Socio-Cultural Modelling of Operational Interaction with Influential Actors

Preliminary Investigation

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Sammanfattning

Interaktionen med inflytelserika aktörer under internationella insatser är väsentligt för att få tillgång till information, genomföra förhandlingar och att informera om insatsstyrkans motiv och intentioner. Problemet är att befälhavaren, förutom sin egen förståelse av situationen, för tillfället bara har ett begränsat stöd, om något, för att utföra den här interaktionen. Sverige och Frankrike planerar därför att gemensamt utveckla en konceptuell demonstrator för ett stödssystem för interaktionen med inflytelserika aktörer. Utvecklingen baseras på produkten Intègre från Normind som använder parakonsistent logik. Intègre kan representera och resonera om aktörernas motstridiga motiv och intentioner och har ett interaktionskoncept för att iterativt utveckla en plan för interaktionen med aktörerna. Den här preliminära studien beskriver motiven för projektet, typiska egenskaper hos inflytelserika aktörer, resultaten från en workshop med svenska officerare med erfarenhet som militärobservatörer, aktuella utvecklingar inom parakonsistent logik och några slutsatser om kravställningen på stödsystemet.

Nyckelord: inflytelserika aktörer, morfologisk analys, parakonsistent logik

Summary

The interaction with the influential actors during international operations is essential for getting access to information, performing negotiations, as well as informing about the international forces' motives and intentions. Currently, however, the commanders only have little support, if any, for planning and performing these interactions besides their own understanding of the situation. Sweden and France therefore plan to cooperatively develop a conceptual demonstrator of a support system for the interaction with influential actors based on the product Intègre by Normind that uses paraconsistent logic. Intègre can represent and reason with the inconsistent motives and intentions among the influential actors, and provides an interaction concept that enables an iterative plan development. This preliminary investigation describes the rationale for the project, typical characteristics of influential actors, results from a workshop with Swedish officers that have experience as military observers, current developments in paraconsistent logic, and some conclusions about the requirements on the support system.

Keywords: influential actors, morphological analysis, paraconsistent logic

Contents

1 Introduction

An important task for the international forces in many contemporary conflicts is to encourage, persuade, and force the influential actors to accept a solution that improves the stability and long-term development. This is usually an incremental process that serves to facilitate and enhance relations among the actors that are positive for the overall development, while simultaneously hinder or reduce the effects of relations that hamper the overall development. Particularly, it is important to understand how the actions of the international forces may escalate or reduce the tensions among the actors.

Ideally, the interaction with influential actors should be based on an understanding of their motives and intentions, as well as how the interaction supports the overall operational plan. Currently, however, the commanders only have little support, if any, for planning and performing these interactions besides their own understanding of the situation. The lack of support is problematic since the interaction with the influential actors is essential for getting access to information, performing negotiations, as well as informing about the international forces' motives and intentions. Since the interaction with the influential actors is so important, it is not surprising that commanders typically spend 20% to 50% of their time on this interaction (Eisenstadt, 2007).

The motives and intentions of the influential actors are partly driven by the distribution of political and economic power along with the socio-cultural dynamics. Each actor then makes their own interpretation of this context and how to improve or consolidate their position within their means and relations to other actors. The result is a complex web of mutually supporting and opposing relationships that the international forces should adapt to and utilize when planning the operation. Figure 1 shows one example such relationships among the influential actors for the ISAF operation in Afghanistan (PA Knowledge, 2009). Further, these relationships are continuously evolving both as a result of the actions of the international forces, as well as from the socio-cultural dynamics.

A key aspect of the relationships among the influential actors is that their motives and intentions usually are inconsistent with each other. This is why there is a conflict in the first place that requires support from the international community. Since inconsistent motives and intentions are inherent in international operations, a planning support tool for the interaction with the influential actors should preferably try to represent these inconsistencies while simultaneously consider the relationships among the actors. Further, the inconsistencies vary from minor to major. The degree of inconsistency therefore provides important information that the international forces can use to indentify and prioritize influential actors for future interaction. Major inconsistencies are of course the most difficult to resolve, but over time the general level of inconsistencies and motives for the conflict should decrease. Typically, any improvement of the situation requires that all actors compromise on their demands to some degree due to the conflicting interests. Only rarely can an actor get everything they want.

A promising modelling approach to represent the inconsistent motives and intentions of the influential actors is paraconsistent logic. Contrary to classical logic where contradictions are not allowed, paraconsistent logic can represent and still reason with contradictions (da Costa et al., 2007). Annotated paraconsistent logic can even represent the degree of inconsistencies (e.g. Martins et al., 2009). Modelling and simulation of the actors' motives and intentions system using paraconsistent logic can therefore potentially serve as planning support tool for the interaction with the influential actors.

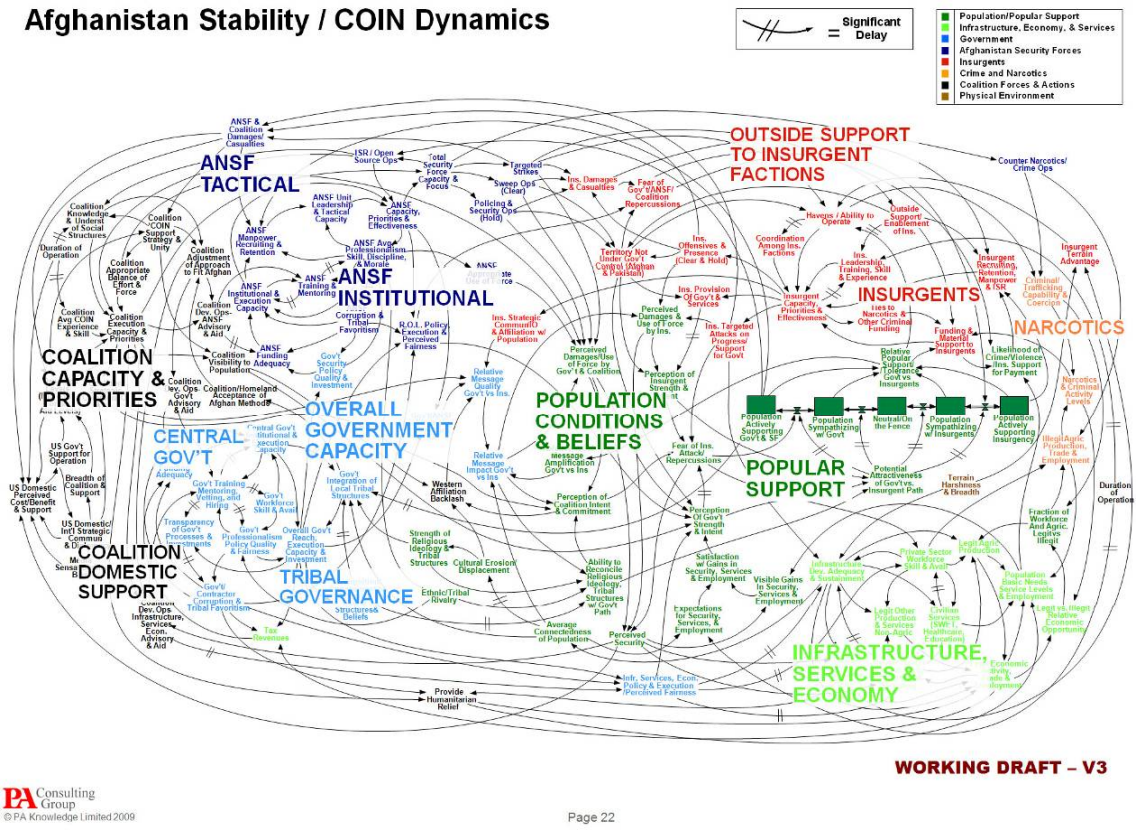

Figure 1. Example of relationships among influential actors for the ISAF operation in Afghanistan.

The potential usefulness of paraconsistent logic as a planning support tool for the interaction with influential actors has prompted France, Sweden and Belgium to cooperatively develop a simulator. France contributes with expertise in paraconsistent logic and their tool Intègre which is developed by Normind and utilize paraconsistent logic (Pierre, 2010). Intègre has been applied to diagnosis of prostate cancer, tax planning, utilization of nuclear weapons, hostage operations, and strategic doctrines. Sweden, on the other hand, contributes with expertise in the Xland scenario which is a fictional scenario that is representative for the complexity of contemporary conflicts. Finally, Belgium plans to evaluate the final simulator. The simulator is developed as a part of the European Defence Agency (EDA) project Socio-Cultural Modelling (SOCUMOD) (EDA, 2011).

As a preparation for the future development of the simulator, there is a need to scope the problem of modelling influential actors with paraconsistent logic. The scoping begins with a review of how typical motives and intentions are based on common reasons for conflicts. Thereafter follows a summary of typical issues in the interaction with influential actors as seen by subject matter specialists, such as military observers. Thereafter follows a description of the influential actors in Xland and the inconsistencies of their motives and intentions. Then the concepts of paraconsistent logic are introduced, as well as what they may mean for the modelling of influential actors in Xland. Finally, there are some conclusions for the future development of the simulator.

2 Influential actors in contemporary conflicts

2.1 Motives and intentions of influential actors

The contexts within which influential actors exert their influence differ, and so do their incentives. To some influential actors, the position of power in itself and the benefits that might come with the social position is irresistible. Other influential actors may be idealists and base their actions on an indignation that is evoked by what is perceived as unjust actions taken by some powerful actor against another vulnerable group. Alternatively, the idealist influential actors spread ideas and impose social norms that they regard as superior. Still other influential actors may act from an underdog position, trying to avert some urgent threat to something they cherish, such as their belief system, traditional way of life, environment, or relatives threatened by genocide.

An influential actor has by definition followers that, for some reason, are supportive of and influenced by the actor. For example, the reason may be that they get a share of the profit or have a common concern. Further, the context puts limits on the support to the influential actor. Changes in context will be more important for some actors than others, affecting the strength of the support and sometimes also alter the incentive of an influential actor. Thus, movements, groups, and similar structures splinter, and different parts lose or gain in support and vitality as the contexts change. Finally, the maturity of the actor's structure may be important, and the style of the influential actor may reflect the developmental phase of the structure.

2.2 Morphological analysis of the interaction with influential actors

In order to get a better understanding of typical issues in the interaction with influential actors, a two-day workshop was arranged with eight subject matter specialists that had operative experience from the Swedish Armed Forces, UN or non-Governmental Organizations (Ritchey, 2010). Several of the participants had experience as military observers. The workshop was performed using the focus group method Morphological Analysis where the subject matter specialists are presented with a focus group statement and then with guidance from a moderator cooperatively develop a joint understanding of the problem area (Ritchey, 2006). The focus statement for the workshop was:

In international operations trustful, confidence building relationships with the population and influential actors in the operational area is of central importance. It is through such relationships that a purposeful, constructive interplay among actors is made possible. By way of these relationships we are able to gain knowledge about how the society – or the societies – in the operational area function, what it is that is important for the local population, and who it is that has, or could acquire, influence which can affect developments. This knowledge increases our potential to gain insight into how, and with whose help, we can contribute to the positive development of the op-area.

Table 1 a) and b) shows the morphological parameters and parameter values that the subject matter specialists agreed upon as characterising the interaction with influential actors. The table shows that there are a wide range of actors that may be contacted depending on their role for the mission type. The purpose of the contact may be to directly influence the actor, negotiate, exchange information, or simply to build a contact network and get goodwill. Further, the interaction may focus on the dissemination of information, how the international force's resources can be used for improving or if necessary worsening the living conditions, or simply on the image of the international forces. Ideally, there should of course only be positive intended consequences of the interaction. Frequently, however, the interaction may also have negative consequences for the security and image of the mission. An accurate judgement of these consequences within context of

the overall operational plan is therefore very important. It is noteworthy that the subject matter specialists only briefly appears to consider how the interaction with influential actors is coordinated with the wide range of actions that are required in contemporary conflicts. Except for the notion of "Give synergy effects" they do not appear to consider how a concerted effort is required of military, economic, and political to humanitarian assistance and development of law enforcement agencies. That such a wide range of actions is necessary is illustrated by the development of concepts such as Comprehensive Approach (e.g. Jakobsen, 2008). Similarly, there is only a limited consideration of the secondary effects for how the interaction affects the actor's interaction with the other actors. Finally, the contact should be performed by the proper person, on a suitable location, and in the best way possible.

An important part of Morphological Analysis is to systematically investigate the formal combination of all the parameter values for the parameters. However, due to the time constraints of the workshop, this investigation was limited to how some of the parameters values constrain the values of other parameters regarding how the contact should be performed. Constraints mean here that only some combinations of parameters values are reasonable. The results show that the type of influential actor was central for the selection of who should contact the actor, in what way, and how to influence the actor.

Table 1. a) Morphological parameters for the interaction with influential actors.

Mission type	Type of influential actor	Purpose of contact	Principal type of influence
Peace Enforcement	Religious leaders and scholars	Mutual information exchange in order to influence securing situation	Security, threat, violence
Peace Keeping	Political leaders	Monitoring and investigation	Opinion building
Humanitarian assistance	Police leadership/ chiefs	Goodwill Hearts & minds	Information dissemination
Evacuation	Military leadership	Network building and long-term contact	Image building
Stabilization	Clan leaders	Mediation and negotiation	Infrastructure
	NGO representatives	Direct influence on the influential actor	Humanitarians needs and social services
	Doctors, teachers, and other professionals		
	Militia leaders		
	Business leaders/ entrepreneurs		
	Spouses and relatives		
	Journalists		
	Local, informal influential actors		

b) More morphological parameters for the interaction with influential actors.

Possible positive consequences	Possible negative consequences	Who can/should make contact?	How to contact? (Forum) (Method)	Ways to influence the influential actor
Improved contact channels	Worsened relations between mission forces and the population as a whole	Force commander/ SRSG	Formal meetings	Warn about possible measures
Verify information	Worsened relations between mission forces and a part of the population (faction/group)	Regional chief	Informal meetings	Coercive measures
Give synergy effects	Worsened relations between mission forces and the political structure	Local chief	Spontaneous meetings	Subordination/ pay off
Restraining effect	Worsened security for own forces/units	Military observer	Social meetings/ gatherings	Representative presentation
Increase acceptance	Worsened security for parts of the local population (factions/groups)	Individual female soldiers	Correspondence	Mediate knowledge, information, and competence
	Worsened security for certain influential actors	Individual male soldiers	Humanitarian activities	Presence, posture, profile
	Negative image of mission or mission leadership among own forces	"Culturally competent" officer	Participate in local activities	Recognition
	Restrictions on freedom of movement	"Function officer" (Information, Liaison, Priest)	Make contact through third party	Reports about the influential actor
				Personal communication/ conversation

3 Influential actors in Xland

Xland is a small country of about 600.000 citizens and consists of the four municipalities Gävle, Sandviken, Ockelbo, and Hofors. Figure 1 shows the current map of the North Friendly Sea area and figure 2 shows the current map of Xland. About 50% of the population lives in Gävle and Sandviken cities and along Highway 80 (RV80) between Gävle and Sandviken. Xland has a long history of strong tensions between the two main ethnic groups Delta and Echo Christians. Most Delta Christians in Ockelbo municipality have their origin from recent immigration from nearby Northland, while the Echo Christians have their origin from Westland. Although Echo and Delta Christians share a similar religious orientation in the form of Christianity, their religious roots from Westland and Northland respectively are very different. Xland was originally a province of Northland, but was lost to Westland following an offensive to establish a corridor to the North Friendly Sea. Eventually, Northland regained most of their territory, although the territory that later became Xland remained under Westland control. In 1909, Xland was declared a sovereign state.

Since the Echo Christian population in Xland was very vulnerable, they early on established laws, practises, and social networks that enable them to control most of the political and economic powers. For example, only Echo Christians are allowed to own any real estate. The power distribution was for a long time not an issue and accepted by the Delta Christian population. However, this all changed during the 1930 depression when a huge influx of Delta Christians from Northland in the western and northern part of Xland changed the ethnic composition in these areas. Social tensions mounted when the Delta

Christians were especially affected by the depression. Since then there has been repeated clashes and even massacres. The ongoing political oppression and deteriorating standard of living for Delta Christians during the late 1990s also favoured the emergence of Delta Christian fundamentalist groups. One of these groups was the Klykers who now control the western part of Ockelbo and Sandviken and eastern part of Hofors. The Klykers consistently practise "management by fear" to increase their influence. Therefore, there are no Echo Christians left in the countryside controlled by the Klykers, only in Hofors city. The western part of Hofors is controlled by the Valliens, a maffia-type organisation that is part of the ethnic Valliens population who settled in Hofors in the 17th century.

The fragile security situation in Xland and deteriorating standards of living with 25% HIV/AIDS and ecologically unsustainable logging, forced the authorities to turn to the international community for assistance. The Delta Christians demanded free and fair elections and a date has been set. A formal request for assistance, regarding security and organisation of the election, was forwarded to the UN Secretary General on 27 June 2009. The UN mandated a Chapter VII operation, focusing on a security assistance mission linked to parliament elections in Xland. The security assistance for the election is provided by a European Battlegroup.

Figure 1: Map of the North Friendly Sea area.

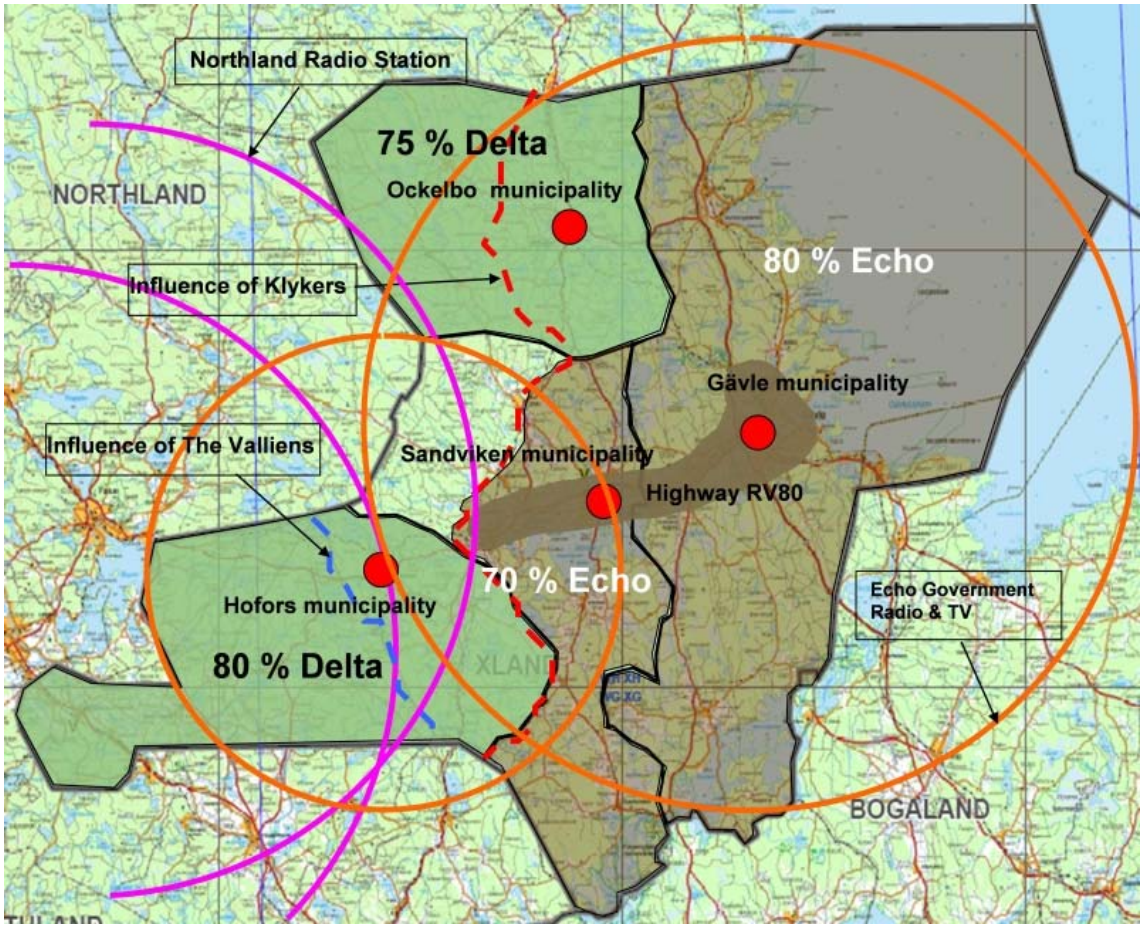

Figure 2: Map of Xland

There are many influential actors in Xland that each have their own and partially incompatible goals on how to reverse the degrading situation in Xland. Although there is a general agreement that a new constitution and reforms are necessary, there are many views on in which direction and to which extent the constitution should change. All these views are represented by a wide range of political parties in Xland that want to participate in the election. The main political parties in Xland are (1) The Echo Christian Party (ECP) who wants to maintain stability and honour tradition, with a minimum of reform, in order to overcome the hard times and strive into a prosperous future, (2) The Delta Liberation Front (DLF) who wants a new constitution with democratic rights such as freedom of speech, free media and press, and the right to demonstrate, (3) The Environmental Movement (EM) who wants reconciliation, democratic and equal rights, and ecologically sustainable forestry and tungsten extraction, (4) Xland Communist Party (XCP) who wants a centralized government, a Marxist one-party system, politicise police, and state ownership of all enterprises, (5) Gastrikans Nationalistic Party (GNP) who wants an Echo Christian society with traditional values and without immigrants, and (6) Vallien Labour Party (VLP) who wants social justice, economic democracy, and solidarity.

The main task for the international force is to enable a free and fair election by providing security and organizing the election so that people can form and express their own opinion about the political parties. Although most of the influential actors are positive towards the election, many of them may well try to influence the election in way that is advantageous for themselves, such as fundamentalist Delta and Echo Christian groups, and security forces that risk loosing their privileges. Since the majority of the voters are Echo Christians it is especially important that the Delta Christians can vote freely.

There are many means that the international force can use to enable a free and fair election, such as:

- providing security to politicians and populations that are threatened
- prosecute and attack violent actors
- threaten to arrest actors that perform illegal activities
- manifest their presence to discourage threats and violence
- build infrastructure
- provide humanitarian needs and social services
- facilitate international aid and support
- enhance an actor's status and recognition of power
- opinion building to reduce the effect of biased actors
- information dissemination to affect how events and initiatives are portrayed

Such means can be used in the interaction with influential actors to:

- facilitate information exchange
- facilitate monitoring and investigation
- improve the goodwill to gain trust
- win hearts and minds to increase the support for the mission
- facilitate network building and long-term contact
- facilitate mediation and negotiation
- directly influence an actor

However, since the means are limited, they must be used judiciously to reach the goal of the mission. Each initiative must therefore be assessed depending on how it affects the beliefs of the influential actor, as well as future interactions among the actors and with the international force. The next section describes some potential characteristics of a planning support system for the interaction with the influential actors that is based on paraconsistent logic.

4 Some applications of paraconsistent logic

Researchers have for a long time been interested in making logical formalisms more applicable by defining the meaning of common uncertainties, such as incompleteness, inconsistencies, vagueness, ambiguity, etc. The logical rigor and reasoning can thereby also be utilized in a meaningful way for applications with irreducible uncertainties. Paraconsistent logic is one such extension of classical logic that mainly focuses on how to reason with inconsistencies. One approach to paraconsistent logic is to extend the traditional true and false logic values with values that represent inconsistency (both true and false) and unknown (neither true nor false) (Belnap, 1977). As an illustration of what these values may mean, here is example that is mentioned in the paraconsistent literature (e.g. Villadsen, 2002). The example describes a small knowledge base in medicine where three experts cooperate in diagnosing diseases.

Expert I (a clinician):

> Symptom-1 and symptom-2 together imply disease-1.
>
> Symptom-1 and symptom-3 together imply disease-2.
>
> Disease-1 and disease-2 exclude each other.

Expert II (also a clinician):

> Symptom-1 and symptom-4 together imply disease-1.
>
> Symptom-3 implies disease-2 if symptom-1 is not present.

Expert III (a pathologist):

> Only John has symptom-1 and symptom-4.
>
> Neither John nor Bill has symptom-2.
>
> Both John and Bill have symptom-3.

The implementation of paraconsistent logic in the Paralog system uses these multi-values of true, false, inconsistent, and unknown. Paralog can thereby answer questions about the diseases of John and Bill (Abe & Nakamatsu, 2009). The answers by Paralog shows that the available information is inconsistent whether John has either of the diseases, true that Bill has disease-2, and unknown whether Bill has disease-1.

Paraconsistent logic is since a few decades in a rapid development conceptually within philosophy, formally within mathematics, and computationally within computers science. These developments enable an increasing number of applications that use paraconsistent logic, as is evident by the success of Intègre (e.g. Logica, 2010). Unfortunately, the constant developments of paraconsistent logic also mean that the area is fragmented. There is therefore no mature overall framework that can be used for identify the characteristics of a planning support system for the interaction with influential actors. Instead, the rest of this section reviews some examples of paraconsistent logic that have features of interest for the planning support system. Finally, there is a summary of the potentially relevant characteristics of the planning support system.

4.1 Paraconsistent reasoning

Some examples of how paraconsistent reasoning (as in the medical example above) can be used for analysing practical problems are the many applications that have been investigated using Intègre. The Intègre system is specifically developed by Normind to represent and reason with paraconsistent problems. Some of the applications that have been investigated using Intègre during the eight years of development are:

- *Health care systems*. Representing medical knowledge in Intègre makes it available for diagnosis of patients. Doctors may otherwise have difficulty keeping up with the latest development, since the available medical knowledge increases by four times during a doctor's career. Using Intègre, the doctor can also adapt the diagnosis and find the parts of the knowledge that is applicable to the needs of the patient.
- *Law systems*. Similar to health care systems, Intègre can find which parts of the behaviour that is not consistent with the legal requirements. Intègre can also incorporate the lawyer's advice and provide recommendations about how to correct any mistakes.
- *Geopolitical analysis*. Intègre provides recommendations and identifies contradictions regarding potential nuclear weapons when one party does not follow international treaties.
- *Tactics for hostage rescue operations*. Intègre provides recommendations for how to approach a specific situation based on a representation of the official doctrine.
- *Strategic wargaming*. Intègre identifies behaviour that is inconsistent with the official doctrine and provides recommendations about what to do.

4.2 Paraconsistent belief integration

Another application of paraconsistent logic is how to integrate peoples' different beliefs about some statement into a joint belief, as well as characterize the amount of coherency among the people for this joint belief. For example, Albuquerque et al. (2009) describe a study of belief integration regarding risk evaluation in vehicle manufacturing. 23

specialists rated 107 failure modes regarding the criticality degree and criticality inexistence degree. These ratings where then integrated using annotated paraconsistent logic. Three levels of criteria for coherent, inconsistent, and incomplete evaluations were created using the two parameters minimum and maximum exigency level. The least conservative criteria calculated coherency among the specialist for all the failure modes, while the most conservative criteria only calculated coherency for 71% of the failure modes. A comparison with the manufacturers current method shows that the only the least conservative criteria was fully coherent with the manufacturers ratings. Overall, annotated paraconsistent logic is a value tool to more reliably identity both the criticality of failure modes and amount of consensus in the risk assessment.

4.3 Paraconsistent negotiation

The next step after integrating the beliefs and identifying potential conflicts is to negotiate and adjust the beliefs in order to reach a consensus. For example, Bagheri and Ghorbani (2009) describe one such system for development and integration of paraconsistent conceptual models in the development of computer systems. The system uses subjective logic that implements logical primitives using Dempster-Shafer theory of evidence (Josang, 2001). A Dempster-Shafer belief representation consists of three values: the belief that some evidence is true, the belief that the evidence is false, and the uncertainty whether the evidence is true or false. Figure X shows the mapping from the experts' *agreement* regarding some aspect of the conceptual model and their *certainty* regarding that agreement to the Dempster-Shafer belief, disbelief, and uncertainty.

The benefit of the Dempster-Shafer belief representation is that Yager's rule of combination can be used to calculate the degree of conflict between the beliefs as a representation of the inconsistency between the beliefs. The system then combines the inconsistency with the experts' certainty in the agreement to recommend changes of viewpoints that will accelerate the process for consensus formation. The idea is that viewpoints with a low certainty are more likely to change towards a consensus. The system may also use the certainty from a third-party since there is always a risk of subjective bias regarding the certainty. The effectiveness of the consensus formation is measured with *ambiguity* for the degree of confusion of the overall viewpoints,

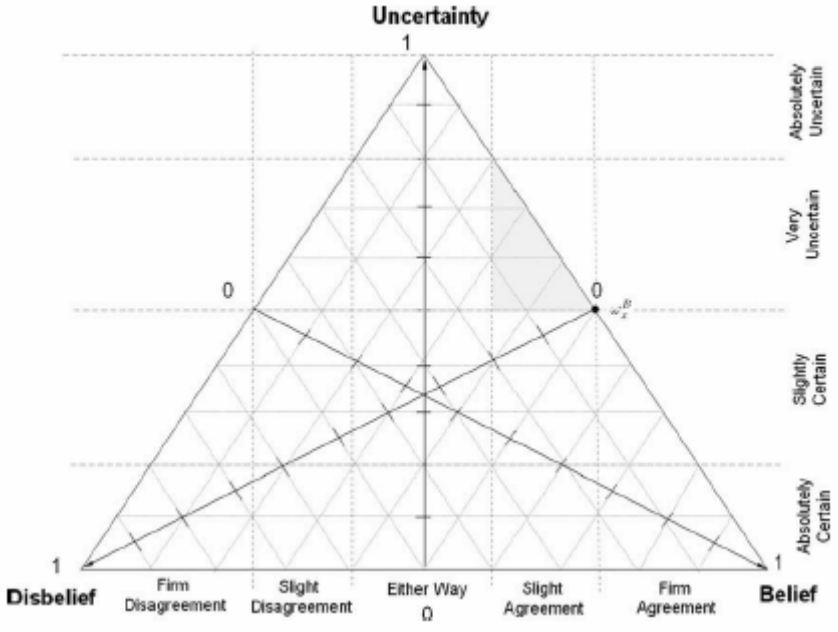

Figure 3. Mapping from opinion space to Dempster-Shafer beliefs.

indecisiveness for the firmness of the assertion in the viewpoints, and finally *conflicts* for the degree of inconsistency in the viewpoints. These measures are then used to suggest suitable viewpoints where an adjustment of the certainty belief is most likely and where an adjustment that will significantly contribute to the consensus formation. If it is not possible to form a consensus, the degree of *potency* can be calculated for the viewpoints to identify the suitable choice. An evaluation of the system shows how the system supports the negotiation and model integration process between three conceptual modellers. All three consensus effectiveness measures, ambiguity, indecisiveness, and conflict decrease over time.

4.4 Paraconsistent belief revision

Paraconsistent belief integration and negotiation usually do not consider why people have a certain belief. Paraconsistent belief revision, on the other hand, models how people may revise their beliefs when they receive new information that is often inconsistent with their current information. For example, Arieli (2007) uses distance semantics to minimize the belief revision to what is really implied by the new information. Distance semantics uses distances functions, such as Hamming and drastic distance, to calculate the difference between atomic beliefs, and aggregation functions, such as summation, average, and maximum, to calculate a joint distance from several distances. The most plausible theory of two alternatives is then the theory with the least joint distance. Cautious consequence relations, in turn, are only valid if the statement is a subset of the most plausible theory. The distance semantics is adaptive in the sense that it only reflects the inconsistencies that follow from the available information, at least when the aggregation function is summation. Further, distance semantics can be extended from real numbers to multiple-value semantics. Finally, distance semantics is also useful for belief integration and social choice theory, such as group decision making (Lafage & Lang, 2000), preference representation (Lafage & Lang, 2001), and judgment aggregation (Eckert & Pigozzi, 2005; Pigozzi, 2005).

4.5 Paraconsistent agent systems

The final application for paraconsistent systems that is considered here is when people provide offers during negotiations. These offers are often inconsistent with the agent's currents beliefs which may need to be revised based on the offer. Similarly to paraconsistent negotiation, the offers should over time improve the consensus. For example, Hasegawa et al. (2005) uses Evidential Paraconsistent Logic to evaluate offers in a negotiation between organisations for trading of commodities and services. The system ARTificial ORganisations (ARTOR) is a multi-agent system that simulates the negation between selling and purchasing agents. ARTOR represents the range and utility of acceptable offers for the commodity or service that the organisation is willing to sell or buy. An expression of the offer and rules for evaluation in annotated paraconsistent logic is then used to compute the favourable and contrary evidence for the offer. The result determines whether to accept or reject the offer, or adjust some parameters in a counter-offer. Negotiations with paraconsistent logic require fewer interactions among the agents and results in higher utility than with comparable negotiation methods. Please see Abe and Nakamatsu (2009) for a more formal treatment of paraconsistent multi-agent systems.

Finally, there are many parallels between paraconsistent agent system and multi-dimensional dynamic logic programming (MDLP). Leite et al. (2001) describes how this logic programming framework can represent the evolution of knowledge over time, belief revision, reasoning for actions, agent interaction, combine rules from a diversity of agents, and resolve conflicts in metaphorical reasoning. The knowledge updating can represent the evolution of knowledge over time, as well as the strength, hierarchical position, credibility, and opinion precedence of the agent that provides the update. A directed acyclic graph describes the relations between subsets of logic programs. Such graphs can describe both temporal and hierarchical relations, as well as an agent's internal knowledge.

5 Conclusions

This preliminary investigation provides a summary of what is currently known among the project members regarding interaction with influential actors, socio-cultural dynamics of Xland, and potentially relevant aspects of paraconsistent logic. The general conclusion is that paraconsistent logic provides a wide range of options for representing and reasoning with inconsistent beliefs. For example, paraconsistent logic can identify and quantify inconsistencies, provide means for integrating beliefs, suggest revision of beliefs during negotiations and as available information changes over time, and propose offers for negotiations between social agents. Paraconsistent logic therefore provides many options for finding representations of inconsistencies that are useful for a planning support system regarding the interaction with influential actors. However, it is important to distinguish between representations of the actors' atomic beliefs and the logic reasoning for deriving these beliefs. Typically, an actor's atomic beliefs may be easier to obtain than their reasoning behind these beliefs.

The preliminary investigation shows that there are many potentially relevant characteristics that a planning support system may have, such as:

- Interactivity that allows the user to adapt the support depending on the needs for interaction with influential actors.
- An integrated measure of the inconsistencies and how it is reduced with the options for interaction with the influential actors.
- Recommendations for how to cope with the inconsistencies among the influential actors.
- An integrated representation of the task and mandate for the international forces.

This preliminary investigation will serve as a basis for future discussion regarding which aspects are most pertinent and practical for illustrating how paraconsistent logic can be used as a planning support system for the interaction with influential actors. Currently, however, it is doubtful whether a full implementation of all the potentially relevant characteristics is within the scope of the project. Some topics for future discussions are:

- To what extent can paraconsistent atomic beliefs and logical inferences characterize the interaction among the influential actors in Xland?
- What are suitable representations of beliefs and paraconsistent values?
- What conceptual format is suitable for representing the paraconsistent logic of the influential actors in Xland? It may be too difficult to directly write the representations for Intègre from the scenario specification.
- What information may typically be available about the influential actors in actual international operations?
- What planning function will use the planning support system?
- Should the demonstration focus on a wide range of influential actors, only model a few actors in-depth, or something in between?

6 References

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