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Socio-technical interoperability in multi-agency operations

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#### Socio-technical interoperability in multi-agency operations

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#### Abstract

Interoperability is seen as directly influencing the combat effectiveness of multinational forces, acting as a 'force multiplier' that brings strategic, operational and tactical advantages (NATO, 1997; Balducci, 2005). However, the frameworks for interoperability proposed to date have mostly failed to take account of the *interactions* between 'social' and 'technical' issues, generally preferring to address these separately. They have also taken a 'more is better' approach to interoperability, rather than acknowledging that the required level of interoperability is defined by the contextual properties of the task at hand and may be achieved relatively quickly through the exploration of workarounds. In order to focus on delivering pragmatic improvements in interoperability, this paper makes two propositions:

- 1. The problem of interoperability requires an approach informed by socio-technical systems theory;
- 2. An effects-based approach to organisational interoperability would result in more appropriate and efficient solutions.

This paper considers a wide range of factors that impact on the level of interoperability between organisations and presents a new framework for the interoperability 'problem space'. A novel effects-based method for the evaluation of interoperability levels and requirements is presented and two examples of multi-agency operations are used to illustrate its use.

#### 1 Introduction

Military forces now engage in a variety of activities that can be classed as 'operations other than war' and which will bring them into contact with non-military and non-governmental groups, this raises the question of what level of interoperability with these groups is required, in order to cooperate effectively. UK armed forces have learned lessons on interoperability from recent NATO missions, as well as other campaigns; the MoD Joint Discussion Note 'The Comprehensive Approach' (MoD, 2006) describes how operations in Bosnia, Kosovo, Sierra Leone, Iraq and Afghanistan have demonstrated that multinational cooperation (and therefore interoperability) is required at all levels of command. The report also emphasises that military force alone is not sufficient to resolve complex crisis situations and that Other Government Departments (OGDs), Non-Governmental Organisations (NGOs), local populations and other International Organisations (IOs) play a crucial role and that a coordinated approach across them all is therefore required (MoD, 2006). The comprehensive approach focuses on cooperation between government departments and whilst it recognises the importance of NGOs, IOs and other external groups, it does not specify quite what level of cooperation would be desirable or how this is to be achieved. It has been argued that interoperability - "*The ability to operate in synergy in the execution of assigned tasks*" (*NATO 2009*)- can bring significant improvements to the performance of operations carried out by alliances such as NATO, acting as a 'force multiplier' that brings strategic, operational and tactical advantages, along with flexibility and logistical gains (Codner, 2003; Balducci, 2005). It can be inferred from this that interoperability is expected to bring about improvements in the multi-agency coordination of command and control activities (i.e. the collection and analysis of information and intelligence, faster planning, improved decision making), as well as making efficiency and tempo gains in terms of the movement, deployment and resupply of forces.

Codner (2003) warns that the majority of national and NATO interoperability work is classified; however, this report is dealing with the broad issues associated with interoperability, rather than specific details, thus avoiding the need to address matters of a restricted nature.

This paper makes two propositions regarding the resolution of interoperability issues, in order to focus on delivering pragmatic and relevant improvements in interoperability:

1. The problem of interoperability requires an approach informed by socio-technical systems theory

Socio-technical systems theory holds that the performance of a system arises from the complex interactions of the social and technical elements from which it is made; systems design should therefore aspire to optimise the two in parallel (Walker et al., 2007). In the past, there has predominantly been a technical focus to discussions of interoperability. More recently, reports looking into 'non-technical issues' have appeared; though from the sociotechnical systems perspective, this division of the concept into 'technical' and 'non-technical' (social) is both artificial (the distinction between the two is not so clear cut) and counterproductive, as a focus on either one alone can result in unpredictable side-effects due to their interdependent nature

Walker et al. (2007) highlight the close fit between socio-technical systems theory and Network Enabled Capability (NEC), such as the focus on flexibility, autonomy and flattened hierarchies. Given that network enabled and network centric approaches have achieved dominance, the adoption of a compatible perspective to the resolution of interoperability issues would seem sensible.

2. An effects-based approach to organisational interoperability would result in more appropriate and efficient solutions.

As will be discussed in this report, thus far models of interoperability have predominantly been architectural, with a 'more is better' approach to interoperability, rather than focussing on the mission at hand in order to determine the most appropriate level of interoperability. Additionally, given the range of scenarios within which multi-agency operations might be required, organisations may find themselves thrown together at very short notice and therefore need to focus on the most effective ways to achieve the required level of interoperability within such a restricting situation.

These propositions will be revisited at the end of this paper.

## 2 Frameworks for interoperability

A number of frameworks for the evaluation of interoperability have been developed, such as the US DoD Levels of Information Systems Interoperability (LISI), the Organisational Interoperability Maturity model (Clark and Jones, 1999), the framework for non-technical interoperability (Stewart et al., 2004) the Layers of Coalition Interoperability (Tolk, 2003) and the Interoperability Continuum (Department for Homeland Security). Ford et al. (2007)\_ provide comprehensive descriptions of these approaches in their 2007 ICCRTS paper on interoperability and so we would direct interested readers to their paper, rather than spend time describing the models here. Despite the range of perspectives on interoperability, the single overarching theme is that the problem relates to both social and technical components of organisations and, as is reflected in some of the models, there is no clear boundary between the two domains, which have overlaps and interactions with one another. This supports the argument that interoperability should therefore be considered as a sociotechnical issue. Whilst these models go a long way towards resolving the description and evaluation of interoperability, a number of issues have been identified which have yet to be addressed:

- Several of the models of interoperability require the use of complex and time consuming analytical methods; this may restrict their use by non-specialist personnel and reduce the likelihood that they will be carried out in a timely fashion, especially in situations where organisations are brought together at short notice.
- Given the long lead times for the resolution of many technical aspects of interoperability (such as procurement lifecycles), it would appear that the more technically focussed models such as LISI are aimed more at the long-term achievement of higher levels of interoperability, rather than to identify and help to address immediate short-term problems.
- It appears that all of the interoperability models mentioned above take the attitude of "the more interoperability the better", as they all seem to measure the current level of interoperability against an idealised 'perfect' state. This has the consequence that all multi-agency operations will be found wanting and will be pushed towards achieving greater levels of interoperability. Codner (2003) observes that interoperability is not an end in itself, but is instead meant to enhance operational effectiveness and improve efficiency. Dorion and Boury-Brisset (2004) argue that lower levels of interoperability may well address the operational requirements and it is these that should be the driving force behind the definition of the appropriate level of interoperability.

# 3 Interoperability dimensions

A number of dimensions that impact on interoperability have been identified from a review of the relevant literature. These dimensions are summarised in Table 1. The columns in the table represent broad categories of interoperability. Each column entry represents a dimension along which the level of compatibility of two or more organisations may range; for example, cooperating organizations might share a common native language, in which case they would be highly interoperable on the 'language' dimension; alternatively, they may have no common languages, relying instead on the use of interpreters, which would equate to a lower level of interoperability.

The different categories were identified through the literature review, yet they appear to closely relate to the UK MoD Defence Lines of Development (DLOD), which represent the various aspects considered during development of military capability (MoD, 2007).

Where the table diverges from the DLOD is in having 'Training', 'Doctrine' and 'Facilities' (i.e. Infrastructure) as dimensions within broader categories; additionally, two further distinct categories of interoperability, namely Operational and Cultural issues were identified, which reflect the fact that interoperability is frequently multinational/multicultural and is also heavily affected by the nature of the operation and the coordination of the partner agencies. Logistics did not feature prominently in any of these models, nevertheless we have included it as a category after Codner's comprehensive review of military interoperability (Codner, 2003).

The columns in Table 1 could be divided into technical problems (such as compatible technologies and logistics processes) and social issues (such as cultural differences and interorganisational cooperation). However, very few of the categories or dimensions listed in the table could be considered to be purely social or purely technical concerns; for example the joint provision of medical care and food will involve both technical components and social considerations.

Table 1 presents the wide range of dimensions which may either act as barriers to or enablers of interoperability and indicates the complexity of the problem, with extensive interdependence across the dimensions within different categories. No single category or dimension is sufficient to ensure interoperability, therefore reliance on one approach (e.g. optimisation of equipment interoperability) at the cost of others is unlikely to result in a satisfactory level of interoperability. Interoperability must be established across the categories in order to enable effective inter-organizational cooperation (Codner, 2003). It is also not possible to consider a single dimension of interoperability in isolation from the others, due to their interdependence with one another (Codner, 2003). Therefore, it is necessary to deal with interoperability holistically – taking social and technical issues into account at the same time, i.e. taking a socio-technical systems approach to the problem.

There may also be different levels of difficulty associated with the alignment of certain dimensions, depending on the circumstances; for example, it may be very difficult to get organisations to agree on the priorities during a mission if they are working under different national interests or with conflicting organizational values.

Interactions between dimensions and categories may mean that there are workarounds to gaps in interoperability, for example, if two organisations have incompatible communications systems and there is not sufficient time to procure interoperable equipment, then one organisation could lend equipment to the other and provide basic training in its use, in order to bridge the gap. However, particular dimensions may be seen as mission critical; this may depend on the task (e.g.: organisational cultural values are less important if only dealing with one nationality) or may be uniformly important (e.g.: goals and priorities).

Whilst the appropriate level of interoperability and the best course of action to achieve it are specific to each situation, it is still possible to provide some broad suggestions for actions which may be taken to address specific problems in the short term and to enable more long term solutions to be found. Hazel and Bopping (2006) suggest that personnel-based (i.e. social) solutions may be easier to rapidly implement than technical ones.

Equipment	Logistics	Information	Operational	Organisation	Culture
<ul> <li>Converging communications networks</li> <li>Hardware platforms</li> <li>Protocols</li> <li>Means of communication support</li> <li>Compatibility of mission planning</li> <li>Security of communications</li> <li>Combat identification</li> <li>Procurement lifecycle</li> </ul>	<ul> <li>Food</li> <li>Medical care</li> <li>Munitions</li> <li>Maintenance and repair</li> <li>Transport</li> <li>Facilities</li> </ul>	<ul> <li>Level of communications, information, intelligence and knowledge sharing</li> <li>Use of information</li> <li>Information security and sharing / access</li> <li>Language</li> <li>Standardized terminology</li> <li>Style of communication: context and non- verbal cues</li> <li>Interpretation of information / of discussions</li> <li>Common intent / shared awareness</li> <li>Common Operating Picture</li> <li>Expectations</li> </ul>	<ul> <li>Goals and priorities</li> <li>Allocation, delegation and sharing of roles and responsibilities</li> <li>Planning and decision-making processes (adaptation, negotiation, consensus etc.)</li> <li>Commander's style: leadership, flexibility, interpersonal relations</li> <li>Command intent (implicit / explicit)</li> <li>Type of mission</li> <li>Size and complexity of force make-up</li> <li>Tempo</li> <li>Synchronisation</li> <li>Roles and responsibilities</li> <li>Mission 'buy in'</li> </ul>	<ul> <li>Organisational culture, structures and pace of change</li> <li>Level of operation (geographic area, task or role specialisation)</li> <li>Budgetary constraints / Funding conditions</li> <li>Training / skill sets</li> <li>Doctrine</li> <li>Time to make decisions / tempo drag</li> <li>Relative position in network</li> <li>Liaison staff</li> <li>Legal considerations</li> <li>Autonomy</li> <li>Status (between organisations)</li> <li>Aggression / risk taking</li> <li>Trust</li> </ul>	<ul> <li>Beliefs &amp; norms governing behaviour</li> <li>Values</li> <li>National interests</li> <li>Media interest</li> <li>Equity of risk and reward</li> </ul>

# Table 1: Interoperability dimensions

## 4 Illustrations of interoperability

In order to illustrate how the various categories of interoperability impact upon the level of cooperation during real situations, two multi-agency operation examples are given on the following pages, with descriptions of how the agencies interoperate.

## Military example: the Grenadier Guards and the Afghan National Army

In 2007, the Grenadier Guards were involved in mentoring Afghan National Army (ANA) infantry during operations in the Sangin Valley of Helmand Province. This was when ANA troops first began to be 'embedded' with British forces and a documentary was made about one of their operations<sup>1</sup>. Reviewing the documentary footage enabled a very basic assessment of the level of interoperability achieved 'on the ground' between the ANA and the Grenadier Guards.

<u>Equipment:</u> There appears to be almost no technical interoperability between the two forces, in terms of equipment, weapons or communications systems.

<u>Logistics</u>: The two groups will have some shared facilities during the operation (e.g. transport and emergency medical care), though their incompatible weapons systems would restrict the sharing of ammunition or roles.

<u>Information</u>: Due to the lack of a common language, resulted in a total reliance on the interpreter to communicate commands from the Grenadier Guards to the ANA. Additionally, the lack of ANA contact with other forces involved in the operation, due to lack of compatible communications, would have contributed to their restricted awareness of the situation.

<u>Operational:</u> The ANA platoon was operating under the close supervision of their Grenadier Guards mentors; the platoon had a restricted 'support' role within the coalition operation in order that they could receive training without compromising the operation.

<u>Organisation</u>: Different experience and training meant that the Grenadier Guards had to direct ANA actions in detail. This was most likely exacerbated by the communication difficulties preventing the ANA soldiers from appreciating the situation fully. The ANA soldiers took a more aggressive approach towards the Taliban, engaging them as soon as they were seen, which is contrary to the more measured and careful approach of the Grenadier Guards.

<u>Cultural</u>: Different cultural norms and values exist between the forces, though these differences were not obvious from the documentary footage, suggesting that they may not be a significant impairment to this type of operation.

#### Comment

Whilst this multi-agency activity will have been planned, the timescales available appear to have precluded any significant improvement in interoperability between the forces (e.g.: equipment, doctrine, language). In fact, these mentoring activities themselves were most likely intended as a way to quickly bring the ANA more in line with NATO ISAF forces and to iron out any difficulties with their taking part in operations, in order that they could become more involved and in greater numbers, such as in the recent Operation Panchai

<sup>&</sup>lt;sup>1</sup> The example is taken from a video journal of an operation against the Taliban, filmed by a former soldier turned war correspondent. The footage was originally shown on Newsnight on BBC2 in September 2007. The full 16 minute documentary can be downloaded from: http://video.google.com/videoplay?docid=8548112614184247543.

Palang (Panther's Claw) offensive in Helmand Province<sup>2</sup>. So, whilst it might initially appear that the level of cooperation achieved within this scenario is so low as to not be worth the effort, the purpose of the multi-agency operation (i.e. to mentor ANA forces during a live operation in order to increase their role in multinational missions) would appear to have been achieved<sup>3</sup>, demonstrating that the focus of interoperability activity should be on identifying and achieving the level of interoperability required for the mission.

## Civil example: UK emergency services

During major incidents, the emergency services may be required to work closely with a wide range of other agencies, including local authorities, utilities companies and the military. This raises issues which are essentially the same as those faced when military forces wish to cooperate with non-governmental organisations. The following assessment of UK emergency services interoperability is based on previous studies the authors have conducted into major incident responses (c.f. McMaster et al., 2007; McMaster and Baber, 2008).

<u>Equipment:</u> The three agencies (Police, Ambulance, Fire and Rescue) have compatible secure digital radio communications systems, so they are able to communicate directly. However, different forces are free to purchase different equipment and levels of service, meaning that not all functionality is enabled for all personnel (ACPO, 2009). In addition, the Fire and Rescue Service have retained the use of their analogue fire ground radio which means that communication between all responding emergency services personnel is still not possible.

<u>Logistics</u>: There is no common vehicle platform or deployment of multi-agency crews and due to the large amount of specialist equipment required by each service, there is virtually no sharing of transportation.

<u>Information</u>: The different emergency services exchange information relatively infrequently. Due to the lack of data exchange, communication at the control room level is done verbally by telephone and is often delay and error prone, with relevant pieces of information not always being passed across in a timely manner (McMaster et al., 2007).

The situation awareness of personnel from different services and agencies attending the same incident may be very different, due to different training, doctrine, tactical goals, priorities and role specialisation, such that the fundamental nature of the situation may be viewed differently (McMaster and Baber, 2008). Additionally, the separate command and control networks (both organisationally and technically) sometimes lead to different information being passed along (McMaster et al, 2007).

<u>Operational:</u> At lower levels of the organisation, common overarching goals can translate into different priorities and tactics, which can sometimes lead to tensions between the responding agencies (McMaster and Baber, 2008).

<u>Organisation:</u> The emergency services operate different organisational structures and manage different geographic areas (e.g. counties vs. regions), which may lead to different priorities. They also have very different doctrine, training, procedures, powers and legal frameworks (though still within the wider laws of the land).

<sup>&</sup>lt;sup>2</sup> MoD online article: *Joint US, Afghan and British operation disrupts Taliban*, 6<sup>th</sup> July 2009 <u>http://www.mod.uk/DefenceInternet/DefenceNews/MilitaryOperations/InPicturesJointUsAfghanAndB</u> <u>ritishOperationDisruptsTaliban.htm</u>

<sup>&</sup>lt;sup>3</sup> Though, from the information available it was not possible to assess the outcome of this operation in terms of training.

<u>Cultural:</u> Personnel from the three services are likely to share the same broad national values and interests.

## Comment

Evaluation of emergency services coordination in response to major incidents is more difficult; there are no formal metrics to assess performance during what are often unique circumstances (McMaster and Baber, 2008) and commentary after the event can very quickly take on a political nature. It is apparent - at least in terms of the initial response - that improvements could be made (McMaster et al., 2007); however it is difficult to avoid judging the services against an idealised fully cooperative (and therefore fully interoperable) state, which could not be achieved without massive reorganisation and investment.

## Discussion of examples

Whilst the primary purpose of these two examples is to illustrate our argument, it is nevertheless interesting to compare the two, in terms of the nature of the tasks. Within the military example, the two organisations are cooperating as part of a well planned operation, where their forces have superior equipment and firepower and uncertainties have been reduced as much as is possible in a conflict environment. The goal therefore is to use limited ANA involvement to gradually increase their ability to take part in ISAF operations, whilst at the same time minimising the risk of a friendly fire incident. The prevention of friendly fire between cooperating organisations during high intensity battles either requires integrated planning, with close cooperation across the organisations before and during the operations, or for one organisation to work under the direction of the other, as was seen in this example.

Within the emergency services, major incidents happen relatively infrequently, but then require the expertise and equipment of all of the emergency services to rapidly resolve them. Whilst major incidents often require large numbers of resources and the deployment of highly specialised equipment and personnel, because the emergency services are responding to unexpected and often unprecedented events, initially there is a high level of uncertainty surrounding the nature of the incident and the appropriate response. The first priority is therefore to gather and share information, in order that an appropriate (and quite possibly novel) response may be generated. The separate nature of the C2 networks of the emergency services and equipment incompatibilities can act as a barrier to the pooling of information and collaborative problem solving which is necessary in these situations (McMaster et al., 2007).

These brief summaries help to illustrate the point that it is necessary to understand the nature of the activity at hand in order to optimise cooperation through the most efficient means, rather than pursuing a 'one size fits all' approach to interoperability.

## 5 Effects-based systems approach to interoperability

In order to address the issue of interoperability in a comprehensive (socio-technical) systems manner, this method takes as its starting point the six categories of interoperability listed in Table 1. For a given situation, each of these categories is to be assessed for the level of interoperability currently evident between the organisations involved in the mission; this is done by referring to the dimensions within that category that are most relevant to the operation. Whilst this process requires a reasonably informed position regarding the nature of the organisations involved, the assessment can be done rapidly and potentially as a multiagency group activity, in order to ensure an accurate understanding of each of the organisations. By repeating this process for each category, the multi-agency operation in question is given six interoperability scores. The scores are described as follows:

- 3 High: Dimensions in this category are predominantly interoperable;
- 2 Medium: Several dimensions are interoperable;
- 1 Low: Limited interoperability across dimensions within this category;
- 0 Non-interoperable: Very little or no interoperability for this category<sup>4</sup>.

The six axes are arranged in such a manner as to have closely related categories next to each other and with the 'technical' end of the socio-technical scale at the top and the more 'social' categories at the bottom. This is to make the overall review of the system and the identification of a more social or technical skew easier. The radar chart does not mark the end of the analysis, as the most important consideration is the response to the two questions identified earlier in this report, namely:

- 1. What is the lowest required level of cooperation (and therefore interoperability) in order to achieve the mission aims?
- 2. What is most effective way to achieve the required level of interoperability?

The two illustrations of interoperability described above will now be used as examples of this approach; Performing a quick review and scoring each of the six categories on the level of interoperability results in a radar chart showing the two example scenarios, which provides an overall assessment of the level of interoperability.

From Figure 1 it can be seen that in both scenarios, there is a low level of interoperability across the more technical categories. Whilst it could be argued that, in the long term, there is room for improvement in both cases, in the short term the priority for improving interoperability will be determined through the two questions above.

Interoperability between the ANA and Grenadier Guards is minimal and primarily operationally based, as the ANA were acting under the close direction of the Grenadier Guards. Whilst the support role of the platoon in this operation meant that the low level of interoperability was tolerated, UK and Afghan forces would need to become more closely integrated (in terms of their information sharing, training and skill sets) in order to allow the ANA to take lead roles during joint operations; this could be achieved through training and joint operations – which was precisely the purpose of the operation in question.

Figure 1 shows that the emergency services have a more socially-skewed integration; whilst the issues of budgetary constraints, role specialisation and work practices mean that there are limited opportunities to improve the current set up, some minor changes to communications equipment (such as compatible command and control software and agreements on the use of radio equipment) would make significant improvements to their ability to share information in a timely and accurate manner. It could therefore be suggested that the optimal level<sup>5</sup> of interoperability for these two examples is similar to that shown in Figure 2, below.

<sup>&</sup>lt;sup>4</sup> This does not mean that organisations cannot cooperate, as there are nearly always workarounds.

<sup>&</sup>lt;sup>5</sup> I.e., the lowest practicable level of interoperability that will enable the achievement of the mission goals.



Figure 1: Radar chart for the interoperability illustrations



Figure 2: Suggested optimal level of interoperability for the illustrations from Section 8

#### Assessment

Whilst the method may seem somewhat rough and ready, it is intended to be used rapidly in situations where organisations need to cooperate at short notice; in the process of asking the questions and identifying the relevant issues which is important, rather than giving an exact score to each category. Having said that, there is no reason why this method would not be suitable for the assessment of interoperability issues for more long term multi-agency operations. Assessors do not need specialist training to use the method, the key considerations are that they have a high level of knowledge regarding the organisations and task at hand and that they are open and frank about these organisations, how they are perceived by one another and their relations with each other; without this, problems to do with conflicting priorities, self-interest or lack of trust are unlikely to be vocalised.

The use of this method does not automatically solve the problem of interoperability, as it is merely the first step; in risk management, the first stage is to identify the issues which have the potential to cause problems, before devising and employing interventions to manage and reduce these risks. In the same way, the effects-based systems approach to interoperability can be thought of as interoperability issue identification, though the method also helps with the identification of a course of action, as the table of interoperability dimensions represents the range of possible options and the radar chart indicates areas for potentially low cost improvements (e.g. it may be easier to improve coordination by finding workarounds within a category where there is already a high level of interoperability).

Whitfield (2006) points out that it is important to consider the level of analysis, as this will have a bearing on interoperability issues. The effects-based systems approach could be used to assess interoperability at any level, from small units up to entire services or forces; however, there are specific considerations depending on the level of analysis:

- At lower levels of analysis, it is important to bear in mind that factors outside the immediate situation which may not form part of the assessment can still have an impact on interoperability (such as national interests and procurement issues);
- At higher levels of abstraction, scores are less likely to have any particular significance, for example: is it really meaningful to say that UK and US militaries have 'medium' information interoperability? It is the performance of the assessment that is important: the consideration of the different categories, the identification of dimensions that might be important and planning for issues that will need to be resolved prior to the operation, rather than achieving a specific score.

#### Further work

It may be possible to further develop this interoperability assessment tool, by producing a set of questions to be used when carrying out the assessment; these questions could guide the assessor through the process and help with the identification of dimensions which pose particular difficulties for a given situation, as well as pointing to areas where quick improvements or workarounds may be found. It is hoped that interviews with personnel working in civil-military liaison roles carried out as part of this ongoing research project will assist with this. As a first step, a draft handout is shown in Figure 3 (in the Appendix); this could be used by personnel to assist them in rapidly carrying out an initial interoperability assessment.

## 6 Discussion

This paper raises questions about the focus on standardization adopted by NATO and other groups in order to improve interoperability. Given that interoperability is a complex socio-technical issue, is it possible to develop standards across interoperability categories and dimensions in parallel, especially as in reality, interoperability dimensions are more of a cloud of interrelated issues, rather than a neatly defined and categorised table. Some issues, such as those found within the 'Culture' category obviously cannot be standardized at all and it is often those factors that lie outside of clear definition and assessment which turn out to be the most problematic.

Clearly, NATOs efforts to increase heterogeneity across the military forces of member states and partners are beneficial and should continue, as in the long term, this leads to more effective cooperation and thus improved multi-agency performance. However, it must be recognised that the wide variety of organisations involved in modern military and civilmilitary operations means that in any given situation there will always be mismatches between partner organisations which will need to be resolved or mitigated in order for them to cooperate effectively; therefore a focus on the practical level of interoperability required in order to complete the task at hand is necessary.

Even for planned multi-agency operations, once the various partners are assembled, the unique constraints of the situation will likely require some form adaptation in order for the parties to be able to cooperate effectively to complete the mission successfully. Therefore, there is a requirement for techniques for rapidly establishing the interoperability requirements of novel situations and identifying the most effective means for achieving these requirements.

This report does not offer long lists of solutions for interoperability problems, as our discussion of multi-agency interoperability has not focussed on finding 'solutions' to the 'problem' of interoperability; instead, we have argued that interoperability is a means to an end – cooperation, and we have proposed viewing the different variables associated with group and multi-agency operations as both barriers to and enablers of interoperability and therefore cooperation. The interdependent nature of these variables means that whilst there may be a number of barriers to cooperation, there will also be a number of potential ways to enable it.

We have proposed an effects-based approach to the analysis of interoperability, whereby the process of establishing the current and required levels of interoperability should help to suggest the most appropriate and efficient ways of achieving interoperability between organisations.

# 7 Conclusions

Earlier in this paper, two propositions were made regarding the nature of interoperability; they were:

1. The problem of interoperability requires an approach informed by socio-technical systems theory;

The literature review generated a set of dimensions, each of which may either enhance or detract from inter-organisational interoperability. Categorisation of these dimensions produces a continuum of categories from more technical issues (such as equipment interoperability) to more social issues (such as cultural differences); they also broadly reflect components of the UK MoD Defence Lines of Development. No single category or dimension alone is sufficient to ensure interoperability, therefore reliance on one approach

(such as optimisation of equipment interoperability) is unlikely to result in interoperable organisations. The categories and dimensions are also interdependent and so should not be considered in isolation. It is therefore necessary to deal with interoperability holistically by taking a socio-technical systems approach to the problem.

Notions of network centric warfare pre-suppose high levels of technical interoperability and information exchange; whilst these things are required to achieve networking of forces, NEC cannot be delivered through technology alone.

2. An effects-based approach to organisational interoperability would result in more appropriate and efficient solutions.

Earlier models of interoperability tended to focus on either social aspects of the issue or more often just on purely technical issues; whilst more models have been developed which acknowledge that both social and technical issues are of concern, they still treat these interrelated issues in isolation, rather than considering interoperability across all categories at once. These models also seem to treat interoperability as an end in itself, whereas it is merely a means to achieve better cooperation between partner organisations, so the main concerns should be over the levels of interoperability required to perform the task at hand and the most efficient way to deliver that level of interoperability. We have presented an effects-based approach to interoperability which has as its central concern the achievement of the task in hand through the identification of the minimum level of interoperability. This approach may be used rapidly by non-specialists and allows them the freedom to choose the most appropriate course of action, rather than unnecessarily chasing an unnecessary and unattainably high level of interoperability.

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## Appendix

Assessing multi-agency interoperability requirements				
Interoperability relates to the ability of different organisations to work closely together. It can be assessed by comparing two organisations in terms of their compatibility across 6 categories:				
Equipment:	military platforms, weapons and communications equipment.			
Logistics:	provision of supplies, medical care, transportation and maintenance of equipment.			
Information:	collection, analysis, sharing and use of information and intelligence; language.			
<b>Operations:</b>	goals; roles and responsibilities; planning and decision-making processes.			
Organisation:	structures, strategy and doctrine; ethos, aggression and attitudes to risk.			
Culture:	national interests, behaviours, values and religious beliefs.			

The level of interoperability between two organisations can be quickly graded for each of these categories using a low-medium-high scoring system; these scores may then be plotted on a radar chart, for example:



Example radar chart showing levels of interoperability between two organisations

Next, decide what is the lowest required level of cooperation in order to achieve the mission. Plot the required level of interoperability for the 6 categories on the radar chart – are there any shortfalls in the current level of interoperability?

Now consider potential solutions to problem areas and identify the most effective solutions - given the constraints of your situation (i.e. budget, time, training, environment, mission). The more highly compatible categories might offer ways to work around the problem, for example:

Problem areas	Quick solutions	Longer term solutions			
Lack of awareness of each other's activities and intentions; unfamiliarity and low levels of trust between organisations.	Greater information sharing, lend communications equipment, establish command and intelligence liaison roles.	Joint planning and analysis of information, shared communications networks.			
Fundamental differences in doctrine, training, equipment or ability.	Role specialisation; if necessary, geographic separation of activities.	Joint training and eventual phased introduction of joint operations.			
Review all six categories – will the planned changes cause any knock-on effects?					

