

Analysis to Support Change and Continuity in Future Command and Control

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ABSTRACT

Maintaining the continuity of command and control (C2), in the face of rapidly evolving technologies, force structures and tasks, demands a level of awareness and co-ordination previously unthinkable in traditional defence organisations. It is no longer possible to cleanly separate procurement from operations, nor to consider system changes in isolation from organisational ones. Increasing pressure towards integration of information and communication services (ICS), allied with the consequent pressure to change the way forces organise to deliver their capabilities, has made the task of maintaining C2 over time a difficult act of co-ordination between many actors and activities. In order to provide rational analytic support to such a process it is necessary to clearly understand what questions need to be addressed and what decisions need to be made. This paper discusses the results of a study which has sought to derive the analysis requirements arising out of the need to co-ordinate a force wide digitization programme. The product of the research has been a 'route-map' to analysis needs which can apply to any co-ordination activity or, with minor amendment, to the capability creation activity itself. The route-map is implemented as a website which can act both as a guide to analysis needs and as the front-end for a collection of management tools required by the co-ordination activity itself.

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1. Introduction and background

Maintaining the continuity of command and control (C2), in the face of rapidly evolving technologies, force structures and tasks, demands a level of awareness and co-ordination previously unthinkable in traditional defence organisations. The increasing demand for integrated joint and combined operations, as well as an ability to interact closely with non-governmental organisations (NGO), and in ad hoc coalitions, presents challenges which are social as well as technical; political as well as military.

Most major military nations have a history of procuring equipment on a service by service basis with consequent disjoints in technical specification and organisational structures. Increasingly, there is a drive towards truly joint procurement, predicated on delivering an overall operational capability. This, in turn, demands changes in the way procurement operates so that scarce national resources can be efficiently husbanded.

External and internal politics have always played a part in the practice of procurement, even when decision-making is ostensibly based on rational argument and purely military need. Organisational change, which is a largely social activity, is intrinsically bound up with the integration of information technologies. It is no longer possible to cleanly separate procurement from operations, nor to consider system changes in isolation from organisational ones. Increasing pressure towards integration of information and communication services (ICS), allied with the consequent pressure to change the way forces organise to deliver their

capabilities, has made the task of maintaining C2 over time a difficult act of co-ordination between many actors and activities.

Equipment procurement programmes must consider how military systems, particularly communications and information systems (CIS), are likely to integrate with legacy systems and organisational structures to modify the overall ‘system of systems’ which is a modern defence force. In order to provide rational analytic support to such a process it is necessary to clearly understand what questions need to be addressed and what decisions need to be made. This paper discusses the results of a study that has sought to derive the analysis requirements arising out of the need to co-ordinate a force wide battlespace digitization programme.

2. Analysis Approach

Change can only come about through action. Consequently, information and knowledge can only be deemed effective and be ascribed significance if they lead to a change in what would otherwise be the chosen course of action. When considering how to implement a visionary programme of digitization, a key function is that of co-ordination. Balancing the benefits flowing from tightly defined, project based procurement of systems with the need to maintain overall coherence of the emergent ‘system of systems’ requires a clear-sighted co-ordination activity which continuously maintains an awareness of the ‘big picture’ without unduly constraining freedom of action by individual project managers.

The research reported here seeks to identify those analysis and knowledge creation activities needed to support such a co-ordination activity. The approach taken starts by asking, “What actions arise from co-ordination?”. Each action is then considered to flow from one or more Decisions. In order to take such decisions rationally, a body of knowledge must be created. By following this

line of reasoning, it is possible to derive logically the knowledge creation activities required to support rational co-ordination decisions. The resultant Action-Decision-Knowledge structure is illustrated in Figure 1.



Figure 1 : Illustration of the Action-Decision-Knowledge structure (arrows represent dependency rather than causation)

In practice, in most countries, authority to take the necessary co-ordination actions is distributed amongst many stakeholders. Typically, the logic of co-ordination is lost in the complexities of organisational politics and procedures. In order to maintain clarity in the analysis, a notional ‘Co-ordination Authority’ is postulated. Although this body may not be responsible for all of the activities required to effectively co-ordinate, it does have a legitimate interest in them all. The military doctrinal concepts of Area of Responsibility and Area of Interest are useful analogies here.

Using the Action-Decision-Knowledge model illustrated above, the research produced a route-map which allows the Co-ordination Authority to identify what knowledge is required, what shortfalls exist in planned knowledge generation activities and, thus, which new knowledge generation activities need to be commissioned. The route-map is implemented as a web-site which can act both as a guide to analysis needs and as the front-

end for the collection of records and management tools required by the Co-ordination Authority.

Originally focused on the problem of co-ordinating procurement projects, the approach is equally relevant across a wide range of C2-related activities from research to planning. Indeed, the task of developing and maintaining coherent, integrated C2 over time necessarily spans this range. It is likely that any practical co-ordination activity must involve research leaders, operational requirements staff, procurement agencies and operational commands. This is a substantially different problem than that which previous programme management activities have addressed, and requires a rigorously logical approach to avoid institutional friction and inertia.

Since co-ordination is not a one-off task, the model includes a continuous maintenance role through which the consequences of previous decisions can be assessed and changes to the analysis requirement identified.

3. Developing the Route-Map

The initial set of co-ordination actions was derived through the use of Soft Systems Methodology (SSM). SSM considers activity systems and seeks to derive output activities and transforms based upon a root definition of the activity system being analysed. In this research the method was used to give an initial rough scope to the problem. An SSM analysis was carried within the research team in order to identify what the outputs of a co-ordination activity were likely to be.

The root definition used to characterise the digitization co-ordination activity was:

An activity to ensure achievement of the digitization vision by means of strategy and co-ordination of CIS in order to achieve improved operational effectiveness.

Using this as a starting point the study team derived a short, but comprehensive set of generic co-ordination actions.

3.1 Co-ordination Actions

The set of co-ordination actions represents those actions which together implement the co-ordination activity, no matter who actually takes them. The actions are unlikely to be under the direct control of the Co-ordination Authority, but must be considered as part of the overall activity. The set of co-ordination actions is listed below and defined in the subsequent text.

1. Exclude projects from the co-ordination activity;
2. Produce user requirements;
3. Change user requirements;
4. Cancel user requirements;
5. Change 'ownership' of requirements;
6. Specify standards;
7. Cluster projects;
8. Revise schedules.

The use of the terms "user requirement" and "project" in the above actions warrants some explanation. It was assumed in this research that the procurement activities would be driven by explicitly stated user requirements and that these would be maintained by an operational requirements organisation, which would be the de-facto 'customer' for the procurement activity. The term 'project' is used here to signify not only equipment procurement projects, but also research items, user requirements, the operation of in-service elements (including concepts of operation and organisational procedures), and other elements of Defence (e.g. training). Wherever the term "Project" is used within this paper, it may generally be taken to encompass all of the above types of co-ordinated activity.

The first action, ['Exclude projects from the co-ordination activity'](#) (1) involves deciding whether or not to consider a given project (or research item, requirement, in-service element,

etc.) as within the scope of the digitization co-ordination activity. This key initial action assumes the maintenance of a formal register of projects to be co-ordinated and the action is a change to this register. The importance of a formal register, called the Co-ordination Set, becomes clear when Foundation Knowledge sets are discussed later in the paper.

Having decided which projects should co-ordinated, the subsequent co-ordination actions may apply.

[‘Produce user requirements’ \(2\)](#) involves raising a new requirement, usually to fill a major gap in the existing planned capability.

[Change user requirements \(3\)](#) is concerned with gaps in capability which are less extensive and can be addressed by modifying a existing requirement.

[Cancel user requirements \(4\)](#) involves canceling an existing requirement and not proceeding with consequent investment.

[Change ‘ownership’ of requirements \(5\)](#) is about whether existing requirements are inappropriately placed and should be moved to another group within the operational requirements organisation. The desire to change could arise for a number of reasons. For example, it may be seen as more technically coherent to give common ownership to a related set of procurements, or it may be considered advantageous politically to distribute key capabilities across the procurement organisation. Where procurement is based upon well-defined military capability areas, such movement could be within a capability area or between capability areas, and the authority empowered to take the actions may differ in each case. However, it is assumed that a coherent co-ordination activity would need to consider both.

[Specify standards \(6\)](#) can be seen as producing generic requirements. Although the generation of standards, per se, may be outside the scope

of co-ordination, the co-ordination activity will be interested to identify where and when standardisation is required.

[Cluster projects \(7\)](#) is concerned with getting projects to work more closely together in a way which falls short of bringing them under common management. Examples might range from declaring a dependency, to setting up a special liaison process.

[Revise schedule \(8\)](#) is undertaken when it is decided that Projects require greater synchronisation of dates and milestones.

Composite actions are also possible. For example, it could be desirable to fill a short term capability gap by requiring an existing Project to deliver an interim operational capability. This may, in turn, require a change to the schedule for delivery of final operational capability.

It has been noted that the list of actions does not include actions required to ‘sell’ the co-ordination activity to the various stakeholders who are authorised to take the actions. Whilst this activity is undoubtedly important in any real Defence organisation, it was decided to put it to one side as requiring a form of political rationality which was culturally specific and unlikely to survive generalisation.

Having identified a comprehensive set of co-ordination actions, the next step in developing the route map was to infer the decisions which are implied by those actions, and the knowledge required for those decisions to be made rationally.

3.2 Decisions implied by Actions

Nine key decisions were identified as necessary for the co-ordination activity. (Numbers in parenthesis are unique identifiers, intended to aid cross-referencing).

- Decide that a project does not impact sufficiently to be co-ordinated (20)

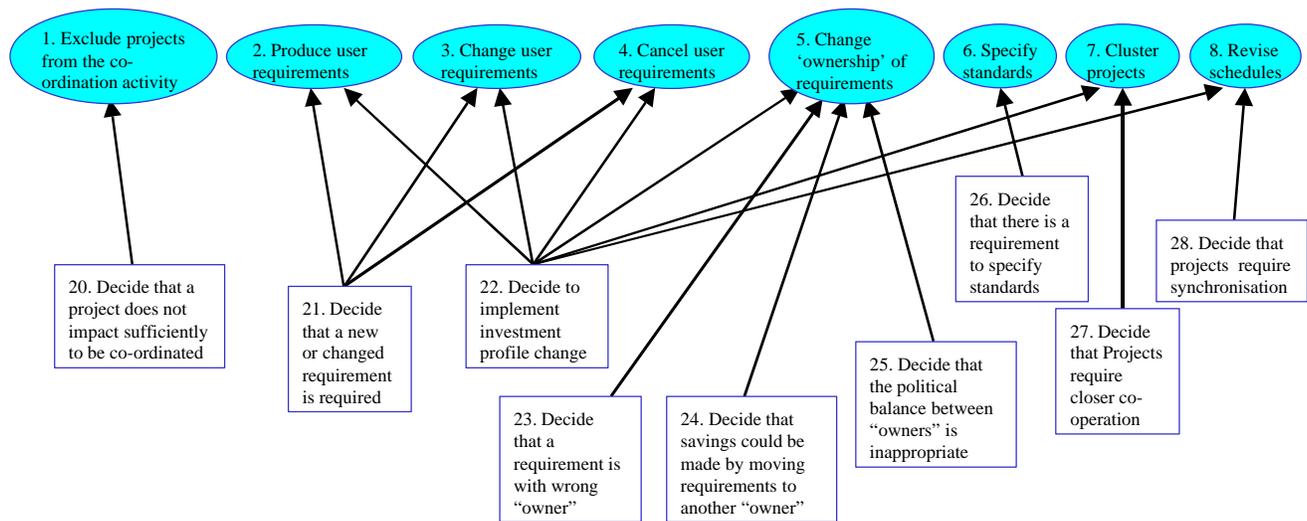


Figure 2 : Decision-Action linkages

- Decide that a new or changed requirement is required (21)
- Decide to implement investment profile change (22)
- Decide that a requirement is with wrong “owner” (23).
- Decide that savings could be made by moving requirements to another “owner” (24).
- Decide that the political balance between “owners” is inappropriate (25)
- Decide that there is a requirement to specify standards (26)
- Decide that projects require closer co-operation (27)
- Decide that projects require synchronisation (28)

Figure 2 illustrates the mapping between decisions and actions, indicating that some actions require multiple decisions, and some decisions may lead to multiple actions.

For example, a significant factor in changing (3), canceling (4) or moving requirements (5) is a Balance of Investment Study (BOI), indicating that improvements in the overall C2 investment profile can be made. It is for this reason that a separate decision, [Decide an investment profile change is required \(22\)](#), has been included. This decision leads to multiple actions.

Each of the decisions is described below, along with an indication of the knowledge required for that decision.

[Decide that a project does not impact sufficiently to be co-ordinated \(20\)](#)

This is the decision to either co-ordinate a project, in which case it becomes an element in the Co-ordination Set, or to exclude it, which means that it can be ignored from a co-ordination point of view. However a project which has been excluded may at a future date be included if the overall Digitization Vision² changes or the requirement for capability changes. The knowledge required for this decision is the relative value/importance of each project's contribution to the Digitization Vision.

[Decide that a new or changed requirement is required \(21\)](#)

This decision could be taken for a number of reasons. The capability needs may have changed, project status may change either in cost or schedule terms or a project may not be providing the desired capability. This decision, therefore, requires knowledge about:

- any divergence in planned capability from the Digitization Vision;

² The ‘Digitization Vision’ is a Foundation Knowledge set which is more fully described later.

- which projects are over/under spent;
- the capability impact of any schedule divergence.

This decision could also arise because of a recognition that rationalisation is possible across different user communities provided only that they would adopt common ways of working. This requires knowledge of the operational significance of any existing differences in users' working practices.

[Decide to implement investment profile change \(22\)](#)

This decision is about modifying the investment profile to satisfy the needs of capability by balancing investment profile choices. This could be due to a change in the capability needs or simply to balance the books across projects. This decision leads to a number of actions, modifying the requirements in some way either by adding, changing, canceling or moving. Clustering projects or adjusting the schedules of projects are other options open to implement this co-ordination decision. Knowledge required for this decision comes from the following sources, namely:

- the relative importance of each project's contribution to the Digitization Vision;
- the derived value of different investment profiles;
- a knowledge of which Projects are over or under spent.

[Decide that a requirement is with wrong "owner" \(23\)](#)

This decision simply implies that a requirement has been identified as belonging to the wrong "owner"³ within the operational requirements community. The owner may be considered "wrong" either because their technical scope is mismatched with the specific requirement under consideration, or because there may be some organisational or economic advantage in changing ownership. This decision leads to a

³ The "owner" of a requirement is the operational requirements authority responsible for overseeing the satisfaction of a particular requirement.

single action - moving the requirement. This knowledge required for this decision may be:

- the relative importance of each project's contribution to the Digitization Vision;
- any divergence in planned capability from Digitization Vision;
- knowledge of benefits and costs of restructuring requirements 'ownership';
- knowledge of savings from moving projects around (e.g. from rationalisation; economies of scale).

[Decide that savings could be made by moving requirements to another owner \(24\)](#)

This decision is about savings due to rationalisation and economies of scale and leads to only one action, that of moving requirements between owners. This decision requires knowledge of whole life costs for projects under different requirement ownership schemes.

[Decide that the political balance between projects is inappropriate \(25\)](#)

This decision is about the political implications of where a requirement lies and leads to only one action, that of moving requirements between owners in order to balance the power holding of different areas. This decision depends upon the Co-ordination Authority having a clear idea of the desirable political balance and knowledge of the existing balance.

[Decide that there is a requirement to specify standards \(26\)](#)

This decision leads to the action of specifying standards, which can be considered as generic requirements. The decision is dependent on:

- knowledge of the usefulness and appropriateness of current standards;
- knowledge of the need to standardise practice across different users;
- knowledge of architectural design gaps in the digitized system of systems.

[Decide that projects require closer co-operation \(27\)](#)

This decision is not about merging projects but about deciding that there is a need for them to interact in some way and that the interaction requires co-ordination. The need for interaction could be due to the projects having some overlap or because one project depends on the output of another. This decision will result in the action of clustering of projects and it requires knowledge of gaps in co-operation between projects with a technical overlap.

Decide that projects require synchronisation (28)

This is the decision to ensure that projects, which are dependent upon each other, deliver their capability or technical output at the appropriate time. This leads to the action to revise project schedules. The decision requires knowledge of planned project time-scales.

3.8 Knowledge Requirements

As indicated in Figure 1, the route-map was developed further to include nodes representing sets of knowledge and knowledge creation activities. As illustrated in Figure 3, the complete route-map contains three knowledge-related layers. Immediately below the Decision layer are nodes representing the specific knowledge required for each decision. The layer below comprises knowledge creation activities required to create the decision knowledge. The final knowledge layer comprises sets of Foundation Knowledge, which must be maintained on a continuous basis to underpin the specific decision knowledge creation and also to provide a trigger for identifying that decisions may be required. The development and maintenance of Foundation Knowledge sets is the key to an effective co-ordination strategy.

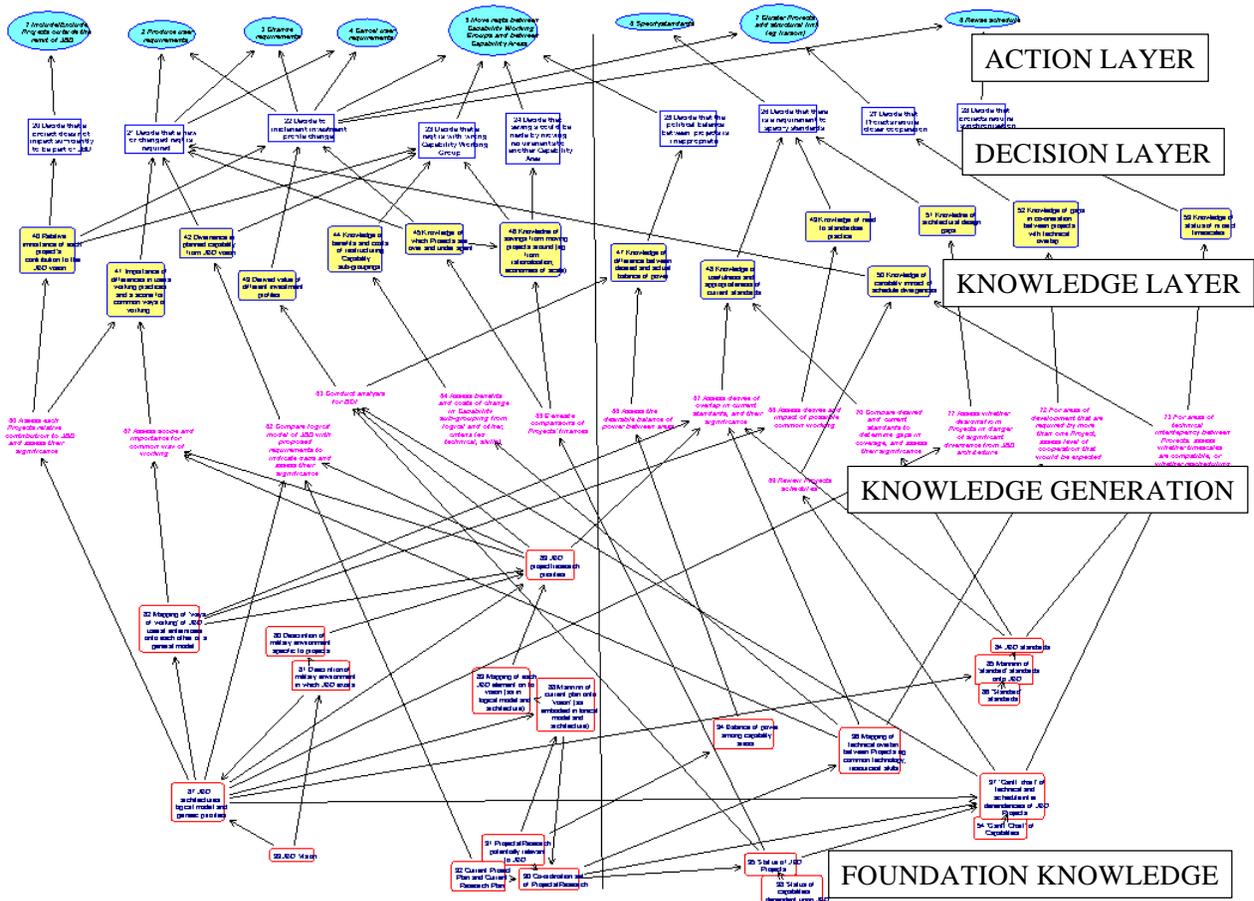


Figure 3 : Illustration of complete route map, showing the different layers

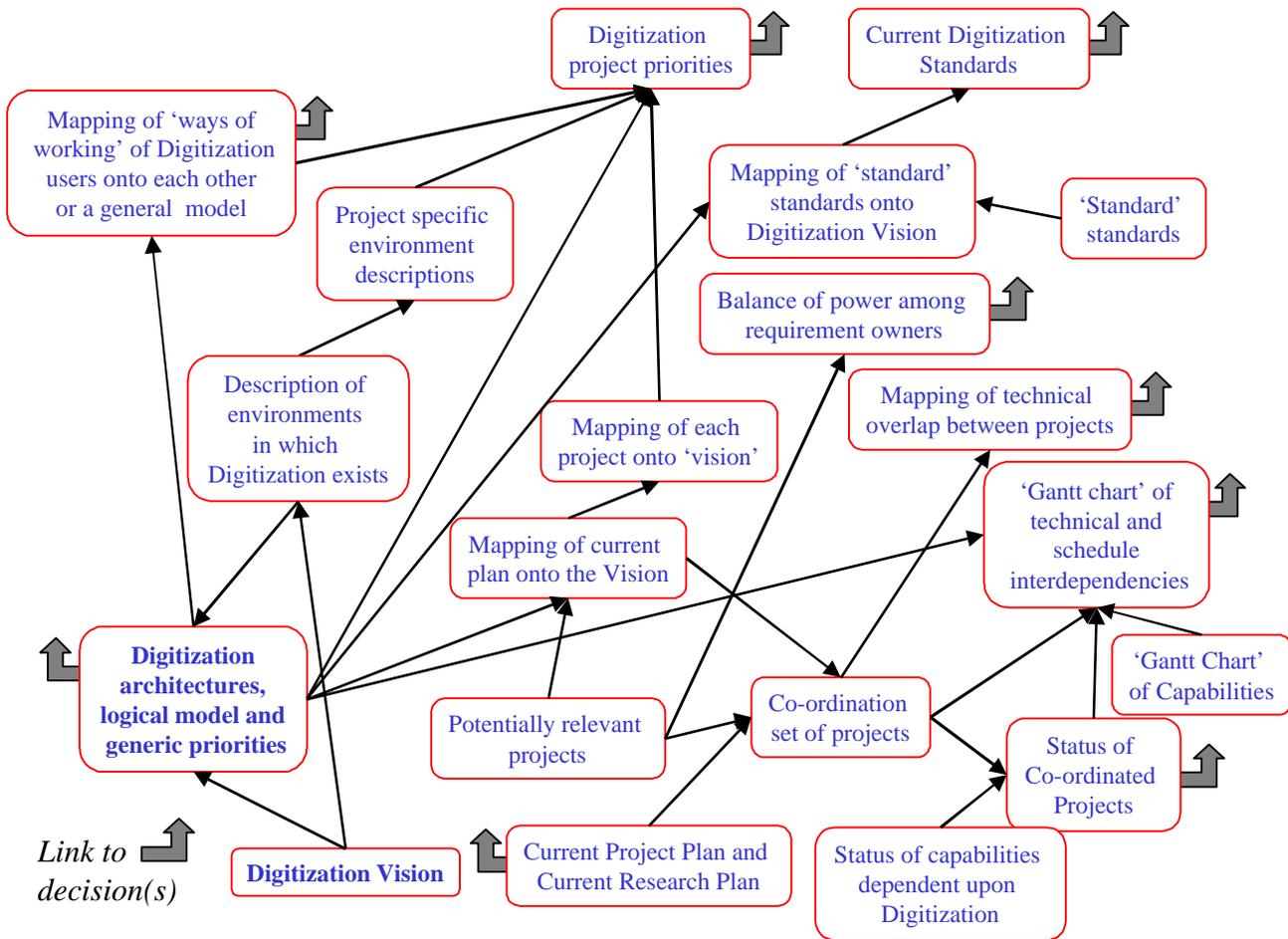


Figure 4 : Foundation Knowledge sets

3.4 Foundation Knowledge sets

By analogy to military doctrine, the maintenance of Foundation Knowledge sets can be equated to a surveillance activity, intended to locate and identify changes with the Area of Interest in order to stimulate action within the Area of Responsibility. Keeping with this military doctrinal analogy, the decision-specific Knowledge Creation activities can be equated to mission specific reconnaissance. A key product derived from the development of the route-map is the identification of a surveillance regime, which the Co-ordination Authority requires to implement in order to underpin the Co-ordination Activity.

As illustrated in Figure 4, the Foundation Knowledge sets formed a tightly integrated

whole. They are founded, however, on two key roots:

- the Digitization Vision; and
- the Digitization architectures, logical model and generic priorities.

These key roots are described below, followed by descriptions of the major groupings within the Foundation Knowledge layer.

3.5 Digitization Vision

The [Digitization Vision](#) is a statement of the fundamental purpose and nature of Digitization, as it is striven for by the Co-ordination Authority. The [Digitization architectures, logical model and generic priorities](#) (referred to as the 'Logical Model' for the sake of brevity) represent a tangible expression of that Vision, in a form which can be used to support the Co-ordination Activity.

This knowledge set will comprise a number of different components which together describe the functional, organisational and technical characteristics of the digitized ‘system of systems’ implied by the Vision. In a force-wide digitization programme, likely components of the Logical Model will include:

- a functional model of force command and control and other processes dependent upon digitization (probably joint and combined);
- an organisational model of the force;
- an information flow and processing model;
- a description of the non-functional requirements for the system of systems;
- a desired systems architecture;
- a desired technical architecture;
- a generic description of priorities based upon the linking of the systems and technical architectures to the functional and non-functional models.

It is only against these tangible expressions of the Digitization Vision that the Co-ordination Activity can logically identify potential capability gaps and seek opportunities for more effective and efficient achievement of its goals.

Having established the Vision and the Logical Model, a number of other groups of Foundation Knowledge need to be developed. The principal groups are:

- Co-ordination Set of projects;
- Status of projects and ‘Gantt Chart’;
- Standards.

3.6 Co-ordination Set

An essential step in the development of the Foundation Knowledge sets is to select the range of projects upon which the Co-ordination Activity will focus, termed the Co-ordination Set.

Figure 5 shows the Co-ordination Set and related nodes from the route map. All projects potentially relevant to the Digitization Vision

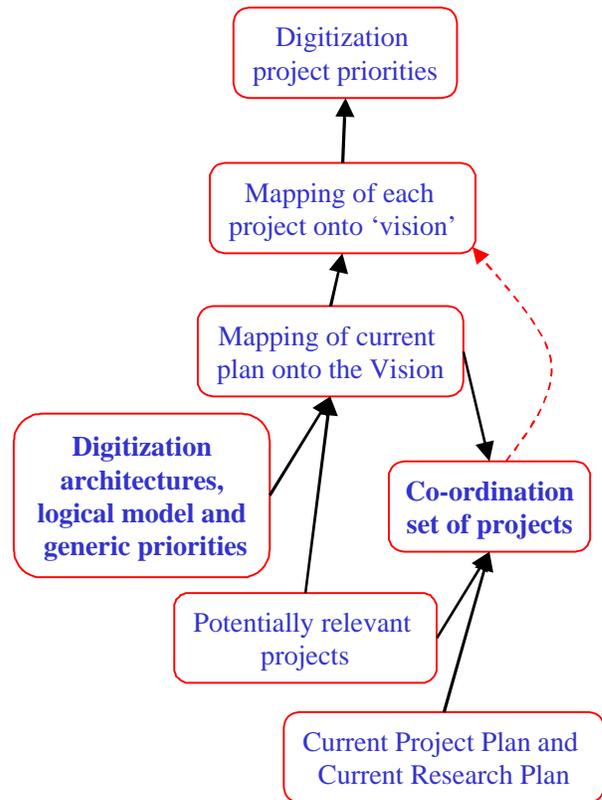


Figure 5 : Co-ordination set of projects

need to be reviewed and mapped onto the Logical Model. From this mapping, the projects most likely to impact significantly on the achievement of the Vision can be identified. For each of these significant projects specific knowledge must be created about its contribution to the Vision, and a decision made about whether to include the project in the formal Co-ordination Set. Only by maintaining a clear set of projects to be co-ordinated, and mapping these onto the Logical Model, can the generic priorities of Digitization be converted into specific priorities which may be used in Balance of Investment and other co-ordination decision-making.

The process of defining and maintaining the Co-ordination Set involves a basic surveillance activity, spanning across all projects. As noted before, ‘projects’ in this context include not only procurement projects but also research items, requirements, concepts of operation, and other Defence activities (e.g. training). This is a very wide remit, which can only be surveyed relatively lightly. By selecting the Co-ordination Set, surveillance resources can be

focused and used more effectively. Most other Foundation Knowledge sets refer specifically to elements of the Co-ordination Set.

3.7 ‘Gantt Chart’ and Status

Figure 6 shows the Foundation Knowledge sets associated with status and scheduling of the projects in the Co-ordination Set. Although the term ‘Gantt Chart’ is used, the knowledge required here is much more than the schedule dependencies traditionally recorded in such charts. The Digitization Co-ordination Activity requires formalised expressions of technical and operational interdependencies between the projects in the Co-ordination Set. Knowledge is also required of the interdependencies between those projects and the wider range of military capabilities. This implies a further ‘Gantt Chart’ expressing the interdependencies of those capabilities. These can probably be expressed at a higher, more aggregated level than that used for the Co-ordination Set projects. In both cases, the level of detail should be the minimum necessary to obtain indications of possible future capability gaps. Evaluating the cost-effectiveness of addressing these gaps can be carried out in support of specific decisions. The route-map identifies a range of specific Knowledge Creation activities.

The ‘Gantt chart’ needs to be formulated to allow potential future capability gaps to be identified across the full scope of the Digitization Vision. Converting the large number of individual project status measures quickly and cheaply into a small number of future capability indicators is no easy task, but must be accomplished if the Co-ordination Activity is to be a comprehensive and rational process.

In addition to the ‘Gantt Chart’, the Co-ordination Activity will need to create a mapping between Co-ordination Set projects showing where there are technical overlaps. Examples of overlaps include the use of common technologies, skills or resources. This

knowledge is required to support identification of, amongst other things, the opportunities for the introduction of common standards. However, to make decisions in this area requires a clear understanding of standards already in use and those potentially available.

3.8 Standards

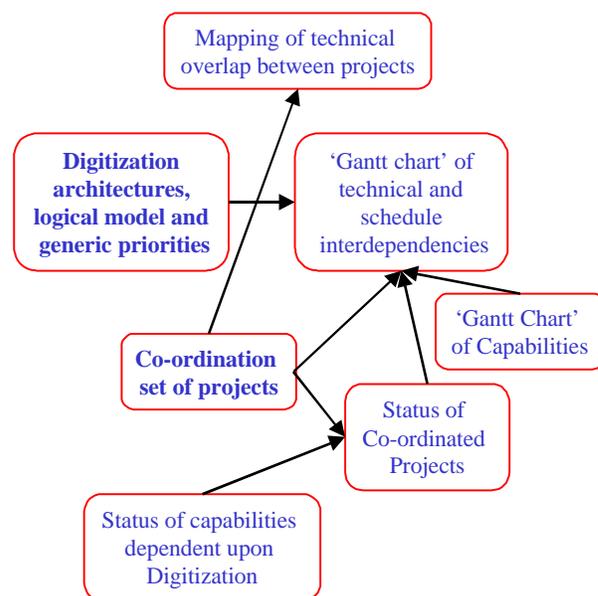


Figure 6 : ‘Gantt chart’ and status of Co-ordination Set

Figure 7 shows the Foundation Knowledge sets required to maintain a clear understanding of relevant standards. By maintaining a mapping of relevant available standards (referred to here as ‘Standard’ standards) onto the Digitization Vision (as expressed in the Logical Model) the Co-ordination Activity can take rational decisions about opportunities and needs for specifying standards

3.9 Environment descriptions

The final main grouping of Foundation Knowledge identified in the route-map covers the environments relevant to the projects of the Co-ordination Set. Describing the project-specific environments depends upon having suitable descriptions of the overall environments in which Digitization exists. A key use for this Foundation Knowledge is to contribute to establishing the project-specific priorities of the Digitization programme. This, in turn, underpins the full range of decisions requiring an assessment of the value to be attached to investment or other changes.

3.10 Foundation Knowledge maintenance

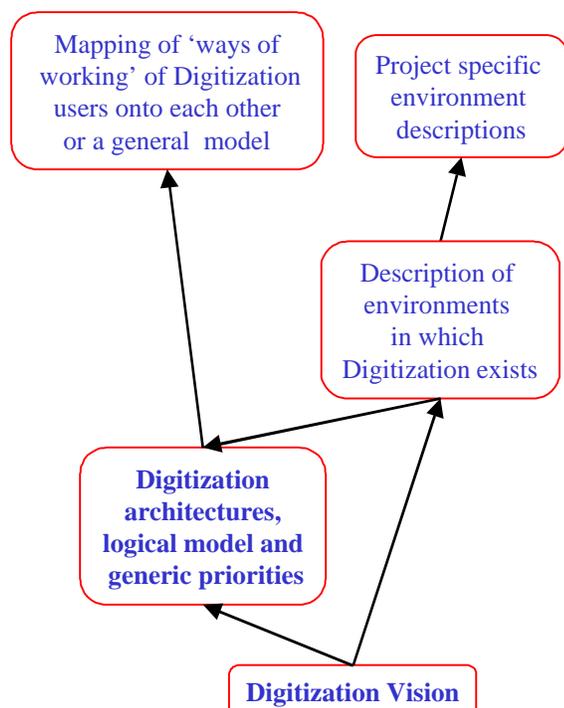


Figure 8 : Environment descriptions

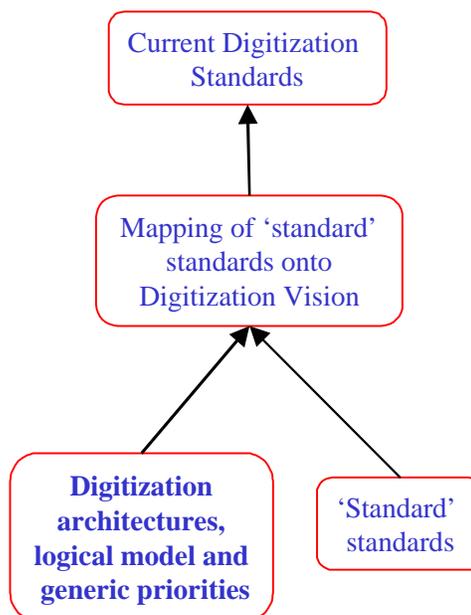


Figure 7 : Standards

The establishment and maintenance of the Foundation Knowledge identified in the route-map has been likened to a surveillance and picture compilation exercise. Like a surveillance picture, Foundation Knowledge sets form a representation of the world from which the Co-ordination Activity can derive triggers for decision-making. This implies a recurrent and managed updating process, not linked to any particular co-ordination decision or action.

Each Foundation Knowledge set can be viewed as a different dimension of the surveillance picture and each needs to be associated with an information acquisition activity which will keep it up-to-date. The combination of such activities will form a collection plan or surveillance strategy which the Co-ordination Activity will need to instigate. The surveillance strategy for co-ordination involves a number of analysis and information management activities. The route-map is intended to provide support to these activities by showing the relationships between actions, decision and knowledge requirements and by forming a management structure.

4. Using the Route-Map

The Co-ordination Route-Map provides a structure with which the Co-ordination Activity can be organised and managed. As well as describing the knowledge and knowledge creation requirements of the co-ordination decisions, the route-map can be used as a front end structure to aid management of this knowledge.

A variant of the route-map specific to UK needs has been implemented in the form of a web-site whose structure follows that shown in Figure 3. The web-site format allows the route-map to be navigated easily and hypertext links allow access to underlying documents which can be used to store status information on the various knowledge sets and decision-making activities.

Using the route-map as a knowledge management tool involves identifying opportunities for co-ordination, or recognising changes in existing plans, and planning responses which progress the Co-ordination Activity towards its goal (as expressed in the Digitization Vision).

Opportunities for effective co-ordination actions will arise principally from changes which are reflected in the Foundation Knowledge sets. These changes can be both external and internal. External changes include new technologies, changes to the military environments or changes to the Digitization Vision. Recognising external changes requires a regular surveillance (i.e. updating and reviewing) of those Foundation Knowledge sets representing the status of the Digitization programme.

Internal changes are those which arise from the actions of the Co-ordination Activity itself. These may be the results of actions intended to close a predicted capability gap, but which have additional, unintended side-effects. The

full ramifications of internal changes can be assessed by taking them back into the Foundation Knowledge sets and using the route-map to explore their consequences.

5. Summary

This paper has described the problems of co-ordinating the development of a joint force digitization programme. It has described the development of a route-map identifying the relationships between co-ordination actions, the decisions implied by those actions and the knowledge required to take those decisions rationally. The route-map is based upon the concept of a Digitization Co-ordination Activity which is charged with co-ordinating a diverse programme of digitization in order to achieve an overall Digitization Vision.

The route-map identifies diverse sets of Foundation Knowledge which must be maintained by the Co-ordination Activity in order to ensure the identification of requirements and opportunities for co-ordination. It also provides a mechanism for exploring the knowledge creation and maintenance activities which are needed to support decision making to capitalise on those requirements and opportunities.

The co-ordination route-map can be implemented as a web-based tool to support the Co-ordination Activity by providing an active, browsable form which supports decision-making and knowledge management. The tool acts as a front end for the storage of documents describing the status of Foundation Knowledge sets and co-ordination Decisions.

6. The Way Ahead

Although still in development, the digitization route-map already provides a powerful means to identify analysis and knowledge generation requirements for co-ordinating a joint force digitization programme. Future developments proposed include:

- development of metrics and tools to implement the ‘Gantt Chart’ required to project forwards into the future capability development programme to identify emergent capability gaps;
- adaptation of the route-map to cover the whole of the Digitization capability development activity as opposed to the narrower scope of co-ordination;
- introduction of more specific details in the route-map reflecting the organisation of the relevant Digitization Authority, in order to properly account for internal political and organisational aspects of management, including the need to establish influence where executive authority is not available.

