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How can Network-Enabled Capability contribute to better Command and Control?

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How can Network-Enabled Capability contribute to better Command and Control?[1]

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Abstract

This paper reports some of the findings of a FY-03 study for DEC(CC&II) on the need for Network Enabled Capability.   The paper outlines an analytical approach for understanding the connectivity and capacity needs for information networking posed by Fighting Operations. The approach analyses the Fighting Operations in terms of the structure and content of purposeful activity-networks. It derives structures for the employed forces and their command, examines the degree of autonomy needed across the command structures to manage the activity networks to achieve operational success, and shows how to derive the associated networked information use and flow. Additional insight includes indications of how to assist Information Management and how to recognise when Self-Synchronization is appropriate and when not.

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1. INTRODUCTION

1.1   Background

Network Enabled Capability (NEC) [1] is a UK initiative intended to facilitate improvement of the Armed Forces' total operating Capability by the use of information networking technology. NEC seeks to improve Command and Inform Capabilities [2] so that the other Capabilities may be better orchestrated and applied to achieve operational success, as illustrated below:
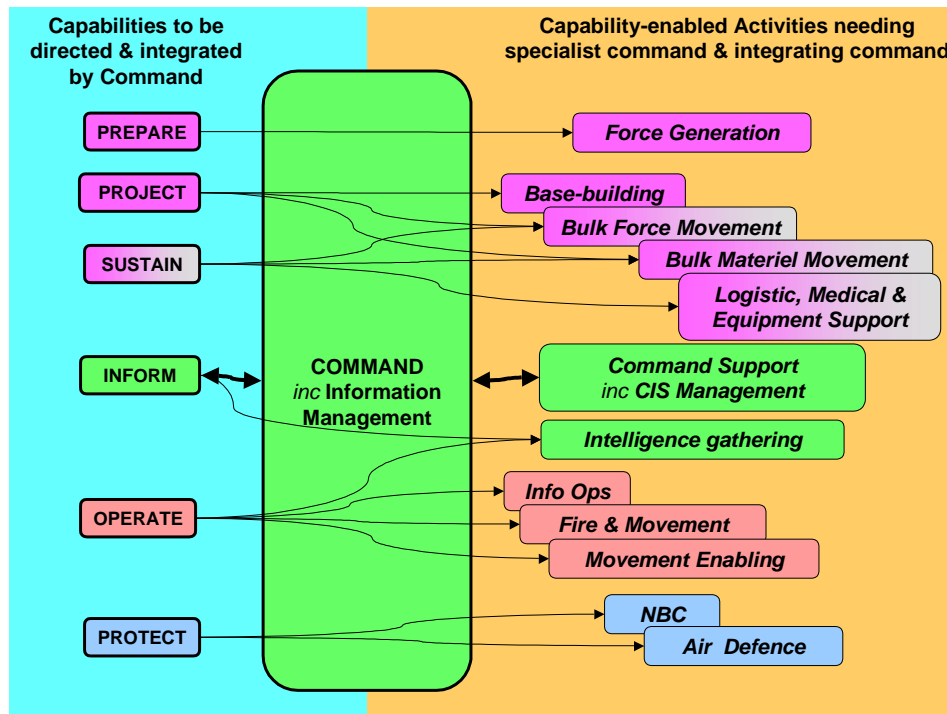

Fig 1.1 Total Capability to be improved by NEC

Information Networking involves the exchange and sharing of information products, and also collaboration in the product-generating processes mainly within the *Command* and *Inform* areas, but reaching out beyond HQs and Command Posts to the platforms and assets actually performing the physical activities of the other Capability areas.

The sharing/collaboration may occur vertically, horizontally or diagonally across a deployed Force. The information products of interest include the Situation Pictures, Plans and Orders, which flow between HQs. The products also include the information needed to target weapons, ISTAR and key items of logistic support.

The NEC-sponsored study reported in this paper examined the need for information networking in forms of Fighting[2] Operation likely to be experienced out to 2015. It did this by:

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[2] 'Fighting' implies that the use of violence, or the heavy threat of its use, to achieve desired end-states. Policing and Aiding operations were not addressed.

- Developing operating concepts expressed in activity terms, based on an analysis of likely combinations of Strategic, Operational and Tactical Ends and Deployed Force scale and capability.[3] [3,4,5,6,7,8,9,10,11,12,13]
- Using this operational background to deduce
  - The way in which command would be exercised over the military activity.
  - The implications of that 'way of command' for the networking of information flow and use.

The study team acknowledges with gratitude the expert assistance received from Lt General Sir Rupert Smith and Lt Col Nick Newell.

1.2 Purpose and provenance of this paper

This paper presents an outline view of a selection of the study's findings, in order to stimulate debate on the nature and need for NEC:
- The nature and form of future Fighting Operations, as the foundation for the other findings.
- A language and approach for describing the way in which command is exercised (i.e. for the *Way of Command*)
- The Way of Command in future Fighting Operations.
- The implications for information flow.
- The appropriateness of use of "Self Synchronisation".

The study was undertaken during FY 2002 – 2003 for MOD (UK) CMIS within Research Entity 501 of the Applied Research Programme Package 13. The study was performed by a team from the Defence Science & Technology Laboratory (Dstl) and from QinetiQ plc.

2. FUTURE FIGHTING OPERATIONS

In the remainder of the paper, UK commanders and forces are referred to as *Blue*, and adversary commanders and forces as *Red.*

2.1 Likely Types of Fighting Operation
Our study indicated that all credible adversaries would be inferior to UK and its allies in the key conventional war-fighting capabilities of command, ISTAR and long-reach firepower. There are then two likely types of Fighting Operation in the near/medium-term, which are consistent with UK Defence Policy, namely:

- *Force-on-Force*, where Red fights as an overt regular formed force, but offsets Blue superiority through the use of suitable manoeuvre and counter ISTAR tactics and techniques. To this type the study team have given the short-title *Quasi-Symmetric Fighting Operation* (QFO).

- *Counter-insurgent*, where Red side-steps Blue superiority by fighting as an irregular, distributed and covert force, using techniques of terrorism and

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[3] The source material used during this analysis has been included as a bibliography at the end of the paper.

guerrilla warfare. To this type the study team have given the short-title *Asymmetric Fighting Operation* (AFO).

In rural QFO, Red disperses to evade and dilute Blue's long reach firepower, and Blue disperses to evade and dilute Red's CBRN weapons. Both still need to concentrate forces to bring effect against the other. This places a premium on Blue force spatial and organisational agility, and on agile C2W to degrade Red's agility. These are accepted aims of NEC. The nature of Blue's ISTAR provides Red with opportunities to degrade or dis-inform it, creating situations where dispersed Blue forces encounter locally superior Red forces, and demanding a Blue ability to react quickly over distance to remedy the situation, by evasion, reinforcement, or neutralisation of the threat.

Urban QFO continues to provide Red with opportunities to defeat or degrade nominally superior Blue forces, hiding within the complex terrain, using the dense civil population as a 'human shield', and thereby forcing friendly forces to strike unfavourable trade-offs between the duration of combat and Blue and/or civil casualties. Existing and planned Blue ISTAR assets have a very limited ability to deal with targets in the urban environment. Useful NEC improvements to Way of Command and Blue urban fighting capability will be hard to find whilst this significant gap persists.

In both urban and rural AFO, Blue's intention is to impede and slow Red's ability to operate, and his ability to sustain itself. Blue must first contain Red at the Middle and Bottom Tactical levels, then defeat him at all levels (see figure 2.1 Common Structure of Operations). The backbone of the *containment* effort is control of areas, routes and boundaries, achieved by activity in the Middle and Bottom levels. This effort will be supported by rapid reaction to Red's typically short, sharp and unpredicted offensive activity, and when possible, by pre-emption of predicted Red activity. The *defeat* of Red will involve pro-active and combined military/non-military operations against his command, infrastructure and resources and to remove his support from the communities where he bases himself. Some of the rural pro-active activities will be similar to those in QFO. All AFO depends very heavily on the quality of Intelligence obtained from military and non-military sources with an emphasis on HUMINT.

2.2   The structural form of Blue Fighting Operations

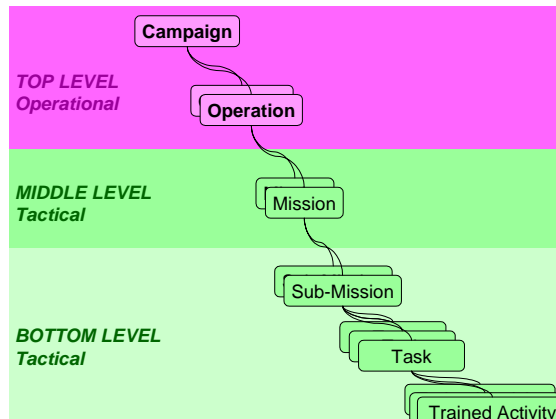Both operation types have the same three-level form as illustrated below.

Figure 2.1 Common Structure of Operations

The character of Fighting Operations can be discerned in the Ways (activities) and Means (force structures) used by the Missions. These are the tools used by the Operational Commander to achieve his Ends. The Ways in Land practice are often described as instantiations of *Operations of War* (OOW) (e.g. Attack, Defend, Delay), linked by a range of *Transitional Operations* (e.g. Advance to Contact, Withdraw, Passage of Lines etc.). The OOWs may occur as Missions, Sub-missions and/or even Tasks; an OOW at one level is generally comprised of a number of smaller scale OOWs at the next level down.   There are broadly similar concepts in Air and Maritime practice.

The scale of UK Missions will generally range from Formation to Sub-unit, with the Bottom levels one and two levels down, and the Top level one and two levels up. In small-scale missions, the distinction between a *Task* and *Trained Activity* will disappear. The command issues and arrangements relevant to NEC are not expected to be particularly sensitive to scale within each Level.

Missions will be relatively independent of each other, and will be conducted by all-arms and/or multi-Component force packages.   Missions will be performed through a *network*[4] of Sub-missions carried out by force elements, which are single-component, but multi-specialist in content.   Sub-missions will be performed as a network of Tasks, each Task being carried out as a *network* of specialist Trained Activities (TAs) performed by a force element, which will be single-component and single-specialism. The TA is conducted according to prescribed tactics, techniques and procedures (TTPs), the use of which is guided by training and experience, but may still demand some intelligence in their application to specific circumstances.

The idea of an activity network provides a means for expressing the interdependencies between the component Sub-missions, Tasks or Trained Activities. In Land parlance they are known as *Synchronization Matrices* and are used in conjunction with a map-

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[4] *Network* in the sense of a PERT or Critical Path Activity/Task Network, rather than the Informatic Network of NEC.

based view of activity and movement, to express a plan. There are three basic forms[5] of these networks as outlined below.

Complementary, in which there are no inter-dependencies between the component activities, and they contribute separately to achieving a common goal. The simple diagram below shows the activities as blobs and the independent contributions to the goal as dotted arrows:
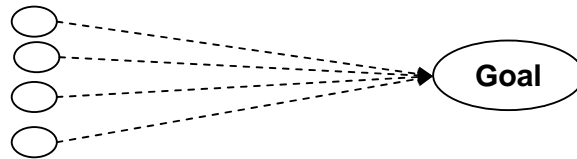
Co-ordinated, in which component activities must occur in a specific sequence in order to achieve the common goal. Some form of synchronising control is desirable to ensure that each activity does not start until the previous depended-on activities have been completed. A simple form of Co-ordinated Network is shown next, in which the sequential dependencies are shown by solid arrows:
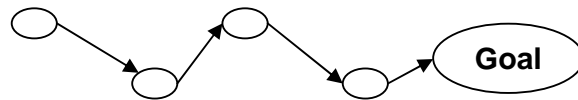
Coherent, in which some component activities must occur in parallel, or even collaboratively, to achieve the common goal. A Coherent Network may also contain sequentially dependent activities as in the Co-ordinated Network. Even more, some form of synchronising control is even more desirable than with the Co-ordinated Network to ensure that the parallel form of dependency is not violated. A simple form of Coherent Network is shown next:
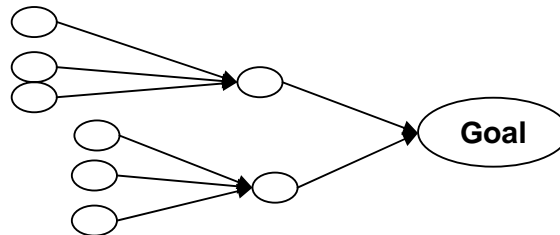
Co-ordinated and *Coherent* Activities can additionally be described as "***Connected***" where Information must flow between activities to enable the Goal to be achieved. The dotted arrows in the diagram show the required flow in the following example of a *Coherent & Connected* Network:

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[5] Due to Lt Gen. Sir Rupert Smith
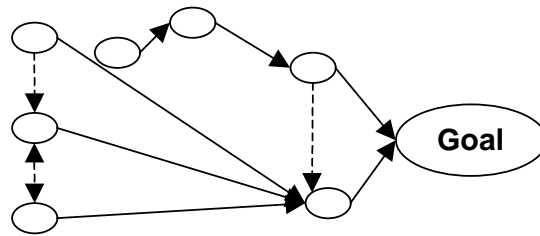
The greater the number and strength of activity interactions that exist within a network, the greater is its *Complexity,* and the greater the need for co-operation in the planning of the activities and for active synchronization of their execution. It is time-pressured Planning and Synchronising/Control, which produces the need for information networking.

The principal types of QFO Mission and the range of Sub-missions they contain are summarised below:
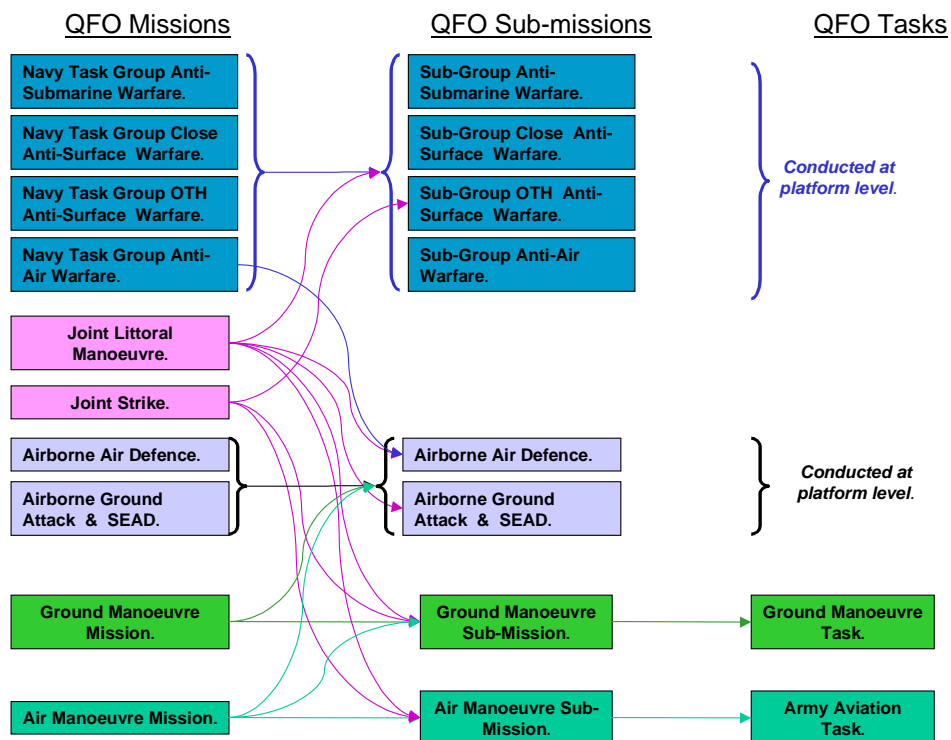

Figure 2.2 Tactical Structure of Force-On-Force Fighting Operations

AFO will make amended use of a fraction of these, and add 'Mission' types for background area control and intelligence gathering.

3.   DESCRIBING *WAY OF COMMAND*

3.1   Meaning and relevance of *Way of Command*

Way of Command is a term the study team has adopted as a convenient label for a semi-formal description of the manner in which command is exercised. The study's terms of reference limited it to consideration of NEC needs arising from the application of the current UK Way of Command to likely forms of future Fighting Operation.

The current UK Way of Command has discernible roots in command practices evolved over the last 150 years to suit the way in which UK campaigns and operations were conducted. It has accommodated the limitations of information-handling technology, which until quite recently was limited to manual processes. In UK, command is regarded as a highly personal matter, its practice is seen to be highly dependent on operational circumstance, and it has therefore not been prescribed in detail. As in the US and NATO, there is a strong convention that Joint Command[6] is only exercised at the Theatre level and above. Consequently, multi-component tactical operations are commanded in a way which splits responsibilities for *planning*, retained within the parent component, and *control of execution*, granted to the operation commander.

The scope and relevance of Way of Command is shown in the following diagram, which also shows the logic of our study. The terminology is explained in 3.2 below.

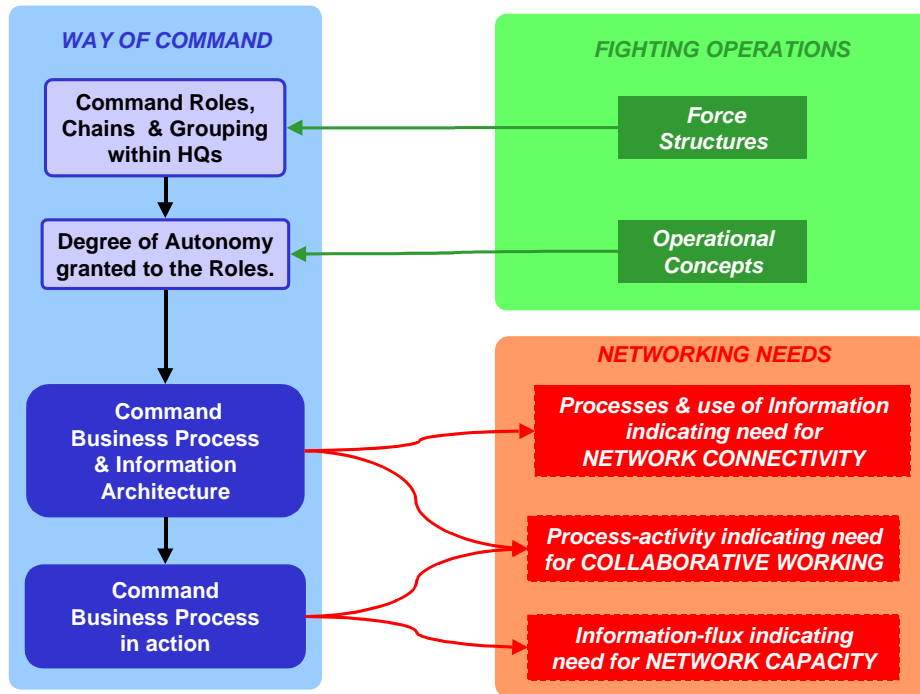**Figure 3.1 Summary of the Way of Command and its relevance to NEC**

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[6] , Joint Command occurs when *one* person commands a force containing elements of *two or more* Components, e.g. Land-Air, Maritime-Air, or the littoral case of Land-Air-Maritime.

We have pursued the analysis indicated above as far as a preliminary view of typical architectures. With this it has been possible to indicate typical hierarchies of roles and their degree of autonomy, and then to indicate the broad consequences for the nature and routing of information-flow. It is not easy to provide genuinely *general* descriptions of the "Business Process in action", except for specific operations. This indicates a need to study a number of specific 'use cases' in order that ruling case estimates of networking need can be quantified and then used to decide how to size the networks' capacities, and how to manage their use in operation.

As an aside, the study team note that this approach to describing Way of Command provides a language for defining a specific commander's intent about how command is to be exercised within a specific operation. It provides a resource for use by the embryonic *Information Management* function, which specifies what Information and Intelligence is likely to be needed when and where and by whom, and also who is to acquire what and share what with whom. This specification is needed by the (currently under-developed) *CIS Management* function to configure and control the CIS's computing and communications infrastructure.

3.2 Way of Command definitions

Way of Command has a structural and a relational aspect. The definitions associated with the former are as follows:

> *Roles*. These occur as *Specialist Command*, of the military specialisms which are provided within a Force and which need to be combined to deliver the various Capabilities in the Land, Sea and Air environments, and *Integrating Command*, which orchestrates the specialisms to achieve operational effect.

> *Chains of Command.* These show how the Roles are subordinated within a hierarchical structure, directly reflecting the structures in which deployed Forces are held and employed.

The Relational aspect deals with the relationship between a Superior and Subordinate, and has the associated definitions dealing with Responsibility and Authority, the latter being expressed in terms of the degree of autonomy granted to the Subordinate:

> *Responsibility.* It is that of the Superior to direct the Subordinate's activity and maintain and manage the Context[7] of that activity. It is that of the Subordinate to achieve the directed objective and to conduct any directed activity.

> *Degree of Command Autonomy.* This has three separate aspects:
> - *Command Freedom,* which is the extent of the problem-solving space which a Role is allowed to work within when complying with its' Superior's direction. Freedom increases as the Superior specifies more about ends and less about ways of achieving them. Higher freedoms demand more command skills, and more mutual trust between the Subordinate and the Superior granting the freedom.

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[7] The context of the activity is defined in terms of the location, type of activity, condition or potential for action of friendly, adversary and neutral assets and of the physical, legal and civic environment.

- *Depth & Frequency of Supervision*, which is used by the Superior to monitor the subordinate's intent and actions, and which may result in varying degrees of intervention by the Superior. Depth of Supervision is not necessarily tightly coupled to degree of Command Freedom[8].
- *Method of Peer-to-Peer Synchronization*, permitting two or more peer subordinates to align their activities against common time, space and/or event markers. It may implemented in isolation by individual subordinates (*self-synchronization)* or by consultation between affected peers (*mutual synchronization),* and either form may be supervised or not by the superior(s).

3.3 Credible forms of Command Autonomy

The following Table indicates credible combinations of the three aspects of Autonomy, based loosely on current UK command practice. Low autonomy occurs at the top of the table, and high autonomy at the bottom.

Freedom of Decision Level	Activity	Supervision	Synchronisation
LF1	Conduct a superior- specified Trained Activity (TA)[9] under close direction by superior	Close	By Superior
LF2	Conduct a superior- specified TA and adapts TA to a Situation.	Some	Peer-to-Peer Mutual
	Conduct a superior- specified TA and adapts TA to a Situation.	Limited	Peer-to-Peer Self
	Conduct a superior- specified TA and adapts TA to a Situation.	Limited	Peer-to-Peer Self
MF1	Conduct a superior-specified Op of War (OOW)[10] as a specified TA sequence.	Close	By superior
MF2	Conduct a specified OOW by choosing and conducting a sequence of TAs to suit the situation including decisions for when and how to transition between the TAs.	Some	Peer-to-Peer Mutual

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[8] Consider the Israeli approach of granting high freedoms but supervising closely, and intervening by exception but decisively. Also the UK approach of granting low freedom at low command levels but supervising very lightly or only when alerted by a subordinate's request for attention.

[9] See 2.2 above.

[10] Ditto.

MF3	Implement a specified higher-level OOW by choosing & conducting a sequence of lower-level OOW to suit situation.	Limited	Peer-to-Peer Mutual/Self
	Implement a specified higher-level OOW by choosing & conducting a sequence of lower-level OOW to suit the situation.	Limited	Peer-to-Peer Mutual/Self
HF1	Achieve a superior- specified objective by choosing a sequence of OOW to suit the situation, & deciding when and how to transition from current OOW to the next.	Limited	Peer-to-Peer Mutual/Self
HF2	Determine and achieve lower-order enabling objectives for a superior- specified higher-order objective.	Limited	Peer-to-Peer Mutual/Self

Table 3.3 Credible forms of Command Autonomy

Way of Command can be described by showing how much Command Autonomy is granted by each superior Role to each of its directly subordinate Roles within the branches of a Chain of Command. This static view can be animated by showing how the Roles are intended to behave and interact when stimulated by situation and events.

3.4   Operational influences on choice of Degrees of Autonomy

Our study has identified a number of operational circumstances, which influence the choice of the degree of Autonomy granted by a Superior to a Subordinate. The influences result from the interactions between the activity-nature of an operation (influenced by the adversary and the environment), and the quality of the Blue commanders and their CIS. The overall effect is summarised as follows:
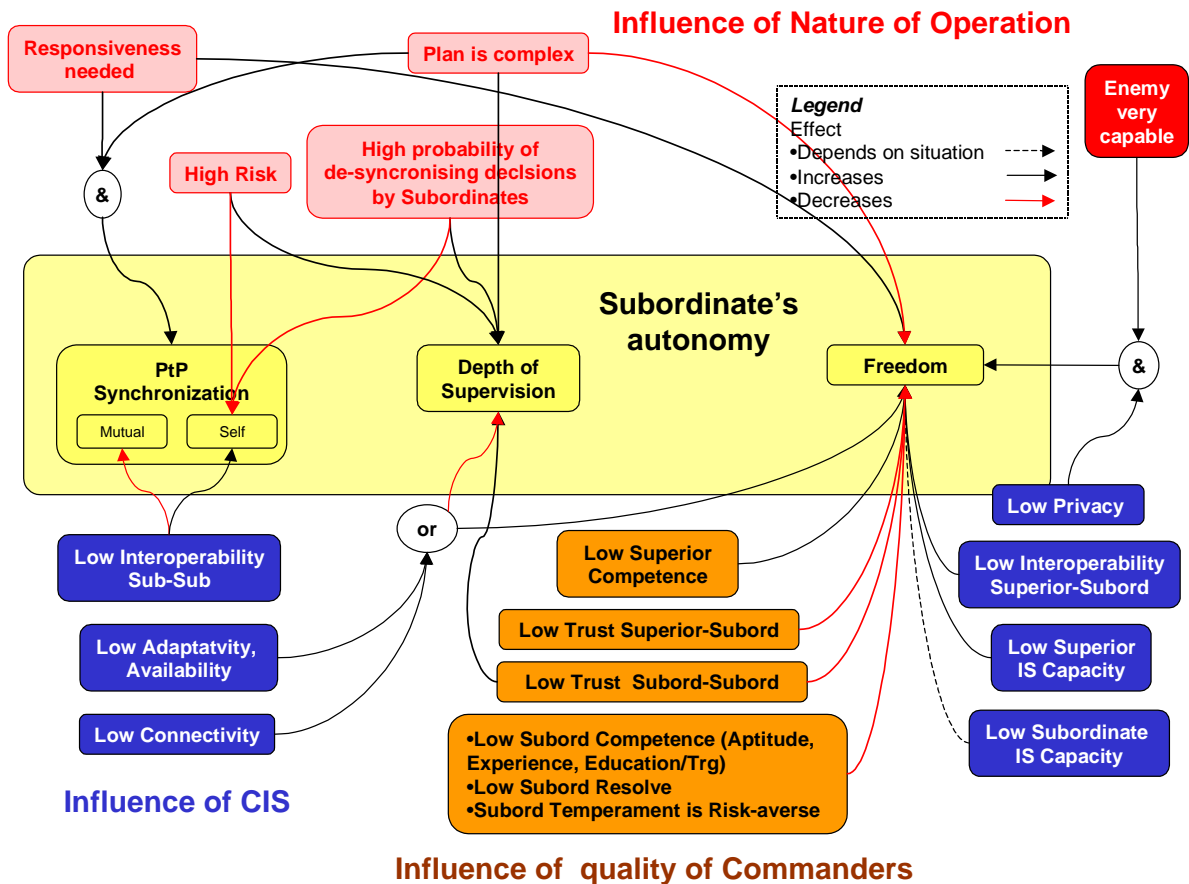
Figure 3.2 Influences on the granting of Autonomy

This diagram shows that there is a non-trivial conflict between:

- The set of factors driving an increase in Autonomy by increasing Freedom, decreasing Supervision and freeing-up Peer-to-Peer Synchronisation.
- The set of factors that inhibit these drives.

Commanders must balance these factors according to the situation that they face. Capability Managers must identify the 'ruling cases', i.e. the most-demanding combinations of these factors, to be used to guide NEC along the Equipment and Human Lines of Development.

Balancing guidance is proposed as follows:

•High Responsiveness indicates the use of Higher Freedoms. This is reinforced by lack of potential for a Superior to achieve adequate understanding of Subordinates' situation.

• Low Responsiveness permits the use of Lower Freedoms, if there are other pressures to do this.

• High Complexity requires the Synchronization of a Subordinates' activities. This can be achieved by the Superior applying some combination of:

- •Reduction of the degree of Freedom of the Subordinate.
- •Maintenance of the degree of Freedom but with an increase in the depth of Supervision.
- •Permission for Subordinates to synchronise themselves on a Peer-to-Peer basis, either by Self or Mutual Synchronization.

•High Complexity *and* High Responsiveness demand the use of Higher Freedoms with Peer-to-Peer Synchronization.

•Self Synchronization should be:

- •Ruled out when decision diversity is high, and/or when decisions have a high impact beyond the scope of the decision-maker.
- •An option when high Responsiveness is required, and decision diversity is low.
- •Considered as a fallback when communications fail to allow Mutual Synchronization activities.

•When Subordinates are over-challenged by a situation, Superiors may:

- •Reduce their Freedom.
- •Increase the depth of their Supervision.
- •Prohibit the use of Peer-to-Peer Synchronization.

4.   CURRENT WAY OF COMMAND APPLIED TO FUTURE FIGHTING OPERATIONS

4.1   Way of Command at the Top Level

This is common to QFO and AFO and is portrayed as follows, in terms of outline structure and the degrees of Autonomy allowed between the major entities (roles) in the Top-Level command chain:
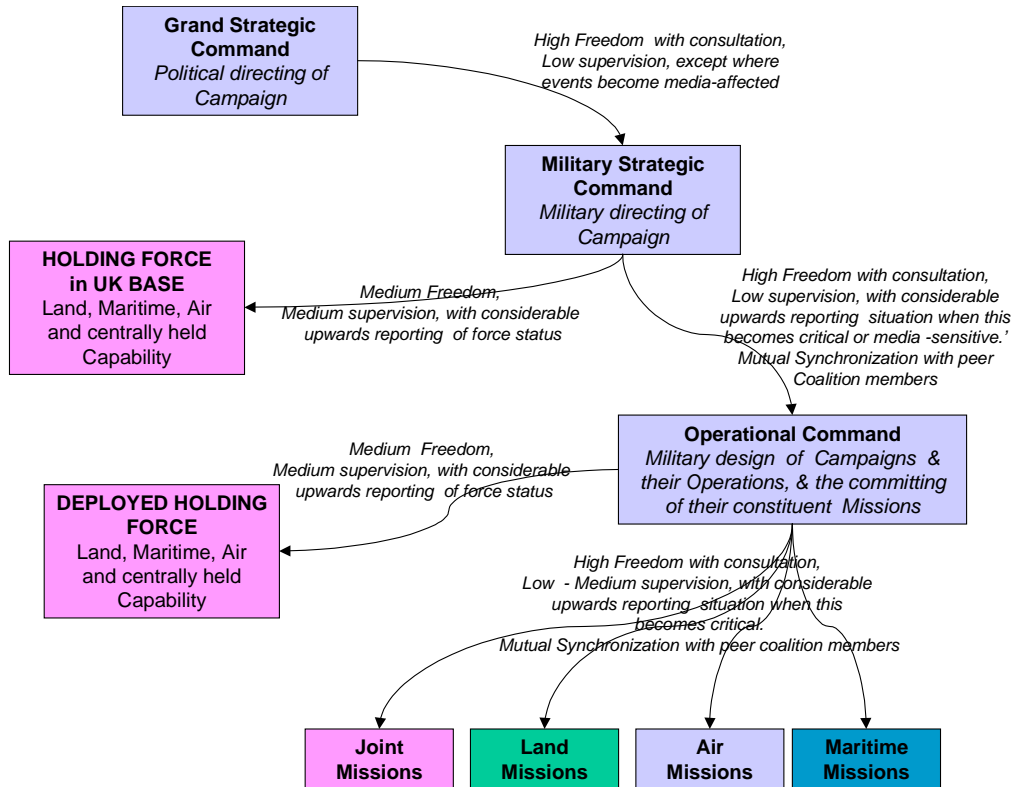

Figure 4.1 Higher Way of Command

Land, Maritime or Air Assets for use in Campaigns and Operations are held centrally in UK under their respective Commanders-in-Chief. Deployed forces are drawn from these holdings under the direction of the Military Strategic Command inside the MOD. The Chief of Joint Operations (CJO) assisted by the UK Principal Joint HQ (PJHQ) takes charge of the detail of expeditionary force planning and preparation, and the subsequent deployment and sustainment in theatre. Once in theatre, the deployed forces come under the command of the Operational Commander (The Joint Task Force Commander). CJO provides a facilitating link in the command chain between MOD and the JTFC. In effect, the Land, Maritime and Air Component Commanders act to hold, sustain and administer the deployed forces on behalf of the JTFC [11].

Under the current Way of Command in UK-alone, NATO or Coalition Operations, each Component Commander retains line command over

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[11] This simple view is varied in NATO Operations and becomes more complicated in Coalition Operations, neither of which have been specifically addressed by the study.

- Mission Commanders whom they appoint for Missions run within their Component.
- Force elements they have allocated to Missions run by other Components.

This can introduce impediments to the agility sought by NEC in QFO rather more than AFO, where tactical Jointness of command has precedents. A need is indicated for progression to a Way of Command in which Component Commanders yield command of assets to the employing Mission Commanders, regardless of which component these come from. This implies the following form of deployed force structure:
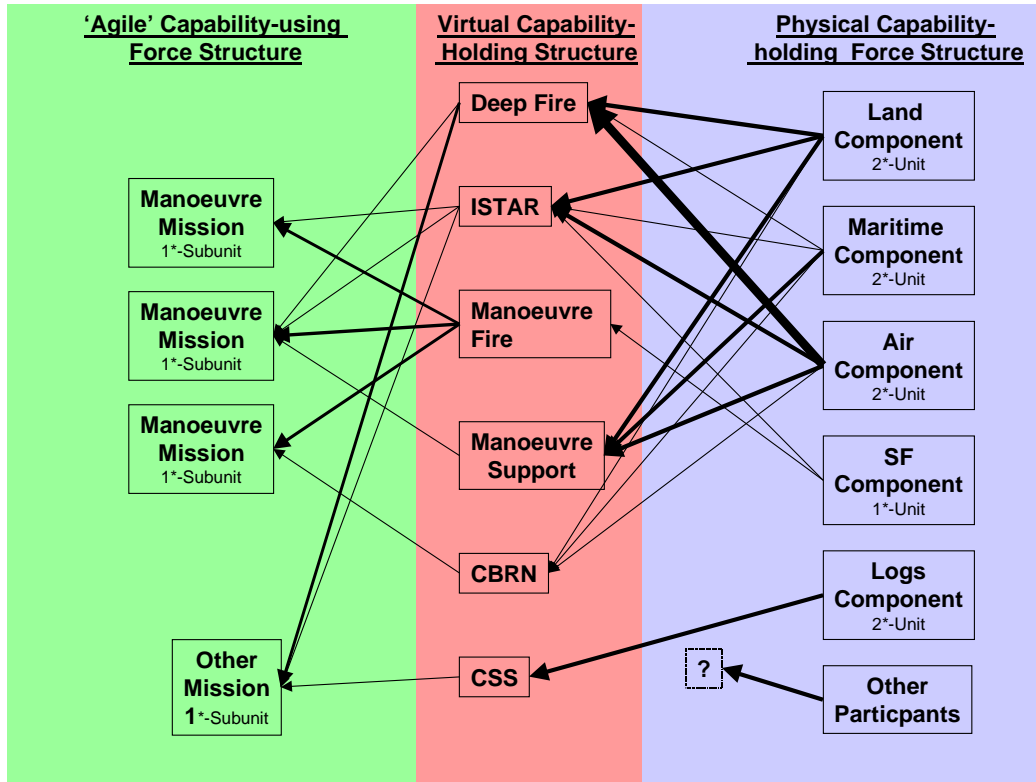
Fig 4.2 Possible new form of deployed Force Structure

The associated form of new Top-Level command structure would then be as follows:
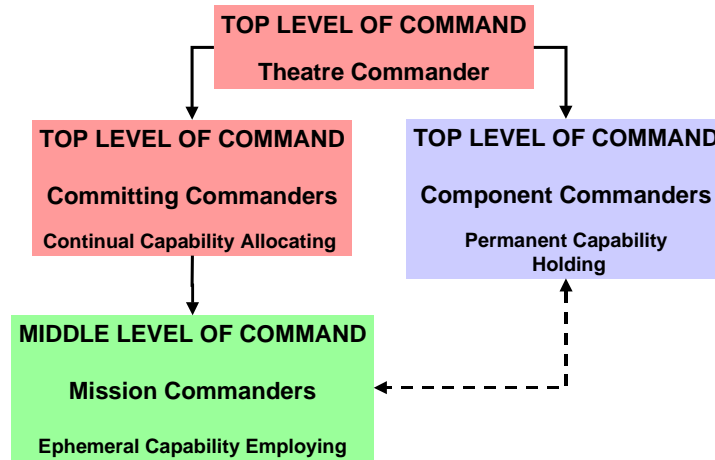
Fig 4.3 Possible new form of deployed Force Command Structure

4.2   Way of Command in the Middle and Bottom levels

Command structures for the Missions have the general form illustrated as follows for a Land-centred Mission:

Fig 4.4 Current approach to Command in Missions

The solid lines indicate line command authority, and the dotted lines indicate control authority, where the mission command team can regulate the detail of the activity

provided by the Mission Support elements, but not alter their sub-missions which have to be agreed at the Top Level with the Component Commanders 'owning' the Support assets.

Typical Command Autonomies occur as follows:
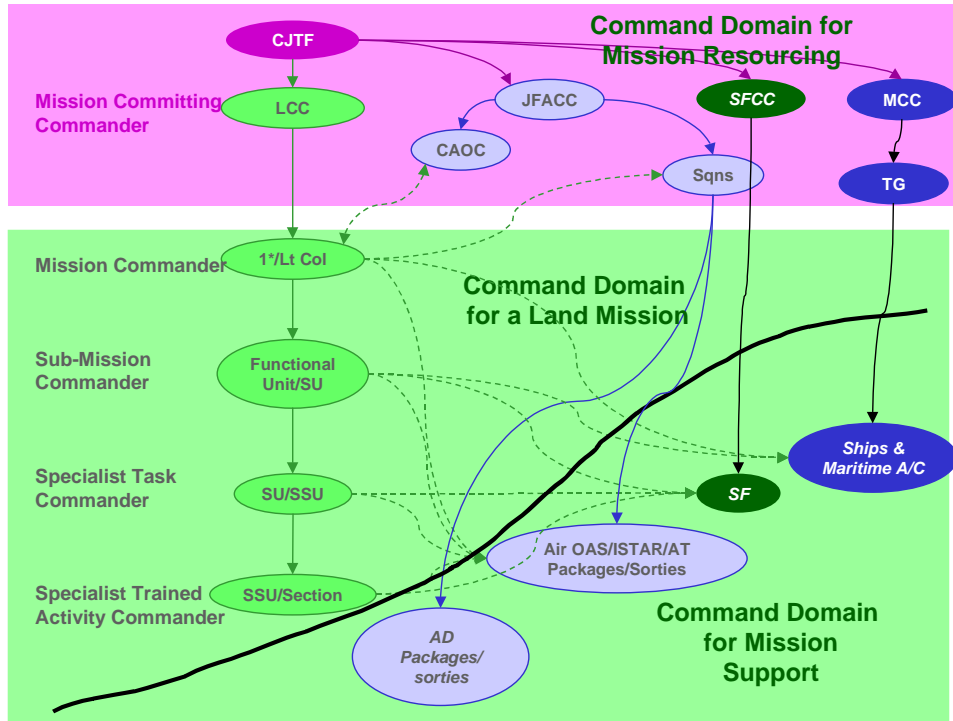- Command at the Mission level requires a range of command skills with some art, and is exercised with High to Medium Autonomy.
- Command at the Sub-Mission level requires a narrower range of command skills, with little art, exercised with Medium to Low Autonomy, chosen to reconcile within the specific sub-mission any conflicting needs for Coherence and Tempo.
- Command at the Task level requires leadership and narrow command skills, exercised with usually Low Autonomy.

Autonomies are currently used as follows in the UK Mission types introduced in 2.2 above:

- Anti Air Warfare missions contain a Medium degree of freedom of decision. It requires a high degree of Supervision and Synchronisation can be achieved by Peer-to-Peer, Mutual or Self-Synchronisation mechanisms.

- Close Anti Submarine Warfare missions contain a Medium degree of freedom of decision. It requires a high degree of Supervision and Synchronisation can be achieved by Peer-to-Peer, Mutual or Self-Synchronisation mechanisms.

- Anti Submarine Warfare missions contain a Low degree of freedom of decision. They require a high degree of Supervision and Synchronisation is achieved through a Mutual synchronisation mechanism or by supervision of a Superior

- Anti Surface Warfare Over The Horizon missions contain a Low degree of freedom of decision. They require a high degree of Supervision and Synchronisation is achieved through a Mutual synchronisation mechanism or by supervision of a Superior

- Task Force Littoral Manoeuvre Missions contain a high degree of freedom of decision, it requires a high degree of supervision and synchronisation can be either mutual or Peer-to-Peer. It is too complex an operation to allow Self-Synchronisation.

- Joint Strike Missions contain a Medium degree of freedom of decision. Supervision can be optional and synchronisation can be either Self-Synchronisation or Mutual or Supervised by a Superior for Air because of the need for Air Space Management.

- Air-Based Air Defence Missions contain a Medium degree of freedom of decision. Supervision can be optional and synchronisation can be either Self-Synchronisation or Mutual or Supervised by a Superior for Air because of the need for Air Space Management.

- Close Air Support /Suppression of Enemy Air Defence Missions contain a Medium degree of freedom of decision. Supervision can be optional and synchronisation can be either Self-Synchronisation or Mutual or Supervised by a Superior for Air because of the need for Air Space Management.

- Ground Manoeuvre Missions contain a high degree of freedom of decision, it requires a high degree of supervision and synchronisation can be either mutual or Peer-to-Peer. It is too complex an operation to allow Self-Synchronisation.

- Ground Manoeuvre Sub-missions Contain a Medium degree of Freedom of decision. It requires a high degree of Supervision and Synchronisation can be achieved through Peer-to-Peer Synchronisation or through Mutual Synchronisation or by supervision by a Superior if Air or Battle Space Management is involved. It is too complex an operation to allow Self-Synchronisation.

- Ground Manoeuvre Tasks contain a Medium degree of freedom of decision. It requires a high degree of Supervision and Synchronisation can be achieved by Peer-to-Peer, Mutual or Self-Synchronisation mechanisms.

- Air Manoeuvre Missions contain a high degree of freedom of decision, it requires a high degree of supervision and synchronisation can be either mutual or Peer-to-Peer. It is too complex an operation to allow Self-Synchronisation.

- Air Manoeuvre Sub-missions Contain a Medium degree of Freedom of decision. It requires a high degree of Supervision and Synchronisation can be achieved through Peer-to-Peer Synchronisation or through Mutual Synchronisation or by supervision by a Superior if Air or Battle Space Management is involved. It is too complex an operation to allow Self-Synchronisation.

- Aviation Tasks contain a Medium degree of freedom of decision. It requires a high degree of Supervision and Synchronisation can be achieved by Peer-to-Peer, Mutual or Self-Synchronisation mechanisms.

5. THE NETWORKING IMPLICATIONS OF WAY OF COMMAND

The information use and flow needs of the various forms of autonomy are summarised in this section by text and graphics. In the latter; arrows indicate the nature of the information traffic which will need to be satisfied by networking. The detailed interpretation of these flows will depend heavily on the roles and command levels of the Subordinate and Superior concerned, the nature of the Subordinate's activities, the adversary's interference with them, and the nature of the operating environment.

5.1 High Freedom/Low Supervision Autonomy

The Superior gives direction to the Subordinates in terms of Ends, Means & Context information. In order to do this the Superior needs his own Situation Picture, which is made up of his Own Force Picture and the Intelligence Picture. The Superior manages the Subordinate's Context. If this management cannot be satisfactorily achieved, the Superior will need to change his direction and/or vary the amount of freedom that the Subordinate has. Where the Superior wishes to supervise a Subordinate, he will use elements of the latter's Situation Picture and Plans.

The Subordinate needs to understand the Superior's direction, through access to the Superiors' statement of End(s) and allocated Means. The Subordinate who needs to synchronise with Peer activity needs access to elements of the Peers' Situation Picture and their Plans. If self-synchronising he will need a larger volume of information than if he is able to confer with the Peer(s). The summarising graphic follows:
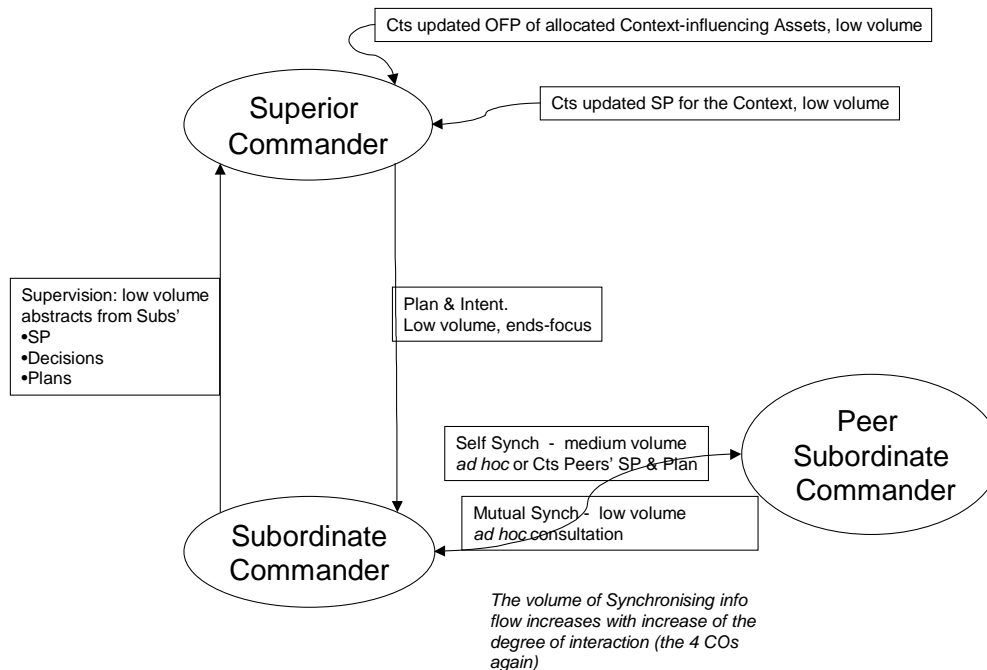

Figure 5.1 Information flow for High Freedom/Low Supervision forms of Autonomy

5.2   Medium Freedom Autonomy

The Superior gives direction to the Subordinates in terms of Ends, Means & an outline activity Plan. In order to make this Plan, the Superior needs elements his own Situation Picture and that of each Subordinate concerned.   The Superior needs to exercise a degree of management of the interactions between Subordinates' activities. To do this, the Superior needs to have continuing access to his own Situation Picture, to elements of the Situation Picture of each Subordinate, and to their various Plans.

The Subordinate needs to understand the Superiors' direction by access to the Superiors' statement of End(s), Plan and allocated Means. He also needs his own extensive Situation Picture and relevant elements of Peers' Situation Pictures and their allocated Ends, Ways and Means. The Peer information is especially needed if he is required to synchronise with them during execution of his Plan.
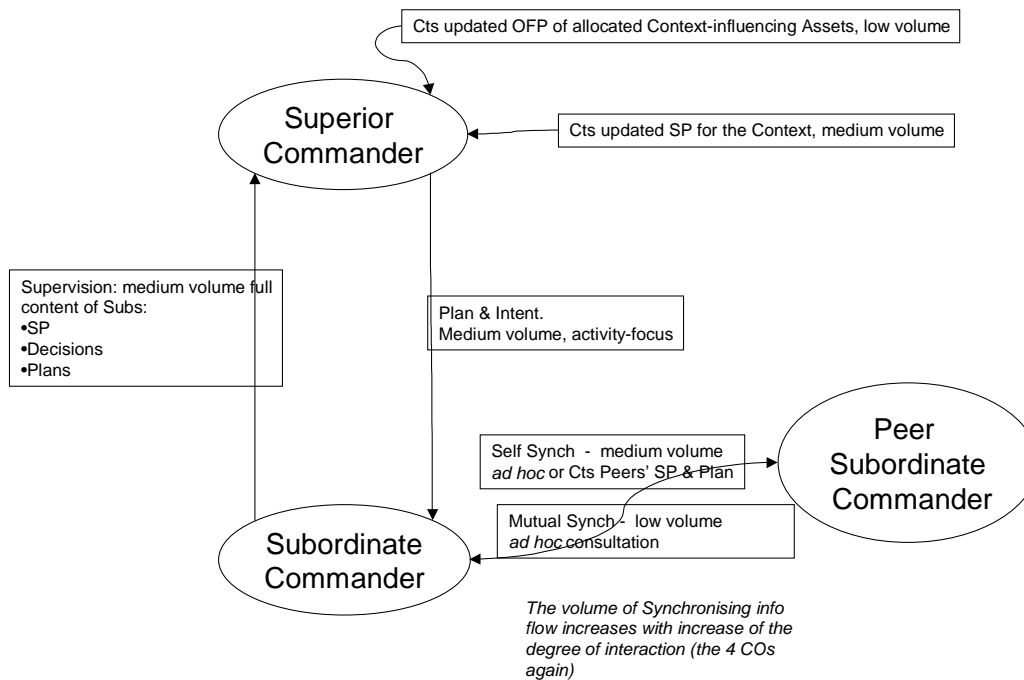
The summarising graphic follows:

Fig 5.2 Information flow for Medium Freedom forms of Autonomy

5.3   Low Freedom Autonomy

The Superior gives direction to each Subordinate in terms of detailed Plans, made using more extensive elements of his own and each of the Subordinate's Situation Pictures. The Superior needs continually to manage the interactions between Subordinates' activities, using a complete view of each Subordinate's Situation Picture and Plan. He also needs elements of the Superiors "Situation Picture" for context.

The Subordinate needs to understand the Superiors' direction. In order to do this he needs his own limited "Situation Picture" and the Superiors' Plan and allocated Means.

The summarising graphic follows:

Cts updated OFP of allocated Context-influencing Assets, low volume

Superior Commander

Cts updated SP for the Context, medium volume

Supervision: high volume full content of Subs:
•SP
•Decisions
•Plans

Plan & Intent.
High volume, activity-focus

Self Synch - low volume
ad hoc or Cts Peers' SP & Plan

Peer Subordinate Commander

Mutual Synch - low volume
ad hoc consultation

Subordinate Commander

The volume of Synchronising info flow will be nil or small when Low Freedoms are used.
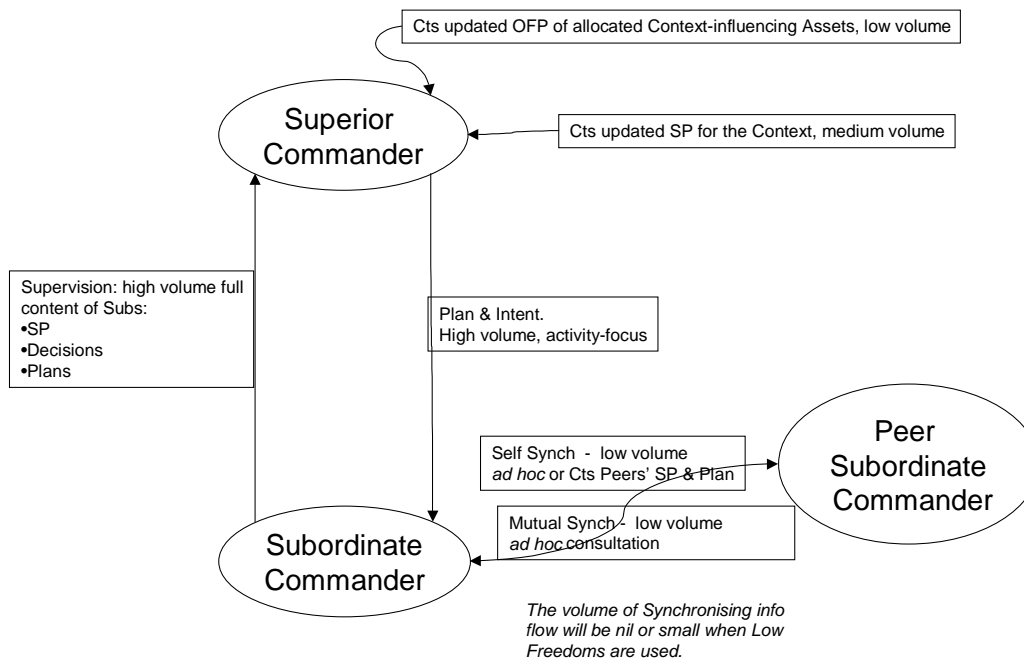
Figure 5.3 Information flow for Low Freedom forms of Autonomy

5.4   Peer-to-Peer Synchronisation

Peers synchronise their activities in space and/or time, according to pre-arranged plan, or on basis of their own assessment. The following table gives our classification of synchronising methods.

Label	Synchronising Process
PS1	Self-synchronise
PS1s	Self-synchronise under Superior's supervision
PS2	Mutually Synchronise by active collaboration with Peer(s)
PS2s	Mutually Synchronise by active collaboration with Peer(s) under Superior's supervision

Mutual Synchronisation involves Peer-to-Peer exchange of the minimum relevant elements of Situation Pictures and of any Plans, which have been recently amended.

Self-Synchronisation does not involve any is no direct exchange of information, but the self-synchroniser needs to be well informed about Peers' situations and plans. The total volume of information flow needed to support Self Synchronization may be much greater than that for Mutual Synchronization, noting that this flow may load the Superior-to-Peer links rather than the Peer-to-Peer links.

Either class may optionally be supervised by Superiors. The associated information flows comprise
- Indication or notification to the Superiors that Synchronisation decisions are imminent/being taken.
- Details of the actual synchronisation decisions.
- Elements of the synchronisers' Situation Pictures and Plans.

Where the synchronising Peers do not have a common Superior directly above them, the affected Superiors may need to consult between themselves, causing yet further loading of the information network.

5.5 Example of information flow in Land-Air Missions

Our study has applied the information flow rules indicated above to the Command Structures expected for a range of Ground and Air Manoeuvre Missions involving extensive Air Support. An example for a typical type of Air Manoeuvre Mission is shown below. The results even at this low level of detail can be used to indicate tactical networking needs in terms of types of communications and options for implementing the IT mechanisms for sharing Situation and Plan information.

AM REAR

AM FORWARD

Nodes shown in diagram: BSG, AH/LUH FOB, Rear HQ, CAOC/ TACC, SH FOB, MC/FC Tac, FC Fwd HQ, OAS & SEAD Packages, FW AD Packages, Firebase Comd, Firebase Protection Inf Coy, Gun Gp, Firebase A-ech, FW + UAV ISTAR sorties, Inf BG Comd, Airbridge Packages, SF Patrols, Inf Coy/ Coy Gp, Avn BG Comd, AvBG Sqn/Sqn Gp, AvBG Inf Coy/ Coy Gp, AvBG A-ech, Inf BG A-ech

INFORMATION FLOW

Down the chain of command
• Current/Future Plans/Orders & CTPs

For peer to peer synch/coord
• Sharing of Plan/Orders & CTP
• Sharing of CTP & oral coord
• Some of the Direct ISTAR feeds
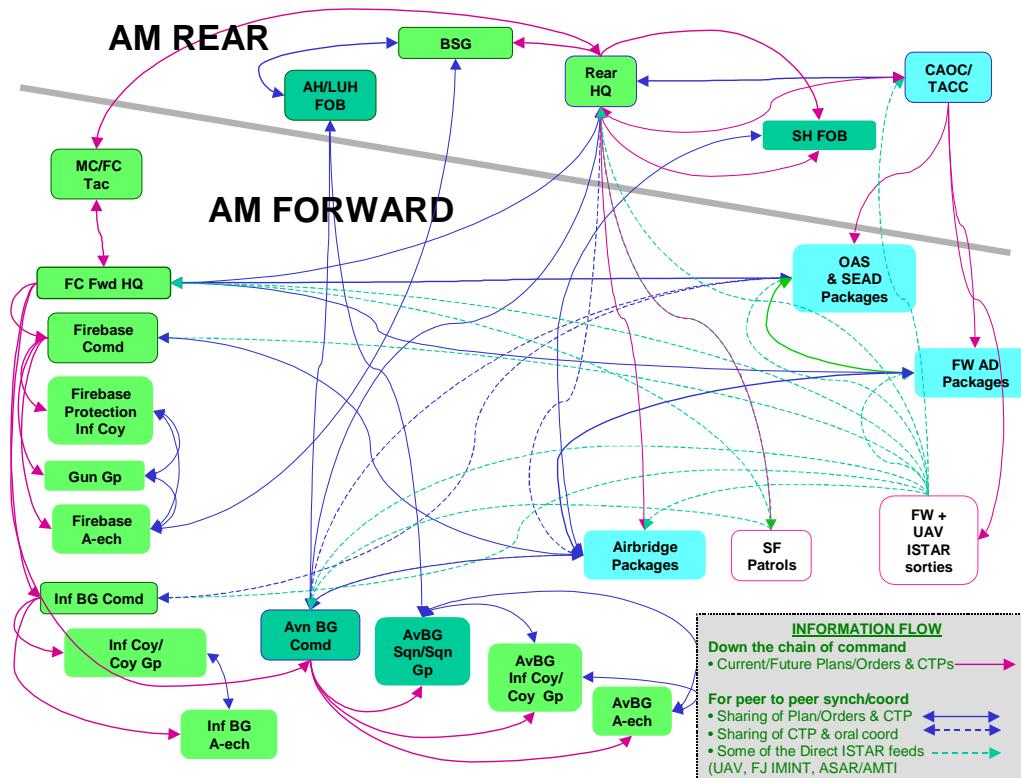(UAV, FJ IMINT, ASAR/AMTI

Figure 5.4 Air Manoeuvre needs for networking connectivity

6.   THE APPROPRIATENESS OF SELF-SYNCHRONISATION

Our study has indicated the following assessments based on the logic portrayed in Fig. 2.2 above and the analysis of Mission types given in 2.2 and 4.2 above.

In all cases, unsupervised Self-Synchronisation is deemed inappropriate wherever commanders performing the synchronization do not have an adequate combination of aptitude and experience to make synchronising decisions reliably and unaided.

6.1. **Inappropriate use of Self-Synchronization.**
It is either not a viable option in the following circumstances**:**
- Where there is high activity complexity combined with high decision diversity producing intolerable risks of badly de-synchronising decisions, with insufficient opportunity for superiors to intervene to remedy matters. Examples include most Ground Manoeuvre (GM) Missions, all Air and Littoral Manoeuvre (AM and LM) Missions.

- Where there is low activity complexity combined with high decision diversity, still producing intolerable risks of badly de-synchronising decisions, with insufficient opportunity for superiors to intervene to remedy matters. Examples include many GM & AM Sub-missions.

It is not a useful option when there is no time-pressure to achieve synchronisation, and this can be managed via superior's direction or by mutual synchronisation, with or without Superior's supervision. Examples include Maritime over-the-horizon Anti-Surface Warfare, and Anti Submarine Warfare.

6.2. **Appropriate use of Self-Synchronization**
It is a viable option in the following circumstances where there is a need for very highly responsive synchronisation, and where there is:

- High complexity but low risk of bad decisions and some real opportunity for superiors to make remedial interventions. Examples include CAS/SEAD, airborne air defence Missions and Sub-missions, Joint Strike Missions or Sub-Missions.

- Low complexity, low risk of bad decisions, and some real opportunity for superiors to make remedial interventions. Examples include Maritime Tasks of Anti-Air Warfare, within-horizon Anti Surface Warfare, some Land Aviation and GM Sub-missions/ Tasks.

Otherwise it may be considered as a fall-back from Mutual Synchronization, as when Peer-to-Peer communications fail, provided that the probability of badly de-synchronising decisions is low enough, and/or superiors have the chance to make remedial interventions.

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