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ORIGINAL ABSTRACT

The *execution* of the close combat contact battle in the Land tactical environment, as distinct from the more *deliberate planning* of the operation, has a number of characteristics which have significant impact on command and control (C2) and on the facilities used to support C2. These characteristics stem from tempo, the stressful and potentially time-critical nature of activities and decision-making, the significance of physical location and geography, and the need for selective interworking between functional specialisms (including those which may be provided by Air, Maritime and Logistics components).

These characteristics are easily lost in conventional representations of military activity. The purpose of this paper is to discuss some examples in which we have sought to retain their visibility. The examples relate to activities at the BattleGroup level and below, including the interactions between mounted and dismounted forces. They exemplify an approach which makes maximum use of:

- targetted modelling, eschewing unnecessary detail in order to achieve specific purposes (such as informing a discussion);
- vignettes selected to illustrate particular episodes of activity which may be particularly stressful or which may exercise particular aspects of capability.

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Introduction

Over the last five years we have been required, on a number of occasions, to generate representations of the execution of military operations in the Land tactical environment[1]. This has arisen in support of both capability planning and specific (equipment-centric) projects. In both contexts our primary concern has been to express the military business[2] in operation, in order to provide context and underpinning to the analysis of technical systems (equipment) used in support of the operation.

The representations in question have usually, but not invariably, been graphical in nature. However, the issues addressed by this paper are not primarily concerned with notation, symbology or diagramming standards; the question is more *what is to be represented*? The question has to be answered in the context of the following:

- The objective is to induce understanding and elicit further input from military stakeholders, rather than to generate detailed specifications. The customers for these representations wish to take decisions, based on an awareness of alternatives and an appreciation of the differential impacts of those alternatives. Hence representations which defy appreciation (because they cannot be interpreted in terms of headfuls of information) are deprecated.

- Understanding may be gained through the promotion of discussion: this means that the representations must refer to (or declare) a language which enables people to talk, draw and argue in seeking to resolve issues. This is partly about making appropriate use of military terms and symbols, but new terminology may be useful if it supports powerful abstractions.

The purpose of this paper is to discuss the motivations behind, and principles emerging from, this modelling experience. Clearly the paper is of relevance to architectural frameworks (e.g. MODAF [1]) and notational issues, but the paper is primarily concerned with the desired content of models (*what* it is that should be expressed) rather than *how* it should be articulated.

Characteristics of the Land execution environment

The Land execution environment is characterised by a high density of entities comprising sensors, weapons, platforms, equipments, people and vehicles which need to be networked. The equipment constraints imposed by vehicle installations, man portability and high stress lead to the requirement for simple MMI, small size, low weight, limited power and wide environmental operating ranges.

In Close Combat operations, close proximity to the enemy requires low- latency and high-reliability information and intelligence, as well as the need for graceful

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[1] I.e. the *Land execution domain* as it is referred to in this paper.

[2] Although the use of the word 'business' sits unhappily in the context of military affairs, we use the word persistently to emphasise that we are not building a model of (technical) systems.

performance degradation and/or equipment re-configurability in the case of damage or failure. Equipment prone to capture must be easy to 'switch off' and purge remotely.

Forces in the Land execution environment are characterised by specialisation (Armour, Infantry, Indirect Fire, Combat Engineering, etc.). The very constitution of the BG is predicated on the necessity for co-operative behaviour by interworking between these specialist teams, as evidenced by the integration of the logistics chain with the fighting elements, and the use of mortar fire via the Mortar Fire Controller. Co-operation is typically characterised either by mutual support and/or mutual protection, or by the composition of 'process-chains' of the type 'sensor – decider - resource – effector'. The variety of these combinations reflects the diversity of environments, targets and effects to which Land operations may relate.

The ability to address this variety of military objectives rests on the flexibility with which the force can be composed of these interworking specialisms, reflected in the capability to Task Organize (on a *deliberate* timescale) and to dynamically re-plan in support of execution (on a more rapid *dynamic* timescale) [2]. There is a requirement to maintain the tempo of operations, which means that re-planning and re-configurations must be expeditable with rapidity.

For the individual soldier, the dominant characteristics of the execution environment are stress (physical and psychological) and urgency. Soldiers need to interact with each other and yet, in Close Combat, there is a need for them to concentrate on their own tasks, whilst retaining high confidence in their colleagues. There is a need to maintain *command dominance*, an understanding of the battlespace that is appropriate to their objective or task, including information requirements, user interface, and workload considerations.

This is achieved through a combination of training, procedures and structures, wrapped around an appropriate use of the available technology. Because of the need for reliance, assurance and trust where there are dependencies on others, personnel in the Land execution environment have a strong preference for the use of voice[3]. The use of digital in this environment is largely untried and untested. With greater familiarity, digital sharing of information may prove in time to be a useful complement provided that it remains purposive, i.e. is clearly related either to the specific task in hand or to the maintenance of military inter-dependencies between personnel and between specialist capabilities.

Whilst acknowledging the impact on the individual of the stress and urgency of the execution environment, there is a need for MOD, through its capability programme, to gain leverage from technology in order to respond to the strategic drivers and pressures on the use of ground forces:

- Accountability of actions with respect to political and strategic direction of forces
- Avoidance of collateral damage

[3] The eyes are the pre-eminent human sensor enabling the soldier to dominate his personal battlespace (his immediate environment). In these circumstances, use of hearing to maintain broader awareness has merits in that it can function concurrently and without interrupting the primary visual sensing.

- Avoidance of fratricide
- Demands for the increasingly effective use of assets and resources (reflecting pressures on defence budgets).

All of the above characteristics – the inter-working, the maintenance of command dominance, the reconfigurability – point to there being enormous potential for the Land execution environment to exploit networking and the principles of network-centric warfare. The NEC Handbook [3] suggests that NEC offers decisive advantage through the timely provision and exploitation of information and intelligence to enable effect decision-making and agile actions. It includes, in a list of likely impacts of NEC, the following:

- Integration of sensors, decision-makers, weapons platforms and support capabilities to enable agility and thus enable commanders to better synchronise effects.
- Enhanced force protection and the reduction of fratricide.
- Optimising the efficient use of available resources, in a robust operational support structure, by improving the precision and timeliness of logistics, medical and personnel information.

These benefits have not yet been proven or shown to be technologically viable at tactical close combat level in the Land environment. However, current practices can be viewed as making extensive use of networking already (albeit almost entirely human-based networking[4]), whilst the Army Field Manual DP BG [4] already defines structural reconfigurations which mirror the NEC principle of agile grouping, "often swiftly formed and optimised to conduct a specific mission or task, and once it is completed, will rapidly regroup for the next" [3]. The challenge is to facilitate and exploit better these networking and reconfigurational activities, rather than simply discarding them.

There is a need to recognise where the possibility of changes can be entertained (e.g. could the Forward Observation Officer's decision-making role in a strike process be fulfilled by a suitably-trained Manoeuvre Officer?) and where there are sound underlying principles which ought to be preserved. Moreover the characteristics of stress and tempo, and the individual's need to maintain command dominance, represent significant factors in embracing networking.

The modelling approaches described in this paper are all aimed, in some measure, at refining our understanding of the desired form of operational networking. The challenge is to facilitate and exploit better current networking and reconfigurational activities, balance the technical advantages of digital networking (volume, speed and variety of information exchange, reach, etc.) with the reactivity, flexibility and agility of human-orientated (and voice-implemented) networking.

[4] With its attendant human-centric attributes, including non-determinism and resilience.

Maintaining a balance between analysis, experimentation and demonstration

MOD's programme to enhance its Land execution capabilities (from the pursuit of NEC principles and the establishment of the NITEworks programme, to the Soldier Modernisation programme centred on FIST) has been characterised by a desire to put practical experimentation and demonstration to the fore. This reflects the perception that:

- Non-technical (e.g. human) and systemic behavioural aspects are perceived as difficult to capture in paper-based analysis or mechanical models.

- There are significant challenges in proceeding from laboratory-scale concepts to military-strength solutions, and hence demonstration activities are seen as providing significant risk reduction and increased confidence in relation to proposals.

However, practical experimentation and demonstration must be preceded by the generation of candidate concepts and solutions and the exploration of alternatives. Moreover, experiments and demonstrations should always be conducted within a well-formed framework of conceptualisation and measurement, without which it is impossible (a) to conduct an experimental design or (b) to assess and interpret observations. Analysis / modelling and experimentation should be viewed as complementary.

Indeed, experience with MOD's NITEworks programme has led to the recongition that more 'up front' work is needed, in order that bounded experiments can be launched with:

- Candidate solutions described and analysed.
- System architectures understood.
- Experimental questions defined.

Prior to this, there is a need to establish that there is a bounded question; and prior to this, that there is a bounded problem: both of these obligations fall to analysis and modelling to satisfy.

There is an implicit requirement for MOD's programme of work to balance the need for practical experimentation and demonstration (bearing in mind the known costs and complexity of large-scale trials and exercises) and the need to generate and explore a range of candidate concepts and solutions. Figure 1 [5] summarises the relative strengths of different forms of study activity.

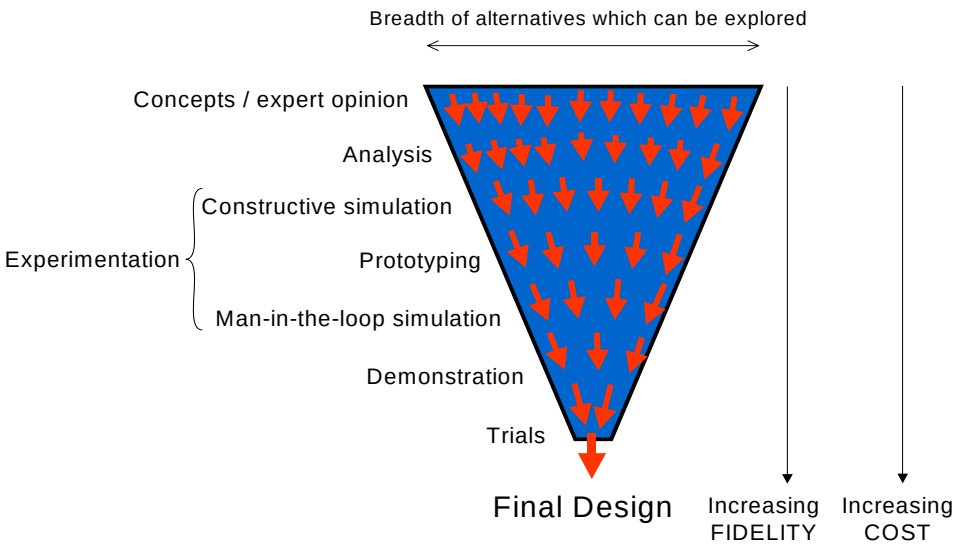

Figure 1: Cost, fidelity and ability to explore alternatives using a range of approaches

The construction of paper-based models and their analysis can never create the fidelity of understanding (from the individual user's perspective) which situated man-in-the-loop experimentation can achieve. But through our use of the modelling approaches described in this paper, we have been able to capture principles (which could be described as the *architecture of collective behaviour and performance*) in ways which have enabled military SMEs to achieve a crystallised understanding of the key C4I issues.

Vignettes and episodes

To be able to relate to models, military SMEs want to see military capability 'in action'. They can relate more easily to the portrayal of realistic events and event-sequences (vignettes) than they do to general or context-free questions (e.g. "How accurate do you need blue forces positional information to be?"). Vignettes are also valuable because they help us to identify key behavioural / performance characteristics which are likely to be key drivers of the form of feasible solutions (implemented through procedures and CIS).

Vignettes have to be modelled using a consistent set of elements which derive from *architecture*, which we describe as a set of building blocks plus a set of rules for how they can be put together. This formula clearly applies to the technical world of IS and communications network configuration, but it is also true in the 'military business' domain: the force is composed of functional-specialist units and sub-units, who carry out defined procedures according to doctrine and training. Architecture (blocks and rules) are the basis for equipment architecture; vignettes, which represent 'use cases' for architecture, are the basis for procedures and training.

Vignettes have to be selected and scoped intelligently. We have operated on the principle that the key requirements derive from a relatively small number of situations which can be described as 'stressing events' or 'stressing episodes', which exercise the man-machine system more profoundly than it is exercised in routine or quiescent

periods. Stressing events and episodes include atomic events (e.g. Check Fire, Air Alerts), configurational events (e.g. Change of Control, Regrouping), connectivity issues (e.g. in context of deep operations), continuity (e.g. reversion to manual modes, and recovery from reversionary mode) and compound events (e.g. casualty evacuation), all of which have to be analysed in the context of prevailing or 'background' activity.

It is also appears to be the case that the impact of different conceptual solutions can be seen in sharpest relief in relation to specific events or episodes. The result is that there are significant modelling economies which can be exploited:

- Vignettes can be captured superficially and then drilled-into to provide an expansion of detail at critical junctures.
- Different scenarios can be evaluated for their capacity to give rise to stressing events or episodes.

Whilst stressing events and episodes may provide the focus for this modelling activity, the analysis must be placed in the context of prevailing or 'background' activity. It is possible for the scope of event / episodic modelling to be too narrow, with the result that the context is not sufficiently understood. This appears to be a favourite failing of the 'kill chain' style of analysis, in which participants are modelled as eagerly standing around waiting for the informatic parcel to be passed to them and the questions "Who are these participants, and why are they waiting?" are never addressed. The defence against this is to do a proper stakeholder and process analysis against which to set the vignette description, as shown below for a sensor-decider-effector link.

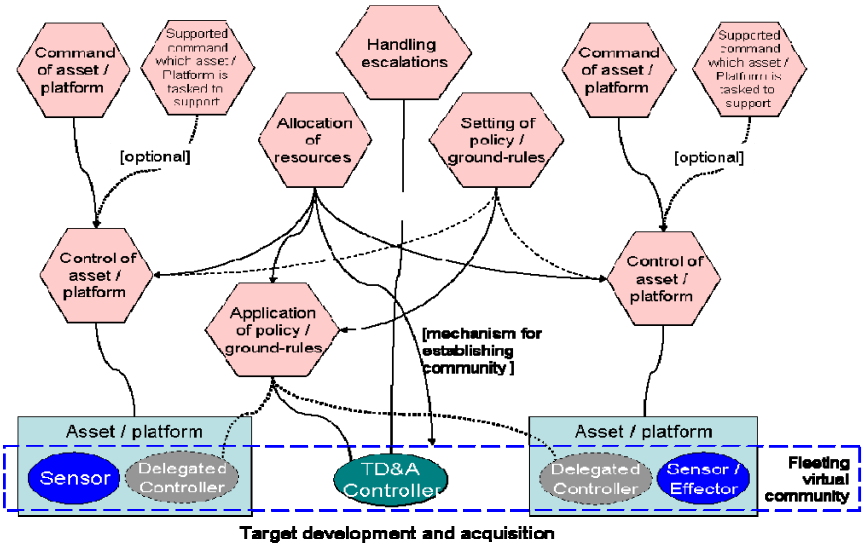

Figure 2: Roles and responsibilities in relation to sensor-decider-effector links

The modeller should use this kind of 'backroom' analysis in order to ensure that the vignette or episode description is complete.

There is another important message attached to Figure 2: this is the sort of diagram which should <u>never</u> be shown to military SMEs. As it happens, this one was shown

unintentionally to a military audience and the reaction was virulent: comments included "dangerous and unrealistic over-simplification", "BG personnel and planners don't think in 'kill chain' terms", "does not reflect the multiplicity of sensors and effectors" and "masks the urgency required at BG level".

Whilst there are undoubtedly limitations and deficiencies in Figure 2, patching up the diagram is not the issue: the challenge is to appreciate the distinction between the world of analysis and the world of action.

Information and action

There is a danger in modelling 'military business' of focussing on the systematic and missing the systemic: in particular, there is a danger of describing the carrier-pigeon business[5] and not the world of cognition, decision-making and action which it is there to support. Bell [6] draws a vivid distinction between the worlds of information and of action, which in warfighting is concerned with the controlled use of violence. A plethora of cultural and doctrinal issues contribute to the observation that the integration of information does not lead inevitably to better decision-making, but two areas stand out in the tactical arena:

- The need to maintain command dominance, which includes the avoidance of information overload but also expresses the cognitive state of 'feeling in control of the situation'.
- The need to live with uncertainty, recognising the diminishing returns of more information, the irreducible uncertainty which will always remains and the negative impact of information acquisition and appreciation on the ability to maintain tempo (more accurately, achieve temporal compression).

This is a significant challenge to the modeller who wants to generate models capable of being understood and appreciated by a military audience, rather than simply capable of generating technical specifications. It means, for example, that the modeller has to embrace the non-determinism associated with human perception and decision-making, rather than being drawn to the deterministic and 'objectified' world view encouraged by technical descriptions. This is a classic differentiation between 'soft systems' and 'hard systems' methodologies.

On a practical level, these objectives are achieved partly by the use of vignettes to situate the discussion in a familiar, military, context, and through the cues which are embedded in the contextual description of vignettes and the use of schematics which emphasise the dominant characteristics of action in the Land execution domain, time and space[6]. But it also achieved by pitching the granularity of description at the right level, which relates to the choice of abstraction. The next Section describes one of the most powerful abstractions we have used, that of communities.

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[5] Information modellers are fond of claiming that their models are 'technology-free' or 'implementation-independent', and hdence that they would remain equally valid if the information was conveyed by carrier-pigeon.

[6] Using map- or –schematic- based representations also helps military practitioners to use their 'focussing' skills to interpret what they are looking at in terms of a headful of information at a time.

Communities

We earlier contrasted the technical capability of networking to facilitate interworking unimpeded by distance (in both spatial and formal organizational terms) structure with the human need to maintain command dominance, a strong element of which is 'focus on the task in hand'. A balance must be sought between the needs of the force as a whole and the needs of the individual.

It is our belief that military personnel achieve this balance themselves by exercising a strong differentiation between their immediate collaborators and the broader force, and their willingness and ability to share and appreciate information is factored similarly. This gives rise to the concept of a community [7] as 'the set of collaborators with mutual trust'. Since trust comes from training and working together, communities will often (but not exclusively) be centred on a pre-existing team of functional specialists, to which other may be affiliated.

This moves the expression of the 'networking problem' (in the Land execution environment) from the level of individual behaviour to that of collective behaviour and performance: how can we build and maintain and re-configure communities, and how can we support (and extend) interactions between communities?

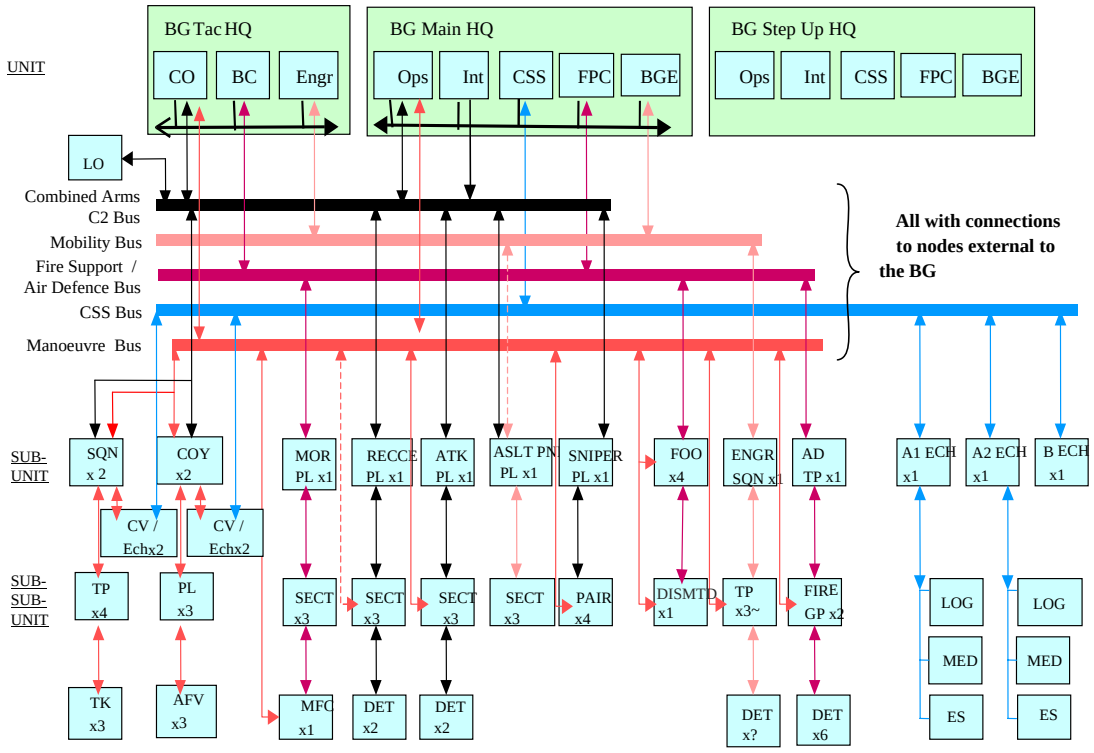

Figure 3: An illustrative diagram of communities within a BG – vertical lines indicate affiliation to communities, shown as horizontal bars [7]

Communities have a strong imprint not only on the organizational structure of interworking, but also on the linguistic structure (i.e. the information model,

semantics and pragmatics). Communities of purpose[7] (e.g. indirect fire) have a defined military language, which may be exemplified by a set of formal messages. Historically they have also had a strong imprint on the structure of communications technology, with communities having their own radio nets. Communities therefore provide a modelling concept capable of bringing the social, linguistic and technical components of networking into a common framework[8].

Note that technological capabilities and constraints (from legacy systems and feasible potential systems) may be part of the model – we are not solely interested in building 'unconstrained' or 'ideal' models. Constraints from technology (e.g. bandwidth, HCI) and people (span of attention, ability to multi-task, etc.) are 'first-class' elements in the systemic description. If appropriately abstracted, this is entirely consistent with the military viewpoint and the world of action: the military mind does have continually to reason about, and take action in respect of, technical constraints and capabilities.

Community views can also be overlaid on other views: Figure 4 below shows a fragment extracted from a larger view of communities operating on a geographical background. This exemplifies the earlier argument about homing in on a particular event to discuss issues of more general significance.. In this case the Coy-level Manoeuvre community is shown as extending across a number of force elements to provide a basis for the distribution of SITREP and CASEVAC messages in the wake of an air attack.

[7] All of our communities are, in the first place, communities of purpose which live in the action domain. In contrast, the term *communities of interest* is widely used within UK MOD, which appears to us to be seeking to place communities first and foremost in the information domain.

[8] They also provide a vehicle for showing up differences in characteristics (between people-based and technology-based networks) which can be potential inhibitors. Whilst people-based communities can, because their nodes can reason, flex to grasp a fleeting advantage or respond to the unexpected or exist in multiple changing layers, technically based information networks are far more rigid, and offer homogeneity of information access and speed of information exchange as a substitute for agility.

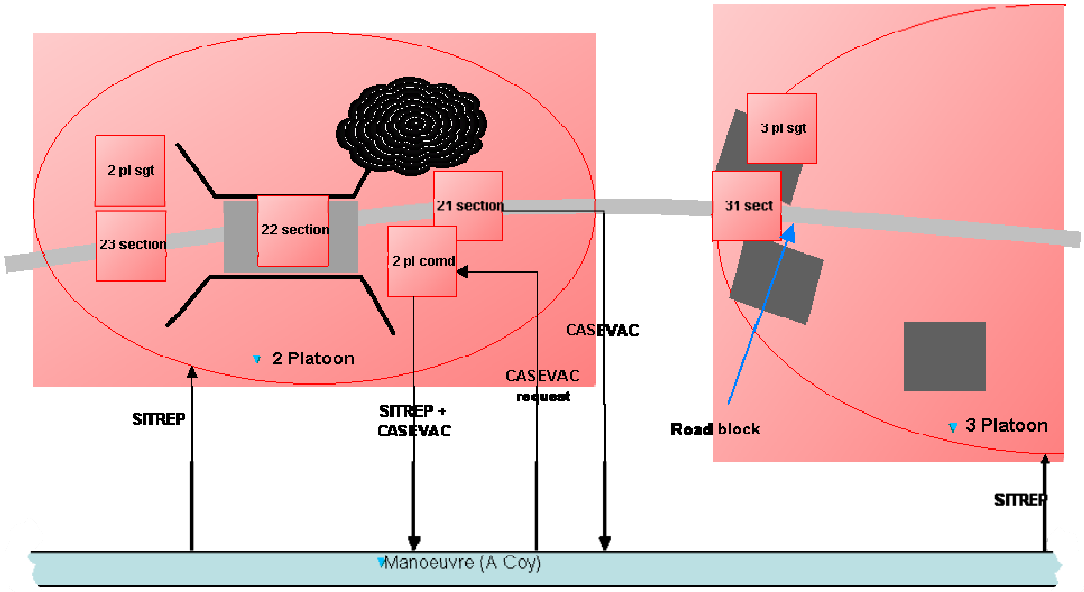

Figure 4: Extract from vignette description dealing with aftermath of air attack in the context of a bridge demolition

The key to the power of expression of communities is the vigorous abstraction applied to descriptions of the technological means (e.g. all-informed networks), teams (training, procedures, roles) and information. We have used community-based modelling as a vehicle for seeking to understand:

- The ability to achieve cohesive action within and between military specialisms, which then drives command and information considerations.
- The need for agility (organizational / social reconfigurability), which drives requirements for reconfigurability of information services and networks.
- The need for mobility (cognitive, psychological, technical) of the individual, which reflects moving between roles in multiple communities.

This has led to a number of representations being used, including:

- Affiliation matrices: community inter-connection matrices, which are useful for identifying the different modalities which may pertain to an individual's or group's membership of a particular community (see Figure 5).

- 'Clouds', which are a 'linguistics-free' way of expressing an ability to form an all-informed communities (at different scales, or different levels of command), each of which may be achieved in practice by being supported by an all-informed communications network, or by patching across multiple networks) (see Figure 6).

		Coy A Comd	Coy A 2IC	Coy B Comd	Coy B 2IC	Coy A CSM	Pl A1 Comd	Pl A1 Sgt	Pl A2 Comd	Pl A2 Sgt
Protect	AD	✓	✓	✓	✓		✓	✓	✓	✓
	NBC	✓	✓	✓	✓		✓	✓	✓	✓
CSS	Command		✓		✓					
	ES									
	Log					(✓)				
	Med		(✓)		(✓)					
CIS	BG		✓		✓					
Manoeuvre dismounted	Inf Coy A	✓	✓	✓		✓	✓	✓	✓	✓
	Inf Coy B	✓		✓	✓					
	Inf Pl A1	(✓)					✓	✓	(✓)	
	Inf Pl A2	(✓)							✓	✓
	Inf Pl B1			(✓)			✓			
	Inf Sect A1a	(✓)					(✓)	(✓)		
	Inf Sect A1b	(✓)					(✓)	(✓)		
	Man Sp Sect A1c	(✓)					(✓)	(✓)		
	Inf Sect A2a	(✓)							(✓)	(✓)

Figure 5: Extract from a matrix showing actors (columns) and their affiliations to communities (rows) within a BattleGroup

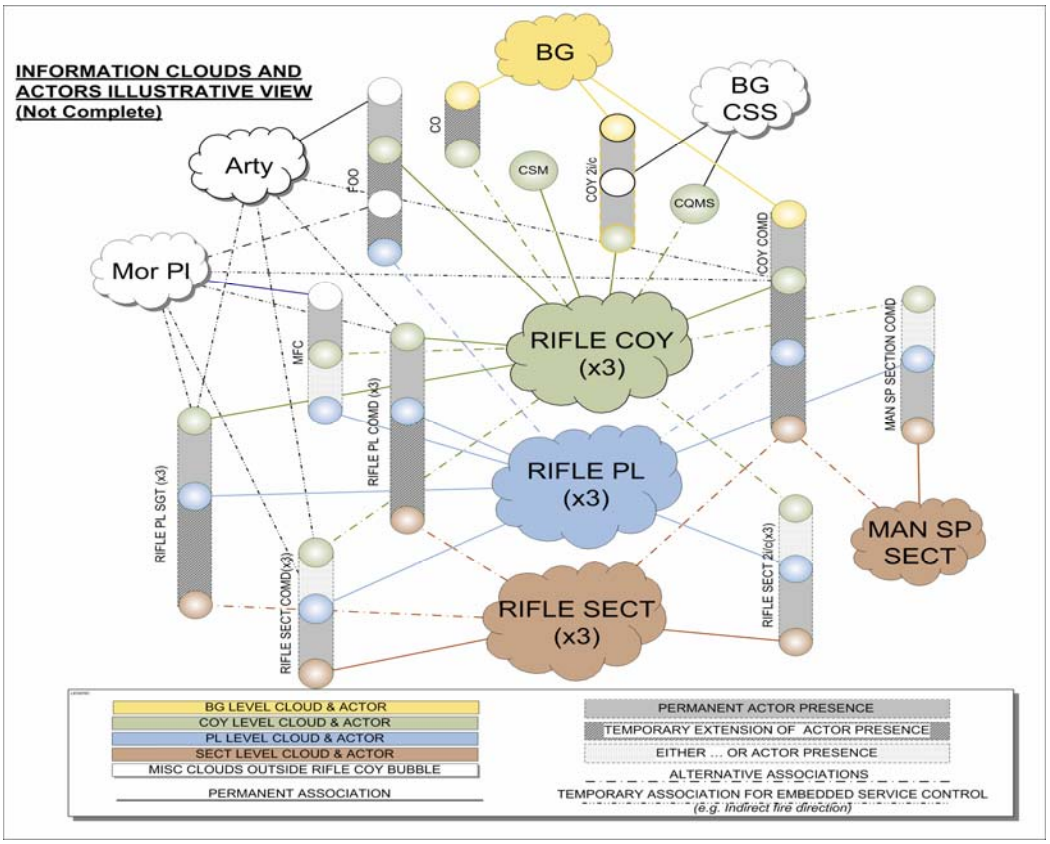

Figure 6: Illustration of the use of clouds to model structure and interactions within the Land execution environment

In summary, communities are highly pertinent to the representation of the Land execution environment in respect of seeking advantage from networking.

Inter-working and its dimensionality

We have discussed inter-working in the context of one of its possible mechanisms (cross-affiliation between communities) and in general terms of its dependence on networking in some form. But what is meant by inter-working? Can it be described in its own terms, or can we only talk about its consequences (e.g. information exchange requirements)?

The aim that modelling should 'tell a story', rather than simply generating 'objective' data for someone else to try to interpret, has required us to employ a 'language of inter-working' which is both descriptive and conceptualising. This language identifies a number of characteristics which may vary in different circumstances, essentially to describe who is co-operating, and in what degree. Many of our models of the Land execution domain have sought to expose precisely such characteristics, showing what is being achieved by inter-working and what are its implications for command and information sharing. Annex A provides a brief summary of the terms used in this language and referenced in the succeeding discussion.

Analysis of a number of vignettes describing dismounted Land operations at the Company, Platoon and Section level (i.e. attack, defence, cordon, urban operations vignettes) revealed that, in these terms, the dominant emerging requirement was for coherent interworking and a participative control style. The latter could be achieved by virtue either of the 'spanning commander' being embedded (i.e. fully engaged in the inter-working task) or of him having delegated to a more consensual (peer-to-peer) form of control being exercised between the inter-working elements (notably in the Urban Operations vignette).

The modelled vignettes identified the maximum size of teams which exhibit coherent interworking and a participative style of execution control, corresponding to inter- and intra- platoon level working (with some supporting battlegroup and combined arms force elements). The vignettes also showed that the optimum team size is dynamic and dependent on the task and the 'execution' phase of the operation (i.e. advance to contact, platoon, or trench clearing, section).

Consistency requirements for interworking

The preceding discussion shows how a general classification scheme allowed us to express inter-working requirements in particular circumstances. However, we can also make the more general observations that:

- There are certain consistency requirements which result in there being only a finite set of combinations of the collaborative index and the engagement index which make sense.
- The different combinations make differential demands on C4I.

Permitted combinations are shown in Figure 7.

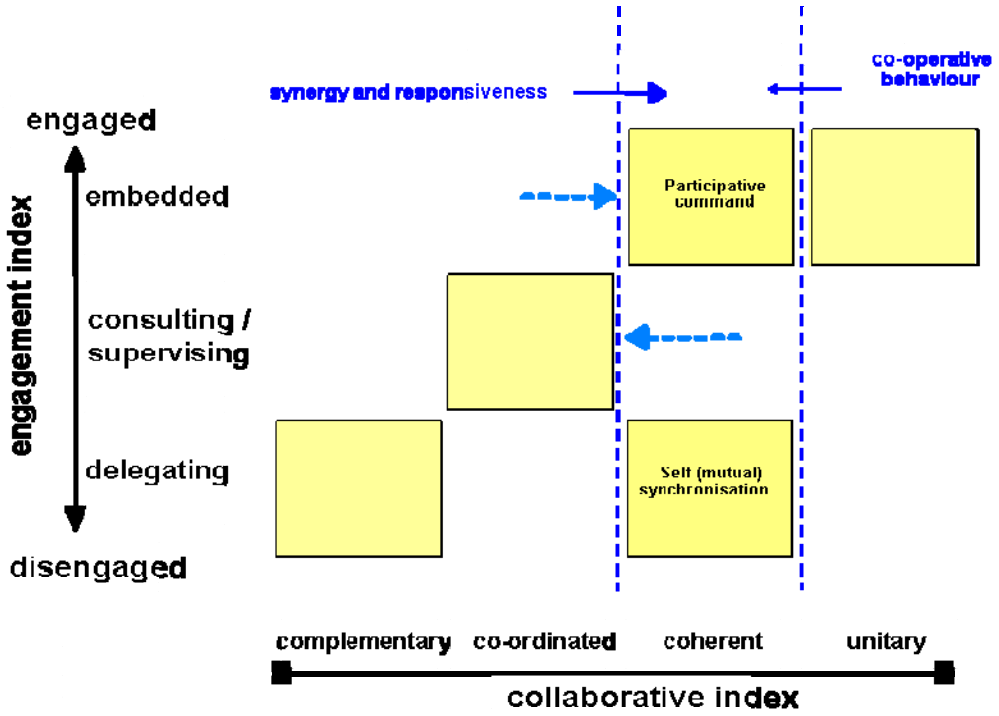

Figure 7: Permitted combinations of collaborative index and commander's engagement index

Hence, some cells in Figure 7 are shown as blank because they are logically meaningless (e.g. there is no co-ordinator in the 'delegated / co-ordinated' cell). The two cells with dashed arrows are logically possible but, we suspect, unstable: there is a tendency to move in the direction indicated. The cells labelled 'participative command' and 'self-synchronised' are the two forms of participative control described above.

The differential demands on C4I are more subtle than is revealed by the cold analysis of atomic information exchanges and radio network range. It is, for example, UK practice to employ Personal Role Radio to fulfil a discursive or 'chat net' role; any attempt to introduce 'command net' protocols could actually undermine attempts to promote coherent behaviour through a participative command style.

Interactions and information

Having discussed communities and interworking, the final section of this paper addresses the consequential information exchanges. In modelling Land execution activities, we have found it important to distinguish clearly between transactional (outcome- and event-driven) flows of information and non-transactional (background) flows of information in support of situational awareness.

Some information flows have transactional qualities, as exemplified by the need to support the class of interactions concerned with sensor-decider-effector co-operation. Something as simple as a target hand-off implies a data content which may be little more than target co-ordinates, but there is also a transaction taking place between the

sender (who has sensed the target) and the recipient (who is being asked to engage the target).

This transaction rests on the roles and tasking of the participants. Importantly, these are not necessarily formally-defined. Either side of the transaction may have adapted their role or task by command or as a self-generated response to local conditions and/or needs. Indeed, for the recipient, the transaction itself may result in this adaptation occurring. The behaviour of the participants will be implied or cued as much by the 'envelope' (e.g. the message type and header) as by the 'contents'.

Some of this flexibility is lost in the technologically-inspired concept of a 'kill chain', which tends to be a rigid construct which is not required to flex in unexpected (but potentially) advantageous ways. Another potential problem stemming from focussing exclusively on 'kill chains' is that this risks losing sight of the information flows which maintain the capacity, willingness and responsibility of individuals to generate and respond to these transactional flows. This includes the maintenance of 'background' situational awareness, which includes the general view of the battlefield situation and the commander's intent. These 'background' flows do not have the same transactional qualities. There is no explicit relationship between the originator of the content and the consumer[9].

The 'picture' metaphor is used to describe a mechanism by which information is aggregated, either implicitly (through its appearance on an all-informed network) or implicitly (through its aggregation and/or collation by a 'picture compiler' and its subsequent dissemination). In the case of the second option, the credence and relevance which the recipient places on the information derive in the first place from his understanding of, and confidence in, the compilation process; the first option (the all-informed network) achieves trustworthiness through a combination of originator recognition and network protocol.

This 'picture' metaphor (and its implementation through digital operating or tactical pictures) is highly appropriate to non-transactional information flows. Application of this metaphor is not debarred from supporting real-time needs, but it is not a good way of describing transactional information flows. Lodging information in a picture which is used by many people is not a good way of getting a specific individual to react in a particular way[10]; and, again, the appreciation of a digital picture requires the visual attention of the recipient.

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[9] [9] uses the terms 'task-orientated' and 'task-free' information to highlight what is approximately the same distinction as between 'transactional' and 'background' information, except that the immediate commander's intent would be classified as 'task-orientated background' information.

[10] This simple rule can be broken by the familiar expedient of confusing the concept with its implementation, so here are a couple of apparent exceptions whose more careful analysis serves to prove the rule:

a) A peer-to-peer message on an all-informed network serves a primary transactional purpose and a secondary non-transactional one (of contributing to broader SA) – clearly we are not going to implement this by sending it a second time to achieve the secondary purpose, and yet conceptually the two information flows are different.

b) It is perfectly possible to implement what is conceptually a peer-to-peer message by storing its content in a database and then sending a notification to the intended recipient. The earlier

There is no doubt that, historically, messaging mechanisms have been employed in order to maintain situational awareness, although some of this usage rests on the duality of all-informed networks (i.e. their ability to achieve both purposes simultaneously). So the increased use of 'picture' orientated mechanisms has the potential to improve the efficiency (and perhaps the effectiveness) of 'background' SA-enabling processes. On the other hand, the representation of vignettes with co-operative behaviour such as sensor-decider-effector links makes it abundantly clear that any attempt to support transactional behaviour via 'picture' processes will break down the provenance and trust relations on which the participants in Land execution rely.

Conclusions

The representations of military activities in the Land execution domain which have been discussed in this paper have been generated with a variety of ultimate objectives in mind:

- Informing debate on doctrine and concepts, techniques, tactics and procedures.
- Informing the identification of capability shortfalls.
- Informing Operational Analysis (OA).
- Generating specifications, test cases, use cases to inform equipment capability acquisition projects.
- Setting up computational modelling (of, for example, loading on potential communications bearers).

Our immediate goals have been more informed and accurate argument, better engagement with military expertise, and more effective analysis of highly dynamic processes in support of these analytical activities.

In seeking to devise models which can be understood and appreciated by a military audience, we have applied the following set of modelling rules:

- Descriptions of the military business in the Land tactical domain must be situated first and foremost in the world of action, not the world of information.

- Vignettes provide a better basis for gaining military SME engagement than static representations.

- Maximum use should be made of contextual cues to the military thinker, and of map- or schematic- based representations which emphasise time and space.

- Vignettes can be modelled selectively, provided that their definition and scope are supported by careful analysis. This backroom analysis will generate

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distinction between content and envelope should be recalled: the envelope expresses the terms of the transaction.

diverse representations which will give insight to the analyst but which must not be exposed directly to military SMEs.

- Understandable views come about through abstraction, and abstractions come from the analyst being prepared to commit to particular conceptual representations of military activity.

- It is unlikely that powerful representations can be 'conceptually neutral'; a purely objective[11] approach to modelling is unlikely to produce useful models.

- A corollary of this is that modellers must declare the conceptual standpoint(s) from which views have been generated.

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[11] This is probably a mythical target anyway: business modelling shares with software and systems engineering the flaw that even standardised and widely-accepted modelling notations and approaches (e.g. UML) are 'value-laden'. If you model the world as workflow, you will conclude that the solution is a workflow engine.

Annex A: Describing interworking in the Land tactical execution environment

The aim that modelling should 'tell a story', rather than simply generating 'objective' data for someone else to try to interpret, has required us to employ a 'language of inter-working' which is both descriptive and conceptualising. The aim of this Annex is to show selected elements of the 'language of interworking'.

It is not difficult to generate potential classifications of inter-working behaviour, but what is needed for modelling purposes is a marriage between an appropriate set of dimensional characteristics and the features of a situation, or class of situation. This is illustrated well by a study of interactions between dismounted forces, in which the following characteristics came to the fore:

- Organizational dimensions.
- Engagement index.
- Collaborative index.

The organizational dimensions of inter-working refer to the *depth* and *span*, in organizational terms, of the structure of force elements involved in this interworking activity. This is illustrated in **Error! Reference source not found.**, which is taken from the Army Field Manual [8].

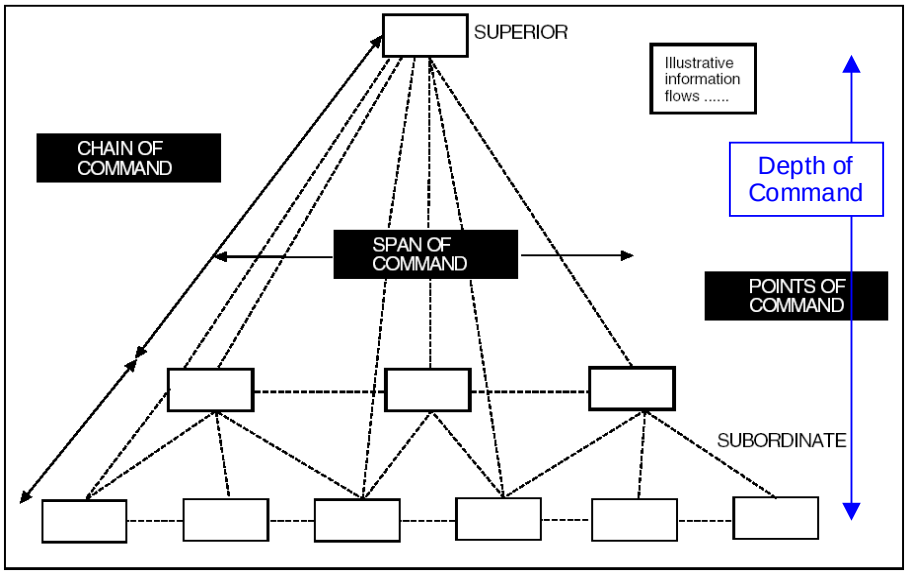

Figure 8: Interworking factors: organizational dimensions

Depth describes the number of levels of command covered by the communication means. There are a number of issues with depth that need to be considered:

- The greater the depth the greater the procedures that need to be in place to ensure it works effectively.
- Radio voice procedures tend be more formal higher up the chain of command, hence greater depth may imply a greater range of procedural formality.

- The greater number of levels of command may deliver gains in rapid response to command intent but this must be balanced against disempowering the lower levels of command. It is therefore important to ensure that the command style (see below) is correct.

Span describes the lateral coverage of the means of communication. There are a number of issues with span that need to be considered:

- Span need not be tied to normal unit boundaries but should conform to task needs.
- Span should connect all members supporting teams and groups.
- Span is dynamic and may change dependent on phase of operation (i.e. mounted or dismounted).
- Span should support co-operative engagement.

The engagement index describes the degree of engagement of the commander whose responsibilities encompass the interworking activity (i.e. the *spanning*[12] *commander*). It is closely related to command style. A commander who delegates is described as disengaged, whereas a commander who participates is fully engaged.

The engagement index is refined to recognise three categories of the commander's engagement:

- Delegating – the spanning commander delegates, through instructions, the delivery of the task to the commanders of the interworking elements.
- Consulting / supervising – the commander instructs the interworking elements to deliver a task but maintains a consultative or supervisory role to support them.
- Embedded – the spanning commander makes himself an integral part of the team(s) delivering the task.

The increasing level of engagement (from delegating (low) to embedded (high)) is paralleled by an increase in the amount of informal interaction between the spanning commander and his subordinates.

Note that:

- The three styles may cover a number of levels of command (depth).
- The commander may adopt different command styles with regard to the various activities within his area of responsibility. Hence an interworking activity in which he chooses to be embedded will be bounded by, but may not encompass, the totality of his span of command.
- A disengaged commander leaves the co-ordination of the interworking execution to the contributing force elements, none of whose commanders have

[12] We use the term *spanning* rather than *superior* for precision (since there may be multiple levels of command involved, not ust two). But *spanning* may also arise through delegation via TASKORG and tasking, so the superior commander may effectively elevate one of his subordinates to the spanning role for the duration of the task.

'spanning' authotity and hence who must adopt a more consensual style of execution control.

- With delegating and consulting / supervising[13], the superior commander interacts with the subordinate command level; when he is embedded he may interact with all members of the team or group.

The collaborative index defines the type of collaboration required between teams, groups and individuals to ensure the successful delivery of a mission. This can be categorised as follows[14]:

- Complementary - there are a number of different tasks, the completion of which will successfully achieve the mission but there is no close interaction between tasks.
- Co-ordinated – there are a number of different tasks that are mutually supportive (or have the potential to conflict) and therefore require co-ordination to ensure the successful completion of the mission.
- Coherent – a number of distinct tasks, each of which only makes sense (i.e. achieves a useful end) in the context of the whole, thus requiring a level of integration (in time, space and effect) which goes beyond support or de-confliction.
- Unitary – the tasks are so inter-dependent that it is not possible to isolate the individual activities, and hence one combined team working as a unit must effectively perform the combined tasks.

[13] We have tended to use the term 'consulting' to relate to (re-)planning and the term 'supervising' to relate to execution.

[14] This scheme is based upon a categorisation offered by Gen Sir Rupert Smith.