plans. In the limit, only one chosen plan is left: the crash plan. By contrast, in the normal political situation many plans are available and chosen at each time.

Usually – though not logically – the convergence goes together with, and in this sense 'implies', a narrowing down of the domain of assumptions occurring in the plans at each point of time, as well as with a narrowing down of those assumptions which are feasible but are not realized. If the set of plans chosen shrinks to one single plan, then usually this plan will need less assumptions than all the plans chosen at earlier times needed together.

An obvious objection to the requirement of convergence is that it puts too much weight on escalation, neglecting the possibility of resolution before the limit is reached. For this reason we introduced the precondition for convergence in H3.3. Convergence obtains only in case the crisis-goals are pursued all the time. If one party gives up its crisis-goal the requirement of convergence stops being operative. In this way the model also captures crises which get resolved.

A second objection might be that in real crises even in the limit there may be other, chosen plans, different from the crash plans. This may be so but those other plans then are of practically no relevance to the evolution of the crisis. Often, relevance may be checked simply with respect to the crisis-goal: the goal of an irrelevant plan does not contribute to the crisis-goal. Such irrelevant plans may be neglected in the application of our model even if they can be clearly identified as being chosen in a real situation.

5 SPECIALIZATIONS

In order to substantiate our claim that the basic models may be specialized in many interesting ways we will describe some such specializations. In doing so we will not spell out all the formal details but stick to the essentials.

A first specialization deals with choice and execution of plans. To choose a plan does not imply that it will be executed, for the execution requires all of the plan's initial assumptions being realized. So from a plan's being chosen we may infer that it is executed only under the additional premiss that its initial assumptions, and subseqently its other assumptions as well, are realized or believed to be true by the corresponding group. This type of inference is of utmost importance when we want to trace causal chains in the development of a crisis, and therefore may be used to characterize a class of special models. These models satisfy the proposition that whenever a plan is chosen by group G and its initial assumptions are belived to be true by G then the plan will be executed by G. The basic step of incorporating this proposition in our models is to add a further primitive expressing which assumptions of a given plan P can be actively realized by a given group (at time t) by performing appropriate actions. We write $perform_G(P, t)$ to denote this set of assumptions. These assumptions in general form a proper subset of plan P's complete set of assumptions. The latter set also may contain assumptions which cannot be influenced by humans (like wheather conditions), and assumptions which are actively 'negated' by the rival group. The basic hypothesis which triggers the above mechanism is that if a group has chosen plan P, and if all of P's initial assumptions are realized except those which the group can actively realize itself (members of $perform_G(P, t)$), then the group *will* perform actions such that these assumptions get realized. In our frame, this hypothesis may be formulated as follows.

CC For all groups G, times t_i, t_{i+1}, and plans P, if G has chosen P at t_i and all assumptions of P except those in $perform_G(P, t_i)$ are elements of $real_G(G, t_i)$ then all members of $perform_G(P, t_i)$ will be realized at t_{i+1}.

Of course, this hypothesis by itself is not sufficient for a crisis to develop. It is possible, however, to state sets of conditions which prove to be sufficient for a system satisfying CC to be a binary crisis. In other words, we may find further conditions which, together with CC, imply that the system gets nearer to the crash, and that in the long run the planning cones converge. There are several different such sets of conditions, each set representing a certain causal mechanism for the generation of crises. It has to be stressed that these causal mechanisms can be described in the vocabulary of Sec.4 plus that of CC. By investigating such sets of conditions we really investigate the causation of crises in a rigorous way. The empirical question in each case – for each set of sufficient conditions – is whether the conditions are realistic enough, and are satisfied, or can be expected to be satisfied, in real crises. These possibilities again show the great potential of the basic models.

A second specialization concentrates on the mechanism of systematically preventing certain assumptions in the 'enemy's' plans from becoming realized,[21]

[21]'Realized' here may be understood in it's primary sense of 'getting materialized' but also in the sense of 'getting perceived'.

and of eliminating in this way more and more plans from being feasible. If both parties successfully pursue this strategy then their sets of chosen plans will get smaller, at least if we assume that plans some assumptions of which are known to be not satisfied are eliminated from the *choice*-sets. The essential axiom characterizing the corresponding models may be formulated as follows.

EL For all times t there is a group G and a plan P chosen by G such that P's goal is realized at t but contradicts some assumption of a non-crash plan chosen by the other group at t.

This assumption under plausible conditions will lead to the elimination of the affected non-crash plan by the other group: it is recognized that one of its assumptions has been negated by the enemy and that therefore the plan is no longer feasible.

Third, let us consider *military dominated* crises. These are binary crises in which each group has several military plans with different goals, and in which each group has committed itself to certain reactions in case the other group should realize a distinguished, military plan. Such kinds of crises were of major importance during the cold war. Their treatment affords two steps. First, we have to say what is a *military* plan, in contrast to a plan in general. Here we simply may use the notion of crash plans, and identify – in the present specialization – military plans with crash plans. Under restriction to military plans thus conceived it is sufficient to add one further primitive to our model, namely a binary relation of commitment. We write $commit_G(P/P')$ as a shorthand for 'group G has committed itself to choose its plan P if the other group should choose plan P'', and we require that commitment, in fact, implies the choice[22] of the plan to which the group has committed itself (MC2 below). Thus we obtain two special hypotheses defining military dominated crises.

MC1 Each group has several military plans.

MC2 For all groups G, G', times t_i, t_{i+1}, and all plans P, P': $commit_G(P/P')$ and $P' \in choice_G(G', t_i)$ imply $P \in choice_G(G, t_{i+1})$.

It is not difficult in this setting to describe constellations of commitments which necessarily – and quickly – lead to convergence of the planning cones. If G chooses P and $commit_{G'}(P'/P)$, G' will choose P'. But G also may have committed itself to choose P_1 under this condition, and G' to choose P'_1 as a reaction to P_1 etc. So, after a few steps, both parties are committed to execute one of the crash plans. Of course, this picture may be further refined. MC2 still leaves room for problems of perception, and we did not address the issue of the plans' assumptions being realized; the corresponding details may easily be added.

Fourth, we may specialize the model by further characterizations of plans. One important condition in the study of dynamics is that a plan's initial assumptions may be fully under control of the group having chosen that plan or

[22] If axiom CC is satisfied, commitment thus will lead to action, if the 'uncontrolled' conditions are favorable.

not. It is easy to define the notion of control as applied to assumptions (propositions). We say that an assumption is under group G's control if the other group has no plans the goals of which could get in conflict with the given assumption. In this way we obtain the notion of a plan being *initially under control* which may be used in different special models.

Another group of specializations aims at more operational forms of the axiom of convergence **H3.3**. Convergence has little empirical impact. For any crisis we can observe only finitely many periods in its development, but these have no implications for convergence. Conversely, convergence does not exclude any finite initial segment, and therefore no observations can possibly refute the hypothesis of convergence. There are two things to note here. First, while it is true that convergence *in general* has no implications for the initial segments, it is not true that convergence cannot have such implications at all. As soon as we introduce further 'theoretical' assumptions about the form of the planning cones convergence may indeed be refuted by finite data. Such theoretical assumptions might require, for instance, that the sequence is constant, or is periodic. A more realistic assumption in our case would be that the planning cones strictly decrease: successive planning cones have fewer plans and propositions. By adding further assumptions on the form of the planning cone, convergence may become empirically relevant. In accordance with our basic approach it is admissible to begin with the general, but empirically empty assumption of convergence, and to leave the empirically relevant forms to specializations of our basic model.[23]

Second, the notion of a converging sequence may itself be submitted to approximation. This leads to more operational versions of **H3.3**, two of which are described in the following section.

6 CONVERGENCE AND ITS OPERATIONALIZATION

Technically, convergence presupposes a notion of similarity or distance. To say that a sequence of states converges to a limit means that the elements in the sequence get ever closer, ever more similar, to the limit. So we have to introduce some standard of closeness for states. As an example we construct a topological space corresponding to the ideas underyling **H3.4**. The entities to be compared have the form of states. These entities form a set M, and on M we will define a topology by defining, for the 'points' of M (i.e. the states) a so called system of neighbourhoods. Each neighbourhood of a state s will be a set of states which to a certain degree – given by a real number ε – are similar to s.

[23]The *same* situation we meet, by the way, in the 'hardest' natural sciences. In classical mechanics and in thermodynamics the basic laws characterizing the basic models are empirically empty; empirical content coming in only through specializations. See Balzer,Moulines,Sneed (1987), Chap.4.

Each state has the form $(feasible_G(G,t), real_G(G,t))$ consisting of a finite set of plans $(feasible_G(G,t))$ and a finite set of propositions $(real_G(G,t))$. Abstractly, the format of a state therefore is this: (X, A), where X is a finite set of plans, and A a finite set of propositions. Each such pair we call a *quasi-state*. As a model contains overall sets of plans $(PLAN)$ and propositions $(\mathcal{A})$ we have well specified domains from which to pick 'all possible' X's and A's. The set of all possible quasi-states (X, A) which can be constructed in a given model, and which contain a given crash plan P_c $(P_c \in X)$ we denote by $M(P_c)$. The problem now is to define a topology 'on' $M(P_c)$. This problem can be reduced, by a standard theorem of topology, to the definition of a system U_s of neighbourhoods of s, for any state s in $M(P_c)$.[24]

For a given set X of plans, by 'the assumptions of X' we mean the set of all assumptions occurring in all the plans of X. By our previous stipulations, the assumptions of a set X of plans form a finite set of propositions, and the same is true for the sets of propositions A occurring in a quasi-state. We define a system of neighbourhoods of a given quasi-state (X, A) in the set $M(P_c)$, and relative to a given, positive constant c. For two quasi-states (X, A), (Y, B), and a given, positive, real number ε we say that (Y, B) lies in the ϵ-neighbourhood $U_\varepsilon(X, A)$,

$$(Y, B) \in U_\varepsilon(X, A)$$

iff two assumptions are satisfied.[25] First, in A, more assumptions of P_c are satisfied than in B but the number of differing assumptions is bounded by $c \cdot \varepsilon$. Second, in B more assumptions of the 'other' plans, i.e. those different from P_c, are satisfied than in A, and again the number of differing assumptions is bounded by $c \cdot \varepsilon$. The constant c has to be very small, and is used in order to overcome the 'coarseness' of cardinal numbers. Without c, $U_\varepsilon(X, A)$ would be degenerate for all $\varepsilon < 1$ in the sense of containing only the point (X, A). Adding to all the sets $U_\varepsilon(X, A)$ so defined all possible supersets (in $M(P_c)$) we obtain a system of neighbourhoods.[26]

By a well known theorem of topology[27] these neighbourhoods induce a topology on $M(P_c)$. Formally, then, we have provided one solution to the problem of explicating convergence of a sequence of states. Any sequence of states after t_0 is a sequence of quasi-states, i.e. of elements of $M(P_c)$. Such a sequence $s_1, s_2, s_3, ...$ converges to limit s in the usual mathematical sense: almost all members of the sequence are contained in arbitrarily small ε-neighbourhoods of s.

Putting the formal definitions to one side the question is whether the neighbourhoods so defined for quasi-states – and thus for states proper – are a satisfactory expression of distance or similarity of states. At the present, early stage of such investigations this question will remain open, but some comments may

[24] The central axiom for such a system U_s says that for each neighbourhood U in U_s there is another neighbourhood V in U_s such that U is a neighbourhood of all of V's points. See Schubert (1964), Sec.2.3., for the corresponding axioms and the theorem mentioned.

[25] When this definition is used to define convergence, (X, A) corresponds to 'the limit'.

[26] See Theorem 1 in the appendix.

[27] Compare, for instance, Schubert (1964), Sec.2.3.

be helpful. Two main objections are that our topology, first, is very crude, and second, is made up *ad hoc*. It is crude because the material it uses, propositions and plans, are crude themselves. It is *ad hoc* because there might be other ways of defining a topology, and we do not offer any survey of the possibilities. To these objections we reply as follows. First, it has to be stressed that our level of abstraction is very high, and therefore the objects we deal with are rather unspecific. However, this is no fundamental deficiency as long as the model can serve as a basis for further specialization. Now from the beginning this was one major goal in constructing our model. We chose our primitives so that they may easily be refined. We have described just one possible definition of a system of neighbourhoods by means of comparing *numbers* of propositions occurring in the states to be compared. This is admittedly a rather coarse way of proceeding. More subtle definitions would refer to *systems* of propositions rather than to mere sets and their numbers of elements, and thus to the meaning relation among propositions. A still more detailed approach would introduce conditional probability as a new primitive and use expressions like 'the probability of crash in the light of a given system of propositions'. On such an account the idea that crash becomes more likely might be expressed in a rather natural way. By putting more content into a space of propositions neighbourhoods thus can be made much more concrete.

As concerns the *ad hoc*-ness we have to admit that no systematic effort was made in exploring alternative definitions. We are ready to change the topology if alternative definitions can be shown to be clearly superior to the one just given.

A point to be stressed here is that our model does not commit us to a particular topology. The abstract notion of convergence is sufficient to draw the basic picture of a crisis, and in order to formulate the requirement of convergence we have to assume only the existence of *some* topology. This yields further flexibility in applications. We might profitably choose *different* topologies when applying different specializations of our model to different real cases.

In application, the requirement of convergence would force us to collect data for infinitely many states of the planning cones – which is impossible. So there is some need for more operational versions of this requirement. We will describe two such approaches which are closely related to the definition of neighbourhood stated above, and to which the previous discussion also applies.

The idea is simply to consider the transition from a given state to its succeeding state, and to express that in such a transition we come closer to the 'limit' situation in which only the crash plans can be executed. There are several different ways of describing such kinds of transitions. In a first version consider two succeeding states $s_t(G) = (Y, B)$ and $s_{t+1}(G) = (X, A)$ of each group G both containing G's crash plan P_c. We say that $s_{t+1}(G)$ is *nearer to the crash than* $s_t(G)$ if (1) the number of assumptions of the crash plan which are believed true is greater in $s_{t+1}(G)$ than in $s_t(G)$, and (2) the number of assumptions in the non-crash plans is smaller in $s_{t+1}(G)$ than in $s_t(G)$. In other words, more assumptions of the crash plan become true while the true assumptions of the 'other', non-crash plans present in $s_t(G)$ decrease[28] in number. With this auxiliary definition we can define an *operational* version of our model by replacing the previous assumption of convergence (**H3.3**) by the following hypothesis.

H3.4 For all instants t succeeding the origin t_0, if both groups at t have chosen plans aiming at the respective crisis-goals then both groups' state at time $t+1$ is nearer to the crash than at t.

It is easy to see how this assumption might be empirically refuted: just check the numbers of assumptions occurring in two succeeding states, and their relation. This procedure obviously is very insensitive to the content of the propositions. In reality, one assumption may be much more important than serveral others taken together, and therefore should have more weight in the comparison. There are several formal ways to refine **H.3.4**. Instead of looking at them in detail let us turn to a much weaker, operational form of **H3.3**.

Instead of requiring the number of assumptions in the non-crash plans to decrease we may concentrate on the reasons why *some* of these assumptions become inoperative, or simply fail to be satisfied. This may come about in at least two ways. First, by means of standing commitments, and assumption's realization might trigger a series of reactions ending with the choice of some crash-plan. If such a chain is realized there is good reason to postpone the original assumption's realization. Second, an assumption simply may become negated by some plan executed by the other group. In the most salient case the other group executes some plan the goal of which is the negation of the assumption. Using these two 'mechanisms' we may formulate the following operational hypothesis.

H3.5 For all instants t succeeding the origin t_0, if both groups at t have chosen plans which aim at their respective crisis-goals, then
(1) the number of assumptions believed true in the respective two crash plans increases during the transition from t to $t+1$,
(2) there exist *some* assumptions believed true in the respective two non-crash plans at t which are no longer believed true at $t+1$ due to actions of the other group or due to their triggering chains of actions by commitment leading to the choice of a crash-plan.

Note that **H3.4** and **H3.5** refer to two given crash-plans as required in **H2** to exist. In some cases it may be convenient to leave some flexibility for the choice of crash-plans. This we can achieve by allowing the crash-plans to vary with time. In order to avoid **H3.4** and **H3.5** becoming trivial, however, we then would have to add a further condition binding together the possibly different crash-plans. One such condition is that their goals must include each other when time goes on. For simplicity we stick to the stronger version here, keeping the crash-plans fixed.

[28] This condition is slightly weaker than the corresponding requirement imposed in the above definition of neighbourhood. Compare the formalizations in the appendix.

7 APPLYING THE MODEL

The question of how to apply models of social phenomena is difficult and has been much discussed, in crisis research as well as in social science in general.[29] From the point of view of our own meta-theory[30] application of the present model to a real system, a real crisis, amounts to three steps. First, as many data as possible are collected from the real crisis, second, these data are transformed into expressions formulated in the vocabulary of our model. Third, it has to be checked whether the transformed expressions are consistent with our hypotheses. If we could deduce singular statements from the hypotheses plus some of the transformed expressions we might add a fourth step consisting in a test ('prediction') of whether the singular statement describes some proposition observed in the system.

Of course, any substantial application of our models to a real crisis is laborious. We can provide here only a brief sketch for one example. Let us choose the example of the Cuban Missile Crisis of 1962 which certainly is a paradigm of a binary crisis.

At the coarsest level possible we may distinguish six points or short periods of time. The first period t_1 is that of detection by the US of the constructions of launching pads going on in Cuba in the first half of October 1962. After that, the executive committee, 'ExCom', was set up which discussed several alternative plans about how to react. The most salient plans were

P_1: to launch an air attack in order to destroy the launching pads
P_2: to invade Cuba
P_3: to set up a sea blockade around Cuba[31]
P_4: to win assent of the organization of american states OAS
P_5: to write a letter to Krushchev and press for secret withdrawal[32]
P_6: to achieve a diplomatic compromise including a missile trade
P_7: to prepare for comprehensive atomic war.

After some time of discussion it was decided at October 20 (which marks our second period t_2) by Kennedy to set up a blockade. After that date, overt US diplomatic activity was successful in getting assent of the OAS for the intended blockade at October 23 (which is our t_3). In period t_4, at October 24-26, the blockade took effect. During period t_5, in October 26-28, P_6 was pursued. After some further intermediate events of military and diplomatic nature at high levels a retreat of USSR missiles began at October 28 which marks the beginning of our period t_6.

[29]Compare, for instance, Singer (1979).
[30]See, for instance, Balzer (1985), Kap. II.
[31]This plan was made contingent on P_1 not being successful.
[32]This plan seems to have been chosen during October 18-20.

On the side of the USSR at these times we may assume the following plans[33]

P'_1: to install medium range missiles in Cuba
P'_2: to defend Cuba against conventional attack by the US
P'_3: to prepare for a comprehensive atomic war
P'_4: to negotiate for a removal of US missiles in Turkey in exchange to stopping the Cuban action
P'_5: by means of diplomatic activities to get the US accepting the missiles in Cuba.

It is not known whether there was a plan to involve West-Berlin in subsequent negotiations, or even to seize the city. However, the US was committed to defend Berlin in case of military attack.

The plans which contain the crisis-goals are relatively easy to determine. The US chose to set up a blockade in order to abandon the missiles, the USSR chose to install missiles in Cuba. Both plans' goals contradict each other, and both plans were chosen at the origin t_2, the time when the US decided to set up a blockade.[34] So **H1** is satisfied.

There are several candidates for crash plans on either side. There is, first, the 'local' US plan of launching an air attack on Cuba, and second, the US plan of invading Cuba, and the corresponding plan of the USSR of defending Cuba against US invasion. Third, there are the global plans of launching a full blown atomic attack at the respective enemy. The simplest picture is obtained by working with local crash plans. Let us choose that of invading Cuba on the US's side, and that of defending Cuba on the side of the USSR.[35] It is clear that the goals of these local crash plans are linked to those of the respective crisis-plans, and so **H2** also is satisfied.

In order to check **H3** we have to note the conditional nature of this hypothesis. It is required that for all periods after the origin both groups have chosen plans whose goals are the crisis-goals. This is not the case in the present example, the USSR giving up its goal of installing missiles in Cuba. So **H3** strictly speaking is satisfied: it is satisfied because its premiss is false. Of course, this is not a very satisfactory way of holding that our model correctly applies to the case under consideration. It is for cases like this that we discussed the 'operational' versions of the model in which **H3.3** is replaced by **H3.4** or **H3.5**. Let us consider **H3.5** and look whether for each period considered the succeeding states got nearer to the crash. As period t_6 is the last one, we have to investigate the transitions from t_i to t_{i+1} for $i = 1, ..., 5$. In the present case, we may work with the stronger version in which the two crash-plans are held constant over time for the two groups, respectively.

[33] In spite of the new data in Blight and Welch (1990) relatively little is known about the plans and activities on the military side of the USSR.

[34] Actually, the USSR's plan was also chosen at earlier times but we are only interested in the situation at the origin.

[35] Note that our axioms require only *some* crash-plans to *exist*. So in application their choice is ours. Note also that the present version of **H3.5** does *not* require consideration of *all* crash-plans.

This affords to compare the sets of chosen plans in any two succeeding states. We see that these sets get smaller or remain identical. After period t_1 the US dropped the plans for an air attack and an invasion.[36] After period t_2 the plan of getting assent by the OAS is realized, and thus can be dropped.

However, the hypothesis is formulated in a more subtle way requiring to compare the assumptions in the plans chosen in any two succeeding periods. This affords to look more closely at which propositions were thought to be true by both parties in the different periods, a task which is very difficult to achieve in detail. We just will indicate some rather clear cut examples. During t_1 the US authorities believed in propositions like

a_1: missiles are set up in Cuba by the USSR
a_2: the missiles in Cuba probably are not yet ready for operation
a_3: invasion of Cuba is feasible
a_4: probability of USSR seizing Berlin in reaction to US attack on Cuba is low.

During t_2 they believe all the propositions just mentioned plus new ones, like for instance

a_5: US air force attack will not destroy the launching pads 100%
a_6: a blockade is most likely to lead to a permanent withdrawal of missiles.

Similar observations hold for t_3 to t_5. During t_5 they believe, among other things, that no russian ship or submarine can pass their blockade undetected. Similar propositions were believed true at the other side.[37]

H3.5 consists of two parts.[38] First, more assumptions of the crash plans get realized. This part is satisfied for the US in the following sense. First, the military preparations of concentrating troops and material near Cuba which may even be regarded as part of that plan were continually going on all the time. Second, we may say that the execution of this plan was made contingent on the failure of preferred plans (blockade, air attack). There was little indication up to t_5 that these preferred plans would succeed. At least, therefore, these contingent assumptions of the crash-plan were unchanged.

The second part of **H3.5** says that at least some assumptions in the chosen non-crash plans get inoperative due to the two 'causes' described above. For the USA this part of **H3.5** is not very interesting. The crucial plan here is P_3 (*blockade*). Clearly, many of this plan's assumptions got realized because the plan was executed. However, from a comprehensive point of view one assumption of that plan was that the blockade should lead to an abandoning of the missiles, and this assumption was getting weaker. The plan contained a constraint to the effect that by October 25 it should become clear that construction work on the launching pads would be stopped until October 28. This assumption was negated by Russian activities; they simply went on in the construction. With respect to P_4 ('winning assent of the OAS') we may say that this plan's

[36] This is true at least in the sense that they did not prepare for immediate realization.
[37] In fact, $a_1, ..., a_5$ are very likely to have been believed by the USSR, too.
[38] We suppress a discussion of which propositions belong to which plans and we stress again that our version of the hypothesis refers to just one pair of crash-plans.

assumptions get inoperative from t_2 to t_3 because the plan's goal was fully achieved. Though this is in the spirit of **H3.5** it does not satisfy its letter for the reason of abandoning the assumptions are different from those mentioned in **H3.5**. On the Russian side the second part of **H3.5** is satisfied rather impressively. The plan of installing missiles in Cuba is finally abandoned, and one reason for this is the negation of the plan's assumption of free access to Cuba which is negated by the US blockade. Also, commitments of the US prevented the USSR from retaliating in Berlin or Turkey (though we did not mention corresponding plans above). The other USSR non-crash-plans are not affected in the sense of **H3.5**. Altogether, therefore, we may say that the second part of **H3.5** is satisfied; for the US in a weak and trivial way, and well for the USSR.

8 ASPECTS OF COMPARISON

Our models 'contain' most characteristics, criteria, or conditions of crises put forward and discussed in the literature. As already stressed, they are intended as *basic* models, i.e. models common to *all* binary crises, and they may be further specialized in order to capture the particular features of particular crises. So we will not expect that they comprise *all* features of crises discussed in the literature in the direct sense of logical implication. We cannot expect that all other concepts discussed can be explicitly defined in terms of ours, and that all other hypotheses discussed are logically implied by ours. What we *can* expect is that all these other concepts and hypotheses can be defined and derived in natural extensions, specializations or refinements of our models, and in this sense are 'contained in' it. Our discussion of several main characteristics of crises recurring in the literature will focus on these possibilities.

1) In a crisis the probability for the use of force is high.[39] This characteristics is directly present in our model by the nature of the groups' limit-states, and the fact that their planning cones converge to these states. Each limit state has just one plan, a crash plan the execution of which usually involves force. As the planning cone converges to this plan, the probability of its execution increases, and so does the probability of the use of force.

2) In a crisis basic values of the group are highly threatened.[40] In our models we did not explicitly introduce the notion of values. It is clear, however, that values are closely linked with goals. In fact, we may even assume that some goals are direct expressions of values. On the other hand, there also are plans the goals of which do not directly correspond to a value. So there is reason for introducing values as an extra primitive. Without extending our vocabulary we may enrich the models by a set of values each value being expressed by one or

[39] See Brecher (1979), 5-6, Lebow (1981), 11.

[40] See Hermann (1972), 3-17, Brecher (1979), 5-6, Lebow (1981), 10.

several propositions. We then may model thread by assuming that the crisis-goals are among, or are closely linked to, those values (where linkage may be expressed by meaning implication $\preceq$).

3) In crises decisions have to be taken under increasing pressure of time.[41] By making explicit the process of interaction taking place among the two groups we can make available expressions like 'the time in which a decision has to be taken'. Our representation of time in terms of a bounded, infinite set of real numbers together with the convergence of the planning cone then will logically imply that decision times become shorter.

4) Crises show a high volume and intensity of events.[42] The category of event or action is not present in our model; we did not need it in order to formulate our hyotheses. It is clear that action is highly relevant to a more fine-grained description of a crisis, but it is also clear that action can be added easily. Actions are described by propositions, so we just have to introduce a predicate *group G performs action a at time t* in order to include the dimension of action. On the other hand, it is not clear whether this will be sufficient to express the characteristics of high intensity of actions. Intuitively, intensity of actions arises from activity of all the diplomatic and/or military apparatus plus the media[43] and therefore should not be ascribed to a group which is taken as an unspecific object. It seems that a further refinement of our model would be necessary in order to express such a condition: the groups would have to be further analyzed as structured sets of persons. Nothing prevents us from doing so.[44]

5) In crises there is a high amount of stress.[45] This points to the dimension of individual psychology, which we did not include here. We do not want to deny that psychological features, including principles of decision making, are, or can be, important to a crisis. They are, however, the most difficult features in this context. Much of the theory on decision making is normative rather than descriptive, and therefore cannot be brought to bear in our context. On the other hand, the psychological situation in a group of crisis managers is most difficult to investigate for usually such groups are not directly accessible to the scientist, indirect information may be strongly biased, and laboratory experiments are too far removed from reality. At the present stage, we do not see how this dimension of individual psychology can be captured by a natural extension of our model.

6) Crises may have a component of surprise[46] This can be modelled in terms of plans and goals. If, at the time of perception of the opposing group's crisis-goal there are no plans at all of how to prevent that group from achieving the goal, we have a situation of surprise.

Some authors discuss disruptive change of the system or challenge to an

[41] See Hermann (1972), 3-17, Brecher (1979), 5-6, Lebow (1981), 12.

[42] See McClelland (1968), 161.

[43] A good illustration is McClelland (1968).

[44] Institutions as analyzed in Balzer (1990) might in fact be 'plugged in' into the present model exactly at this point. Our groups might be analyzed as top-groups of corresponding institutions.

[45] See Holsti (1972).

[46] Hermann (1972), 13.

international system.[47]

7) Challenge of an international system, we think, is partially represented by talking of thread of basic values which was discussed under item 2) above. It is clear that our models cannot be refined such as to include the full international system. The feature of challenge, therefore, is beyond our models.

8) Change of the system[48] – as far as it does not mean challenge of an international or external system – refers to components internal to the system. It is not very clear what is meant here by 'the system', we take it that this expression refers to the institutional setting of each group: it's status and role in it's surrounding social system or state. The inclusion of this criterion affords the extension of our model towards the theory of institutions. As already mentioned, this seems feasible. Balzer (1990) provides an approach that might be used here.

APPENDIX

A *space of propositions* is a structure of the form $(\mathcal{A}, \neg, \wedge, \vee, \mathbf{0}, \mathbf{1}, \preceq,)$ such that 1) $\mathcal{A}$ is a non-empty set, 2) $\mathbf{0}, \mathbf{1}\ \epsilon \mathcal{A}$, $\mathbf{0} \neq \mathbf{1}$, $\neg$ is an unary, and $\wedge, \vee$ are binary operations on $\mathcal{A}$, 3) $(\mathcal{A}, \neg, \wedge, \vee, \mathbf{0}, \mathbf{1})$ is a Boolean algebra, i.e. for all $a, b, c \in \mathcal{A}$: 3.1) $a \wedge b = b \wedge a$, $a \vee b = b \vee a$, $a \wedge (b \wedge c) = (a \wedge b) \wedge c$, $a \vee (b \vee c) = (a \vee b) \vee c$, $a \wedge (b \vee a) = a$, $a \vee (b \wedge a) = a$, 3.2) $a \wedge (b \vee c) = (a \wedge b) \vee (a \wedge c)$, $a \vee (b \wedge c) = (a \vee b) \wedge (a \vee c)$, 3.3) $a \vee \neg a = \mathbf{1}$, $a \wedge \neg a = \mathbf{0}$, 4) for all $a, b \in \mathcal{A}$: if $a \vee b = a$ then $b \preceq a$.

The logical connectives $\neg, \wedge, \vee$ as well as $\mathbf{0}$ and $\mathbf{1}$ will be suppressed in the following.

P is a *plan over* $(\mathcal{A}, \preceq)$ iff there exist z, A, τ and θ such that 1) $P = (z, A, \tau, \theta)$, 2)$A \subseteq \mathcal{A}$ is finite, and contains at least two elements, $\tau \subseteq \mathbb{R}$ is finite and contains at least two elements, 3) $\theta : \tau \to \mathbf{Po}(A)$ and for all $t \in \tau : \theta(t) \neq \emptyset$, 4) $z \in A$, $\theta(max(\tau)) = \{z\}$, and for all $t < max(\tau) : z \notin \theta(t)$, 5) $\mathbf{0} \notin A$, 6) $A = \cup\{\theta(t)/t \in \tau\}$.

We use $\mathbf{Po}_0^e(\mathcal{A})$ to denote $\{A \subseteq \mathcal{A}/\ A$ is finite and $\mathbf{0} \notin A\}$.

A *potential crisis* is a structure of the form $(\mathcal{A}, \preceq, T^*, \Gamma, PLAN, C, choice, real)$ for which there exist $\neg, \wedge, \vee, \mathbf{0}, \mathbf{1}$ such that 1) $(\mathcal{A}, \neg, \wedge, \vee, \mathbf{0}, \mathbf{1}, \preceq)$ is a space of propositions, 2) $T^* = (t_i)_{i \in \mathbb{N}}$ is a strictly monotonously increasing, bounded sequence of real numbers (we set $T = \{t_i/i \in \mathbb{N}\}$), 3) $\Gamma = \{G, G'\}$ with $G \neq G'$, 4) $PLAN$ is a finite set of plans over $(\mathcal{A}, \preceq)$, 5) $C : \Gamma \to \mathbf{Po}(PLAN)$, 6) *choice*: $\Gamma \times \Gamma \times T \to \mathbf{Po}(PLAN)$, 6) *real*: $\Gamma \times \Gamma \times T \to \mathbf{Po}(\mathcal{A})$.

For a plan $P = (z, A, \tau, \theta)$ we set $V(P) = A \setminus \{z\}$, $O(P) = z$, and for a set X of plans over $(\mathcal{A}, \preceq)$ we set $V(X) = \cup\{V(P)/P \in X\}$. A finite set $A = \{a_1, ..., a_n\}$ of propositions is said to *imply* proposition a iff $a_1 \wedge ... \wedge$

[47]Like Hermann (1972), 10, or Brecher et al. (1988), 3.
[48]For instance Brecher (1979), 6.

$a_n \preceq a$. For a potential crisis we define $feasible$: $\Gamma \times \Gamma \times T \rightarrow \mathbf{Po}(PLAN)$ by $P\epsilon feasible_{G'}(G,t)$ iff 1) for all $a\epsilon V(P) : \neg a$ is not implied by $real_{G'}(G,t)$, 2) $P\epsilon choice_{G'}(G,t)$. We define the *planning cone* of G, $PC(G)$, as the sequence $(s_t(G))_{t\in T}$ where, for $t \in T$: $s_t(G) = (feasible_G(G,t), real_G(G,t))$. We say that plans P,P' over a space of propositions are *incompatible* for G and G' at t iff $G \neq G'$ and 1) $P \in choice_G(G,t)$ and $P' \in choice_{G'}(G',t)$, 2) $P \in choice_{G'}(G,t)$ and $P' \in choice_G(G',t)$, 3) $V(P) \subseteq real_G(G,t) \cap real_{G'}(G,t)$ and $V(P') \subseteq real_{G'}(G',t) \cap real_G(G',t)$, 4) $O(P) \preceq \neg O(P')$ or $O(P') \preceq \neg O(P)$. For $P_c \in C_G$, $X,Y \subseteq PLAN$ with $P_c \in X$, $P_c \in Y$, $A,B \subseteq \mathcal{A}$ and $t_i \in T$ we say that , for G at t_i, (X,A) is *nearer to the crash than* (Y,B) iff 1) $V(\{P_c\}) \cap B \cap real_G(G,t_i) \subseteq V(\{P_c\}) \cap A \cap real_G(G,t_{i+1})$ and 2) $V(Y \setminus \{P_c\} \cup A \cup real_G(G,t_{i+1}) \subseteq V(Y \setminus \{P_c\}) \cup B \cup real_G(G,t_i)$.

Let $P_c \in C_G$ and let $M(P_c)$=$\{X \subseteq PLAN/P_c \in X\} \times \mathbf{Po}_0^e(\mathcal{A})$, and let $c > 0$ and $\varepsilon > 0$ be given real numbers. For $(X,A) \in M(P_c)$ we define $U_\varepsilon(X,A)$ as the set of all pairs $(Y,B) \in M(P_c)$ such that 1) $V(\{P_c\}) \cap B \subseteq V(\{P_c\}) \cap A$ and $\parallel (V(\{P_c\}) \cap A) \setminus (V(\{P_c\}) \cap b) \parallel < c \cdot \varepsilon$, and 2) $V(X \setminus \{P_c\}) \cap A \subseteq V(Y \setminus \{P_c\}) \cap B$ and $\parallel (V(Y \setminus \{P_c\}) \cap B) \setminus (V(X \setminus \{P_c\}) \cap A) \parallel < c \cdot \varepsilon$. By $\mathbf{U}(X,A)$ we denote the set $\{U \subseteq M(P_c)/\exists \epsilon > 0(U_\varepsilon(X,A) \subseteq U)\}$.

By using the equality $\parallel C \setminus A \parallel = \parallel C \setminus B \parallel + \parallel B \setminus A \parallel$, for $A \subseteq B \subseteq C$, the following theorem is proved by means of standard techniques from topology.

THEOREM 1 For all $(X,A) \in M(P_c)$, the system $\mathbf{U}(X,A)$ forms a system of neighbourhoods.

A sequence $(s_t)_{t\in T}$ in $M(P_c)$ *converges* to $s \in M(P_c)$ iff for all $\varepsilon > 0$ there is some $t_0 \in T$ such that, for all $t \in T, t \geq t_0$: $s_t \in U_\varepsilon(s)$.

A *crisis* is a structure of the form $(\mathcal{A}, \preceq, T^*, \Gamma, PLAN, C, choice, real)$ satisfying the following requirements:
there exist $G, G' \in \Gamma, G \neq G', t_0 \in T, P_i, P'_i, P_c, P'_c \in PLAN$ and $B, B' \subseteq \mathcal{A}$ such that
1) $(\mathcal{A}, \preceq, T^*, \Gamma, PLAN, C, choice, real)$ is a potential crisis
2) P_i and P'_i are incompatible for G and G' at t_0
3) $P_c \in C_G$ and $P'_c \in C_{G'}$
4) $O(P_c) \preceq O(P_i)$ and $O(P'_c) \preceq O(P'_i)$
5) $V(P_c) \subseteq B$ and $V(P'_c) \subseteq B'$
6) If, for all $t \in T, t > t_0$, there are $P, P' \in PLAN$ such that $P \in choice_G(G,t)$, $O(P) = O(P_i)$, $P' \in choice_{G'}(G',t)$ and $O(P') = O(P'_i)$ then $PC(G)$ converges to $(\{P_c\}, B)$ and $PC(G')$ converges to $(\{P'_c\}, B')$.

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