Organisational Interoperability Maturity Model for C2

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Abstract

Interoperability is essential for the effective formation of Joint, Allied or Coalition task forces. Much work has been done in defining levels of interoperability for information systems in the C4ISR area, in particular, the LISI Reference Model. We assert that understanding organisational interoperability is also vital for the effective command and control of these task forces. DSTO has previously developed a Five Layer Model of C2 Support which includes organisational issues. A model of organisational interoperability is proposed in this paper which extends the LISI model into the more abstract layers of C2 Support, that is, the C2 Frameworks, C2 Processes and Information Management areas.

1. Introduction

The motivation for the work described in this paper is best described by the following quotation. 'Today, more than ever, the primary challenge of conducting joint operations is increasingly summed up in one word, interoperability. The Joint Task Force that fights the next conflict, large or small, does not exist until the need arises.' [C4ISR Architecture Working Group, 1997, Appendix D]. Whilst earlier work has been aimed at the system and technical levels, this paper addresses the issues associated with interoperability at the organisational level, particularly the needs of the C2 environment.

1.1 Background

In 1998 the Defence Science and Technology Organisation (DSTO), in conjunction with the Australian Defence Force (ADF), completed a Command and Control Support (C2S) Study to investigate the extent of support to command and control (C2) within the ADF. Its aim was to identify the strengths and limitation of that support and to make recommendations for enhancements where appropriate. The study team had to develop their own methodology to enable them to make meaningful assessments of the quality of the support and comparisons

between situations. The methodology was reported in [C2SS Working Group, 1996] and [Chin *et al* 1997] and the application of the methodology and the findings and recommendation were reported in [Chin and Clothier, 1998].

The methodology included a new model for C2, a categorisation of C2 support into layers and a means of assessing criticality. The first two of these are important in the context of this paper and are described below.

1.2 Transformation/Intent Model of C2

The C2 model developed for the C2S Study is called the Transformation/Intent model. It examines, in particular, the role of people and knowledge within a C2 system. Models of C2 which are task-based do not explain how tasks relate to each other, how they change over levels of command or in varying situations. C2 is seen as the ability to initiate and coordinate tasks rather than a task itself. Three major factors of C2 are identified in this model - determining relevance, informing and implementation of commander's intent. The C2 model is shown in Figure 1.

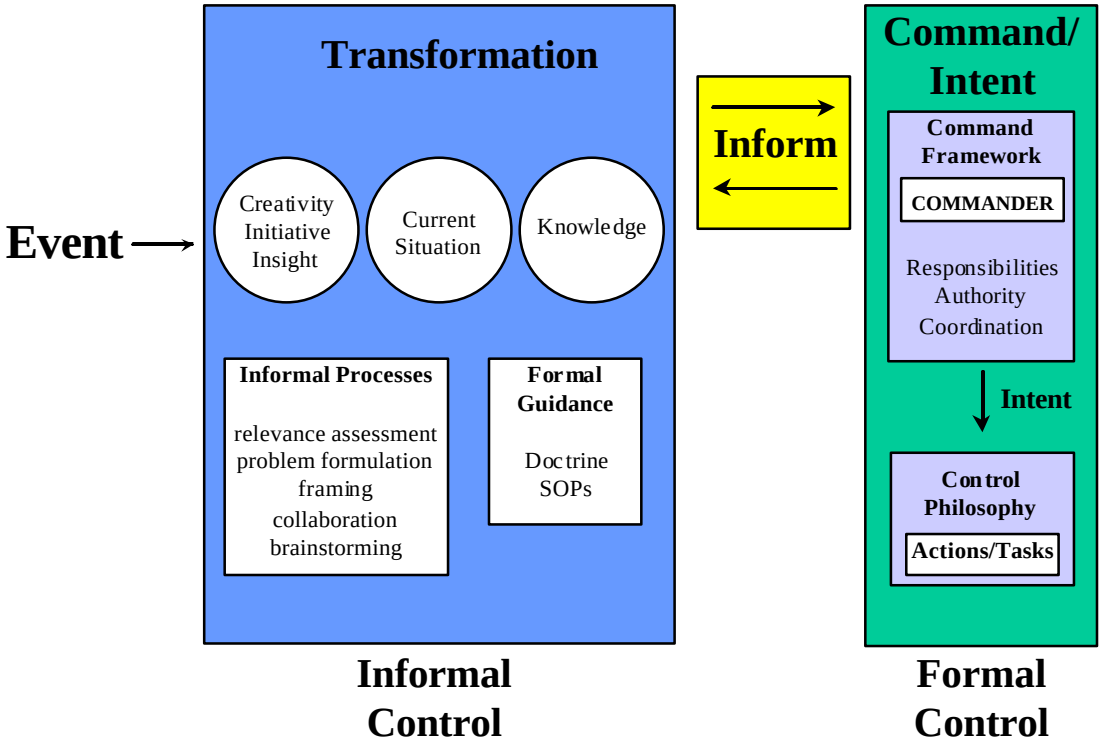

Figure 1. Transformation/Intent Model of C2

1.3 Layers of C2 Support

In the C2S Study the type of C2 support provided to the factors in the C2 model was categorised into five layers. These layers of support range from the very abstract type of support given by an organisational framework, to the very concrete support supplied by communications infrastructure. The C2 Support layers, shown in Figure 2, are:

- C2 Frameworks - which constrain and support the C2 processes. They can be organisational, legal, philosophical, financial or conceptual in nature
- C2 Processes - these identify key sequences of activities, key individuals and groups and illustrates how the C2 organisation operates
- Information Management - the capture, storage and retrieval of information for particular purposes
- Information Technology - the combination of hardware and software which supports the Information management
- Telecommunications - allows the transfer of electronic information as data streams

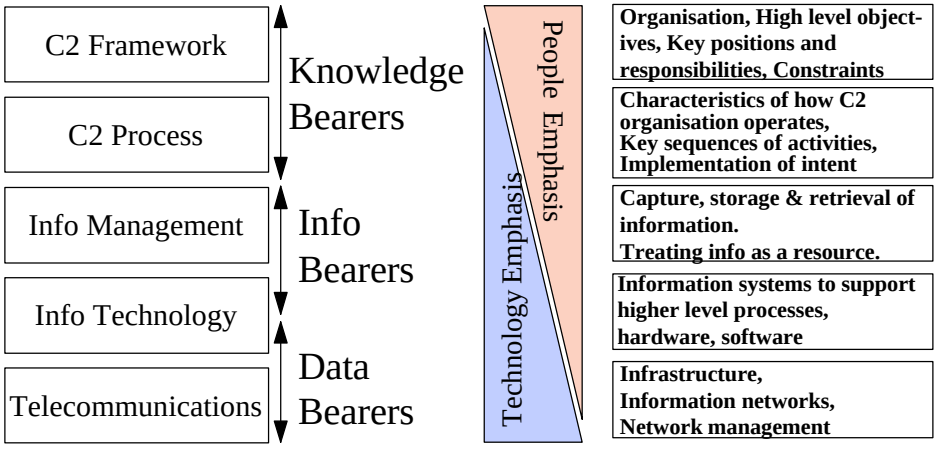

Figure 2. Layers of C2 Support

1.4 Architectural Framework Approach

One of the main recommendations from the Study was that an architectural framework approach is required for the development of ADF C2 capability. Various candidate frameworks are under consideration but the US developed C4ISR Architecture Framework [C4ISR Architecture Working Group, 1997] was investigated in some depth. The information that was collected for the Study was mapped onto this framework to assess the applicability of the framework and to investigate areas in which the architecture models need to be extended.

In particular the application of the Levels of Information Systems Interoperability (LISI) Reference model which is one of the Universal Reference Resources described in [C4ISR Architecture Working Group, 1998] was investigated. Interoperability is fundamental to the

provision of C2 capability, however it was concluded that the LISI model did not easily map onto the C2S study model for the following reasons:

- LISI is strongly technological, as its name suggests;
- It focuses on system and technical compatibility;
- It does not address the higher layers of C2 support. The system-oriented definitions of interoperability levels do not seem to have a natural extension into the higher layers of the model.

1.5 Extending the Model

It was decided to investigate the extension of the LISI model to the higher level abstractions found in the C2 Frameworks, C2 Processes and Information Management layers of the C2 Support Layer Model (see Figure 2); in other words, to look at the layers of the model that deal with organisational issues.

In this paper, a model is proposed that extends the LISI model to cover the organisational aspects of interoperability. Just as LISI does not apply to only one situation or context, the proposed model may also prove to be more generic than C2. However, its generality will probably be dependent on how widely the concept of Support Layers can be applied outside the C2 area.

2. Interoperability

2.1 Definitions of Interoperability

Definitions of interoperability were sought to ensure that the model was properly focussed. The definition of interoperability used by the LISI model is the same as the one supplied in the glossary of the C2S Study Phase 1 report, that is, interoperability is

> "…the ability of systems, units or forces to provide services to, and accept services from, other systems, units or forces and to use the services so exchanged to enable them to operate effectively together without altering or degrading the information exchanged."
> DoD, NATO, ADF C&C Information Systems Plan (1995/6)

Other definitions used in the C2S Study include:

> "The ability of one entity to service another."

> "The need of one group to interact in some way with another group."

It is this last definition that underlies the organisational interoperability model.

2.2 Qualities of Interoperability

The C2S Study identifies two qualities of interoperability - planned and flexible. It also compares compatibility and interoperability.

If interoperability is defined as the ability of one entity to service another then compatibility is defined as the degree to which one electronic system can operate with another - it is a subset of interoperability. Thus, when looking at the layers of C2 support, compatibility is more applicable to the lower technological layers and interoperability to the higher organisational layers.

Where interoperability has been driven by process, the focus is on the situation, the people and commander's intent. This may lead to flexible interoperability but not necessarily to technical compatibility: This may be expressed in a logical format as:

Process =>Flexible Interoperability => limited technology compatibility

Where interoperability has been driven by technology, the focus is on assets, their properties and the levels of compatibility required. This may lead to the exclusion of non-compatible participants. In a logical format:

Technology => Planned Interoperability => limited inter-working

2.3 Interoperability at the organisational level

In this paper, we are guided by the need for flexible interoperability as described in the previous section. This must be driven by process on a needs basis, typically at the point in time when it is needed; a ‘just in time’ approach to joint operations. The very large numbers of situations involving joint operations make it impractical to be completely prescriptive.

This unpredictability does not obviate the need for preparing as much groundwork as possible to cover potential contingencies. Indeed a major focus of the organisational interoperability model introduced in the next sections is to assist in this preparation by providing a framework within which the needs of the situation can be expressed using common terms and structures. In addition, it is hoped that the gaps between the reality and the requirements of the situation can be defined and guidance provided on how these gaps may be filled.

3. Maturity Models

3.1 Definition

Maturity models describe the stages through which systems, processes or organisations progress or evolve as they are defined, implemented and improved.

Intrinsic to a maturity model is the concept of levels - with each level used to characterise the state of the system or organisation. A consistent definition of the levels is therefore required.

The LISI maturity model identifies the stages through which systems should logically progress or "mature" in order to improve their capabilities to interoperate. The five levels are identified by terms that describe both the level of interoperability and the environment in which it occurs.

These pairs are

- isolated/manual,
- connected/peer-to-peer,
- functional/distributed,
- domain/integrated and
- enterprise/universal.

Within the military environment organisations need to come together at short notice to meet a new requirement such as an unexpected contingency or a coalition operation. Information systems may be compatible and interoperable, as defined earlier. However, if the participating organisations do not have the ability to interoperate, their effectiveness in a given situation will be substantially reduced.

3.2 The Organisational Interoperability Maturity Model

The proposed Organisational Interoperability Maturity Model defines the levels of organisational maturity that describe the ability of organisations to interoperate. Five levels are identified:

- unified,
- combined,
- collaborative,
- ad hoc, and
- independent.

Each of the levels is defined in the following section.

3.2.1 Levels of Organisational Interoperability

Level 0 - Independent - The Level 0 interoperability describes the interaction between independent organisations. These are organisations that would normally work without any interaction other than that provided by personal contact. They are likely to be organisations that do not normally share common goals or purpose but that may be required to interoperate in some scenario that has no precedent. Essentially the arrangements are unplanned and unanticipated. Although there are no formal frameworks in place, they are able to communicate for example via telephone, fax and personal contact in meetings. Examples of organisations that may need to interoperate at this level with the ADF could include a remote cattle station, a mining company, a Non Government Organisation (NGO) or a non-traditional ally.

Interoperability between elements of the ADF would normally to be at a higher maturity level because of shared ethos and understanding, if not command style and preparedness.

Level 1 - Ad hoc - At this level of interoperability only very limited organisational frameworks are in place which could support ad hoc arrangements. There will be some guidelines to describe how interoperability will occur but essentially the specific arrangements are still unplanned. There will be some overarching shared goal but individual organisation aspirations will take

precedence and the organisations remain entirely distinct. An example could be interoperation with the State police force for a particular incident or with State Emergency Services. Liaison officers are often the main means of exchange of information and knowledge.

Level 2 - Collaborative - The collaborative organisational interoperability level is where recognised frameworks are in place to support interoperability and shared goals are recognised and roles and responsibilities are allocated as part of on-going responsibilities however the organisations are still distinct. Training is likely to have taken place in some aspects of the interworking and significant communication and sharing of knowledge does occur but the home organisations' frameworks still have a significant influence. An example could be interoperation between the Army and the Logistics organisation, or between Navy and Army tactical units for a joint operation.

Level 3 - Integrated - The integrated level of organisational interoperability is one where there are shared value systems and shared goals, a common understanding and a preparedness to interoperate, for example, detailed doctrine is in place and there is significant experience in using it. The frameworks are in place and practised however there are still residual attachments to a home organisation. An example would be the interoperation between the components in the collocated HQAST or between HQAST and NORCOM. An external example could be the Combined task force HQ of a US-led coalition operation.

Level 4 - Unified - A unified organisation is one in which the organisational goals, value systems, command structure/style, and knowledge bases are shared across the system. The organisation is interoperating on continuing basis. This is really the ideal level where there is no impediment in the organisational frameworks to full and complete interoperation. It is likely to occur only in very homogeneous organisations for example between areas of HQAST.

3.2.2 Alignment with LISI

It is desirable that the levels of organisational interoperability defined above be closely aligned with the environmental descriptions of the LISI model. Table 1 shows the alignment between the LISI levels and the proposed organisational levels.

Organisational Description	**LISI Description**	**LISI Environment**
Unified	Enterprise	Universal
Combined	Domain	Integrated
Collaborative	Functional	Distributed
Ad hoc	Connected	Peer-to-peer
Independent	Isolated	Manual

Table 1 Organisational vs LISI Levels

We assert that organisations with the characteristics described are very likely to require systems and technical interoperability of at least the equivalent LISI levels. Further work needs to be done to validate this assertion. Figure 3 illustrates how the organisational levels may drive the

interoperability requirements of the information systems as defined by LISI, in the context of the C2 layers.

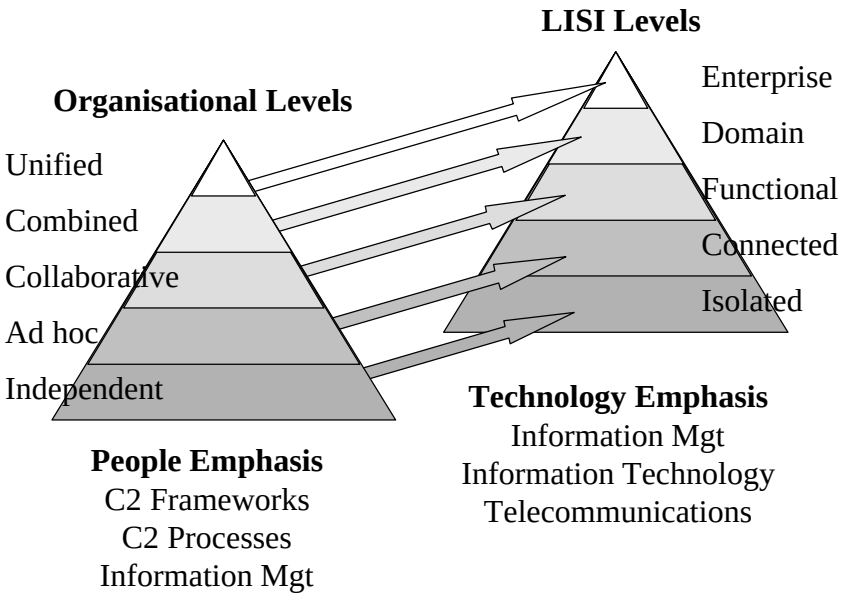

Figure 3. Alignment between Organisational Model and LISI

3.2.3 Attributes of Organisational Interoperability

Four attributes have been identified as the enabling attributes of organisational interoperability. They are:

Preparedness: This attribute describes the preparedness of the organisation to interoperate. It is made up of doctrine, experience and training.

Understanding: The understanding attribute measures the amount of communication and sharing of knowledge and information within the organisation and how the information is used.

Command Style: This is the attribute that describes the management and command style of the organisation – how decisions are made and how roles and responsibilities are allocated/delegated.

Ethos: The ethos attribute is concerned with the culture and value systems of the organisation and the goals and aspiration of the organisation. The level of trust within the organisation is also included.

4. Reference Models

Reference models are a set of concepts, entities, interfaces and diagrams that provide common ground for understanding and comparisons – a means for evaluation and comparison of systems.

4.1 The LISI Reference Model

For the LISI Reference Model the level/attribute intersections represent the broad classifications for addressing the specific capabilities required. At each level a word or phrase highlights the most import aspects of the attributes and the significance and relative impact of each attribute will vary by level.

The attributes identified in LISI are:

- Procedures,
- Applications,
- Infrastructure and
- Data.

One attribute emerges as the primary enabler for achieving each level of interoperability as shown in Table 2.

Level	LISI Description	Procedures	Applications	Infra-structure	Data
4	Enterprise/Universal	✓			
3	Domain/Integrated				✓
2	Functional/Distributed		✓		
1	Connected/Peer-to-peer			✓	
0	Isolated/Manual	✓			

Table 2. LISI Primary Enabling Attributes

4.2 The Organisational Interoperability Reference Model

In the proposed organisational interoperability reference model, it was found that more than one attribute could be considered as the primary attribute for that level. These attributes are shown in Table 3.

	Preparedness	Understanding	Command Style	Ethos
Unified			✓	✓
Combined	✓			✓
Collaborative	✓	✓		
Ad hoc		✓	✓	
Independent		✓		

Table 3. Primary Attributes for Organisational Layer Model

	Preparedness	**Understanding**	**Command Style**	**Ethos**
Unified	Complete - normal day-to-day working	Shared	Homogeneous	Uniform
Combined	Detailed doctrine and experience in using it	Shared comms and shared knowledge	One chain of command and interaction with home org	Shared ethos but with influence from home org
Collaborative	General doctrine in place and some experience	Shared comms and shared knowledge about specific topics	Separate reporting lines of responsibility overlaid with a single command chain	Shared purpose; goals, value system significantly influenced by home org
Ad hoc	General guidelines	Electronic comms and shared information	Separate reporting lines of responsibility	Shared purpose
Independent	No preparedness	Communication via phone etc	No interaction	Limited shared purpose

Table 4. Summary of Organisational Interoperability Reference Model

Table 4 summarises the Organisational Interoperability Reference Model. Annex A contains more detailed descriptions of the aspects of the attributes that are important at each level.

5. Conclusion and Way Forward

The LISI model was developed as one of the C4ISR Universal Reference Resources to define interoperability between information systems. It also provided a mechanism to define the maturity of such systems and a way to proceed from one level to another.

The model presented here can be seen as completing the LISI model in the context of the layers developed in the C2S Study (Figure 2) by extending it into the organisational layers. It can act as a maturity model. However, it is likely that the primary requirement will be for organisations to interoperate at a level that meets the needs of the occasion and that the objective is to establish that the organisational interoperability is adequate for that purpose. Further the organisational need will in turn drive the system interoperability as asserted in Section 3.2.2.

The proposed Organisation Interoperability Maturity Model will be used to investigate interoperability issues in the upper layers of the C2 Support model (that is, the Frameworks, Processes and Information Management layers) with a particular focus on the formation and operation of joint, allied and coalition deployable task forces. Insights from the application of the model should provide further help in the task of improving interoperability in the rapidly formed, complex task forces which will be increasingly used in today's and tomorrow's world.

6. References

[C2SS Working Group, 1996] C2 Support Study Phase 1 Report.

[C4ISR Architecture Working Group, 1997] C4ISR Architecture Framework Version 2.0 18 December 1997

[C4ISR Architecture Working Group, 1998] Levels of Information Systems Interoperability (LISI) 30 March 1998

[Chin et al, 1997] Moira Chin, Jennie Clothier, Malathi Carthigaser, *Command and Control Capability Assessment and the Critiality Issue*, Proceedings of the 1997 Command and Control Research and Technology Symposium, Washington DC, June 1997

[Chin and Clothier, 1998] Moira Chin and Jennie Clothier, *Command and Control Situations and Capability Assessment*, Proceedings of the 1998 Command and Control Research and Technology Symposium, Monterey CA, June 1998

[Clothier et al, 1997] C2 Support Study Phase 2 Report

[Clothier et al, 1998] C2 Support Study Phase 3 Report

Annex A

Description of Attributes at each Level

Level 0 – Independent	
Preparedness	At this level there is no doctrine in place nor any experience or training.
Understanding	To enable interoperability at this level there needs to be some manual communication between organisations in order to exchange information. This will probably take the form of phone, fax and face to face meetings.
Command Style	At this level the organisations may have widely divergent command styles but some acceptance of roles and responsibility may be required.
Ethos	It is not necessary and indeed unlikely for these organisations to have a shared culture or value system, however there needs to be some shared purpose for any interoperability to take place.

Table 5. Independent Level 0

Level 1 - Ad hoc	
Preparedness	Preparedness will typically be in general guidance on how to interoperate with other organisations. There would usually be little or no prior experience of having done this and little or no prior training. No specific doctrine will be available.
Understanding	The level of understanding would include shared information and some knowledge. Communications facilities would be available and used.
Command Style	Some delegation of authority or acceptance of roles and responsibility will be required, some flexibility of approach.
Ethos	Shared goals or purpose for the interoperation will be present and a level of shared values but the home organisation ethos will predominate.

Table 6. Ad hoc Level 1

Level 2 - Collaborative	
Preparedness	At this level guidelines for interoperability and some doctrine and joint training mechanisms are in place.
Understanding	Communication facilities are shared. Knowledge about the situation or context is shared.
Command Style	Although command style will vary across the organisation there will be common acceptance of the imposed chain of command
Ethos	Aspects of the home organisation ethos will still be apparent but shared goals and purpose and values will be used.

Table 7. Collaborative Level 2

Level 3 - Combined	
Preparedness	In a combined or integrated organisation, the distinguishing factor for preparedness will be experience. The organisation is well practised at working in an integrated environment.
Understanding	The organisation has shared knowledge bases and good communications.
Command Style	The command chain is well defined and accepted but some influences from home organisations will occur.
Ethos	There will be shared value systems and shared goals.

Table 8. Combined Level 3

Level 4 - Unified	
Preparedness	The distinguishing feature of a unified organisation will be the completeness of preparation across all aspects of doctrine, training and experience.
Understanding	There is universal communication and shared knowledge across the organisation.
Command Style	The command style will be homogeneous.
Ethos	Organisational goals, value systems and culture are shared across the organisation.

Table 9. Unified Level 4