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### **Paper Title:**

# **Implementing Edge Organizations: Exploiting Complexity**

## **(Part 1: A Framework for the Characterization of Edge Organizations and their Environments)**

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**Abstract**

During 2003, CCRP published "Power to the Edge" which described a new kind of organization, an 'Edge Organization' (EO), which would display exceptional agility. Key to implementing and employing Edge Organisations is achieving an understanding of the types of arrangements which would enable Edge Organisations to work in this manner. This paper provides initial output on four themes from a DoD-sponsored programme of work being carried out in the UK to look into these issues.

This paper contends that Edge Organisations follow a highly-extended, totally unconstrained organisational concept that enables power to be dynamically distributed away from the centre to those involved in execution. Therefore, Edge Organisations will have to have (effectively unlimited) degrees of freedom available to them that non-edge organisations do not have. The challenges to be addressed in the work include: finding out how to characterise Edge Organisations and provide a 'language' for reasoning about them; investigating the degrees of freedom, mechanisms and features that Edge Organisations need to have; understanding the circumstances under which they will and won't work; and indicating how the concept of Military Capability Packages is changed by Edge Organisations. The work will also indicate the kind of programme of experimentation that would be appropriate to Edge Organisations.

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**and their Environments)**

**Structure of the Paper**

This paper provides initial thoughts on four research themes related to Edge Organisations. These initial insights come from a DoD-sponsored programme of work being carried out by QinetiQ in the UK. The paper will start by examining why the concept of Edge Organisations is so important to the future of military operations and in doing so will itemise some of the capabilities required of Edge Organisations and briefly consider issues such as: what might be their necessary features and what kinds of mechanisms might need to be activated for their operation?

In the second theme, the paper will offer a characterisation of Edge Organisations to provide a 'language' for reasoning about them. This leads on to a characterisation of the kinds of environments in which Edge Organisations would need to be able to operate. Next, the third theme comments on the kind of experimental campaigns required to investigate the utility and vulnerabilities of Edge Organisations.

The fourth theme will indicate briefly the issues that these experiments might raise for acquiring, implementing and employing Edge Organisations, such as, how might the concepts of Military Capability Packages be changed by Edge Organisations? Finally, the paper will provide a summary of all these issues and will invite comment.

**Theme 1 - Why are Edge Organisations Important?**

In "Power to the Edge" (PTTE), published in 2003 by the CCRP [1 Alberts], the notion of Edge Organisations is discussed in detail. As part of this discussion, the limitations of current systems are analysed and the book implies that Edge Organisations are essential for future operational success. The question that arises is "What is it about our current world that is so different that we need both a radically different approach to command and new types of organisational capability?". Part of the answer does indeed relate to changes in the wider world (greater varieties of threat and adversary), but some of the need to change comes from better understanding of the mechanisms at large in the world and the ways that they might be influenced to our advantage.

Although it seems obvious to say it, conflict is a complex and uncertain business and, increasingly, the phenomena we observe are volatile and transitory making it hard to gain enough information to make useful decisions. In addition, the world is ever more richly connected and interdependent - where the notion of being able to define rigid boundaries around closed (defended) spaces is a myth. This is illustrated by the fact that Effects-based Approaches (EBA) extend their effects outside the military arena to where coherent effects may coincide at points of influence anywhere in time and 'space' and through any medium.

In all walks of life, not just because of technology, there are new sources of power, new types of interactions and therefore new opportunities and new threats. We need to be able to

adapt to these changes as they arise - shaping the future rather than reacting to the past. We do not have time to wait for the next spiral of acquisition, we need to be able to dynamically adapt what we have now to meet the threat - but current systems inhibit our ability to do this.

This is because our current capabilities were designed and 'optimised' against 'endorsed' threats and for specific missions. These designs were based on reductionist thinking, which limited the ability to react to within pre-planned bounds. Part of the reason for this is that the kind of capabilities we are able to acquire are constrained by procurement processes and their attendant reward and incentive structures. Indeed, it is common to find a mindset that seems to treat the world as engineered machines tractable to Newtonian science - a mindset which doesn't accept the fact that we're actually dealing with myriads of complex adaptive systems characterised by their unbounded nature, their diversity and non-linear processes.

Associated with this is the current emphasis on trying to predict the future - absolutely. This is another myth. It is impossible to predict cascading effects with certainty, despite what some might say. As a result, we spend inordinate amounts of time trying to plan uncertainty out of the future [2 Storr] because we can't adapt to its realities on-the-fly. In future, the reality will be that planning and execution will merge into a single flow of operational effects. The reason that we can't adapt in this agile manner at present is that our current capabilities lack the kind of 'degrees of freedom' (run-time plasticity) that would be needed to shape them dynamically to meet the threats. Indeed, current capabilities are 'brittle', responding poorly to disruption and dislocation - as Kirsch says [3]:

[Industrial Age capabilities are] "unable to control the novelties they cannot prevent, and will be unable to generate the novelties they need. They fall victim to the change they cannot inhibit and the change they cannot induce".

Given these challenges, PTTE contends that an approach is needed which puts the achievement and maintenance of agility<sup>1</sup> as its number one goal. Hence, an approach is needed which delivers capability with the ability to adapt / shape to circumstances on-the-fly - enabling us to change our operational systems, processes and battle rhythms at will [4 Meigs]. This approach should deliver capability which can exert decisive effects against all types of opponents in all types of, so-called, 'challenge spaces' (described further below).

This capability will need to be able to sense the need for change and have mechanisms available so that it can shape itself to respond, to create and exploit fleeting opportunities and to stimulate, influence and exploit emergent phenomena. Other important features include the ability to learn and to exploit learning, and the ability to co-evolve with other actors and the environment. As the organisation cannot converge on a single correct solution, in advance, it needs to be able to accelerate own evolution through training and experimentation by facing challenging situations and (simulated) ruthless opponents<sup>2</sup>.

In organisational terms, future capability should facilitate the evolution and communication of high-level intent without inhibiting mission command<sup>3</sup>. Indeed, in this 'empowered' organisation, warfighters are no longer dumb process followers - working within some pre-

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<sup>1</sup> As you can't have static agility - Edge Organisations have to support the output of a continuous dynamic flow of effects. The road to agility is paved with the degrees of freedom which enable run-time adaptation - though we are short of practitioners who are competent in so-called 'run-time-science'.

<sup>2</sup> Page 229 of PTTE points out the need to remove constraints from those playing adversaries.

<sup>3</sup> In the UK sense of "delegated authority to act within intent and use initiative when opportunities appear".

defined process - but will be active decision-makers, facilitating change supported by C4I & ISTAR which is capable of shaping itself to respond to the changes as they unfold. This will all provide the ability (means and opportunity) to exercise power, to effect, to influence in a distributed manner, but with coherent effect. This is especially important in asymmetric warfare as the topology of 'the edge', between us and our opponent, is moving all the time.

Other features that will be required of agile organisations follow from its being made up of a networks of distributed and diverse components. This will provide resilience and robustness, as well as supporting the ability to form agile groupings - plastic organisational topologies with the flexibility to morph dynamically and in timely manner without disrupting its own processes. The ability to disperse will also enable a light footprint, important when rapid deployments are required.

In practical terms these ideas will eventually need to be instantiated in the 'command arrangements' <sup>4</sup> for Edge Organisations such that the organisations can be implemented, deployed and employed to decisive effect. Key to achieving this is understanding how the role of commander(s) will change. This is especially true for the senior commander who's job is to provide a coherent vision understood by all. Change is then effected by sensing where the organisation has been, where it is, where it wishes to go (including considering the equivalent landspace for other actors) and then identifying the deltas and subsequently enacting change.

It is important to note that facilitating change is not a one shot activity, it is a journey of change with continuous reactive (time-critical) and deliberative (considered) adjustments. Commanders in Edge Organisations will have to do this in a distributed manner, if agility is to be sustained, meaning that agile organisations have to operate as a kind of purposeful, self-synchronising 'distributed consciousness' - an intelligent swarm.

PTTE maintains that Edge Organisations would provide the operational agility that has been discussed above. So, if Edge Organisations are to be the solution, we need to better understand their capabilities, how they work, what are their necessary features, what regulatory mechanisms must be at work, what organisational and social issues are involved and what needs to be considered in their acquisition, implementation and employment. The themes below provide some initial thoughts on these issues.

## **Theme 2 - Initial Strawman Concept for Edge Organisations**

The following is an initial strawman for the concept of Edge Organizations. The strawman contains many key terms that will need formal definition if Edge Organizations are to be formally analyzed and, most importantly, if the concept of Edge Organizations is to be communicated successfully to the wider community. In the following description of the initial strawman these key terms are highlighted:

The strawman sees an Edge Organization as a highly-extended and unconstrained organizational concept that, due to its **agility**, can readily and dynamically reconfigure to perform effectively and efficiently in many **environments** against many types of

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<sup>4</sup> Not in the narrow sense of the command hierarchy / TASKORG, but in a broad sense relating to all of the aspects of command that enable organisations to function.

**adversarial organizations.** We can conceive the **space** that contains the different organizational concepts as a hyper-cube (usually depicted as a dimensionally-reduced cube - see Figure 1 below). **Agility** can then be thought of as the ability to move around, for example, **organisational space**, enabling an Edge Organization to place itself in the **most advantageous position** possible.

Movement within this space will depend on Edge Organizations being able to **create and maintain conditions** within its environment that provide it with greatest **value**. Edge organisations will have extra-ordinary **means** and **mechanisms** that include the ability to sense, assess, re-orient and re-structure as part of their repertoire of **ways**.

To do this, an Edge Organization must be able to **sense and value the conditions** within its environment, must be able to **identify where itself and its adversarial organisations** are in this evaluated space, must have **mechanisms (behaviours and processes)** to **restructure** and **move** itself around in this space, and be able to **create and / or maintain conditions** within this space that will **force an adversary to move** to a space which is subjectively more advantageous to the Edge Organization.

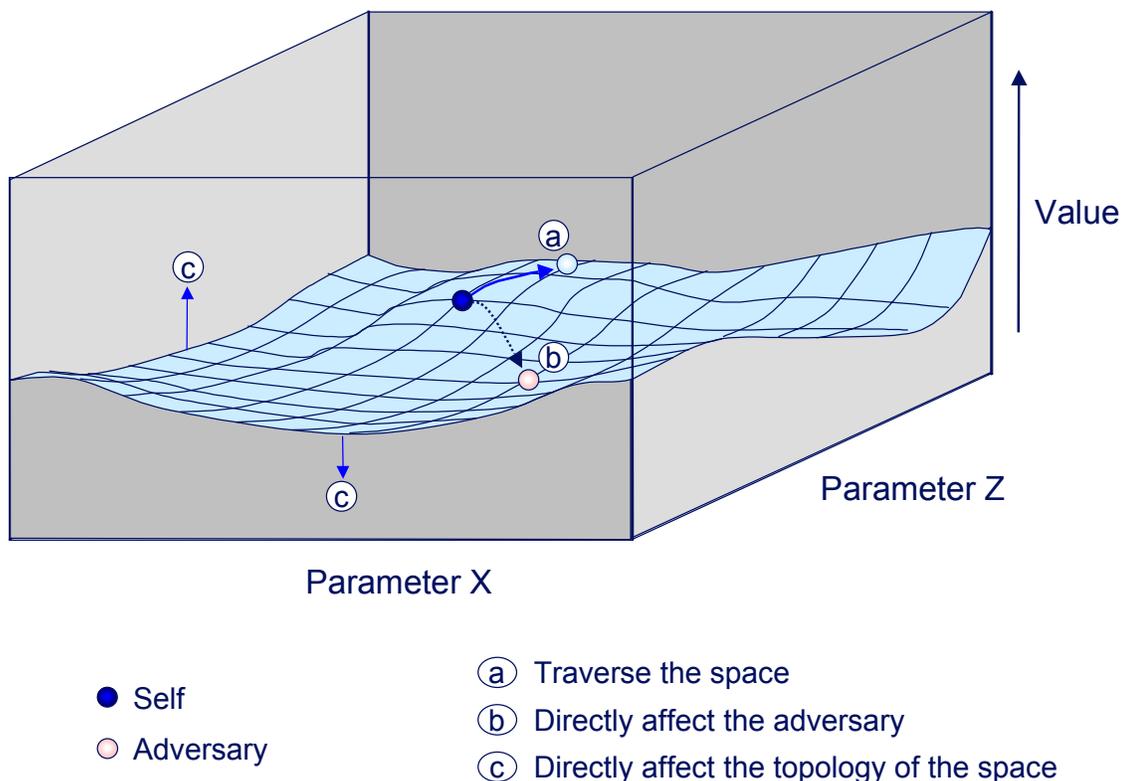


Figure 1 - A cuboid representation of the Value Landscape.

In the cuboid in Figure 1 the surface represents the 'value' of being at a certain point within the space. The blue sphere represents the Edge Organization which can do three things in the space:

- Traverse the space to move to positions of higher value (a);
- Directly affect the adversarial organization to reduce its value (b);
- Change the topology of the space in order to force the adversarial organization to move (c).

To use this concept, Edge Organisations must be parameterized and characterized to a degree that will enable an Experimental Campaign to be designed for the evaluation of the performance and effectiveness of Edge Organizations.

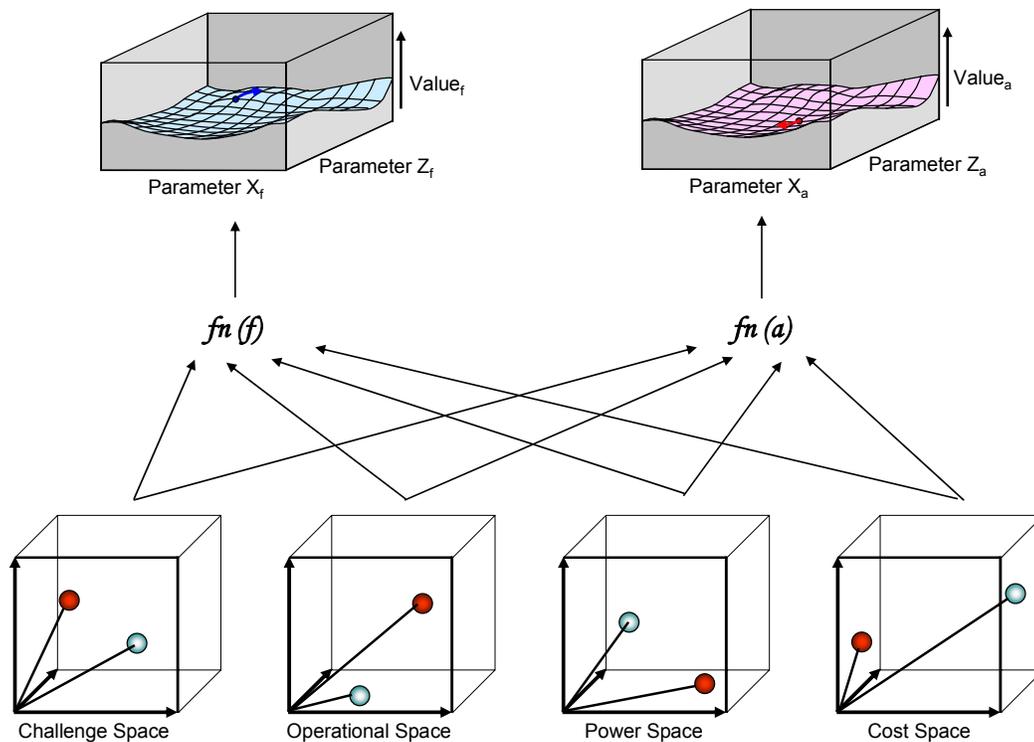


Figure 2 - Value Landscapes and Transfer Functions

This statement is inevitably highly simplified. There will need to be at least two value landscapes; one for friendly forces and one for the adversaries (there may need to be many more, for example neutrals and coalition partners). Each of these value landscapes will have different value measurements regimes; meaning that a value in one landscape will not equate directly with a value in another. The best that any measurement system may be able to offer is to state, for a given set of circumstances, the potential for a change in value for friendly and adversarial forces; the ideal situation being that the circumstances offer the

potential for an increase in value for friendly forces whilst at the same time offering the potential for a decrease in value of adversarial forces.

But what are these 'circumstances'? Obviously they will have to be characteristics of the environment that the friendly forces can influence and / or measure, and they will impact the different value landscapes in different ways; through different transfer functions (see Figure 2 above). The 'circumstances' so far identified are:

- Challenge Space. The set of challenges that the environment, including other forces, has set the organization in question. Most importantly, and probably the metric that will be used in the calculation in the value landscape, is the degree of inherent risk associated with the set of challenges.
- Operational Space. This is a characterization of the type of environment that the organizations are operating within. It provides a way of assessing how fit the goals of the organization are and can be used to indicate areas of the operational space where an organization either does not want to go or where it cannot operate.
- Power Space. Is a representation of the ability of the organisation to exert power and influence in raw terms.
- Cost Space. This is a representation of the costs involved in staying in any one location in the challenge space / operational space for a prolonged period of time. In this sense, being in 'one place' does not infer being static - it relates to the activities involved in maintaining some desired set of states.

This strawman is being further developed to include an 'Influence Map' which indicates the interdependancies between these ideas and their relationships in the context of understanding how Edge Organisations would operate.

### **Theme 3 - Experimental Campaigns to Investigate Edge Organisations**

The rationale behind the experimental campaign is to exert a proper degree of rigour in the characterisations outlined in the strawman such that, the defined characteristics of the organisations and of the challenge space allow not only parameterisation but also formally capture dependencies between experimental variables. The general aims of the experiments within the proposed campaign are:

- to explore the spectrum of behaviours of different organisational structures set against different regions in the challenge space;
- to validate the characterisations of the structural constraints;
- to assess the set of proposed metrics.

The specific aim is to investigate the utility, limitations and vulnerabilities of Edge Organisations with a view to testing the hypothesis that Edge Organisations, given all the characteristics outlined in PTTE, will be able to function effectively and efficiently in all of the most important regions of the challenge space.

The experimental campaign will have to address many difficulties and problems [5 Alberts & Hayes] because Edge Organisations:

- are effectively unconstrained;
- are dynamic and so it is their ability to transform that is under test;
- may be, necessarily, human-centric with emergent collective behaviours;
- are composed of humans, full of personality, experience and embedded knowledge.

It is important to be clear about the three sets of independent variables which are:

- the infrastructure linkages (i.e. supporting communications, ISTAR, information and computing infrastructures);
- the organisation of interactions between processes, individuals, teams, roles (e.g. force structures, command arrangements, social networks, etc) within Edge Organisations;
- the functional requirements of the necessary interdependencies (e.g. need for activities to be coordinated) and their non-functional requirements (e.g. need for accuracy and consistency).

Edge Organisations assume values for the infrastructure linkages (and their implied MEANS) that are at an extreme, unconstrained, end of the parameter spectrum (i.e. no linkages are fixed and the supporting MEANS are unlimited). Interactions within an Edge Organisation are also totally unconstrained such that any node in the structure can interact with any other node on whatever business is deemed appropriate (e.g. giving targeting authority, allocating assets to task, assigning priorities, sharing planning outputs, sharing data, etc). Edge Organisations, then, define the free range of parameters across which the experiments will have to vary the values of the independent variables defining the infrastructures and the interactions.

The remaining set of independent variables (relating to interdependencies) pertains to the challenge space and will set the operating context for the other two sets of variables.

The dependent variables will include tempo measures such as rate of representational events (e.g. command decisions, planning outputs, battlefield boundary crossings), accuracy measures (e.g. compliance with plans / desired objectives, targeting effects, logistics shortages), consistency measures (information entropy, precision / collateral damage), efficiency measures (utilisation of assets, costs of out-sourcing).

There will also be many constants (or fixed parameters) whose values may only hold for certain sub-sets of the experiments. These will cover external settings such as terrain features, physical boundaries, weather and day / night conditions, strategic and socio-political “fixtures”, etc.

The key to characterising the different kinds of edge structures is finding a succinct way to encode different types of infrastructure linkages and organisational interactions.

The experimental campaign is also about formulating a range of suitable test situations of increasing complexity. Essential to this is an understanding "Ashby's Law of Requisite Variety", not only in the coverage of challenge spectrum of the scenarios but also in the

acknowledgement that C2 organisations need to have requisite variety (but not to be over-capable) to match the demands of the operating environments (especially the variety employed by potential adversaries).

The experimental design will also take account of a range of modelling and simulation approaches that could be employed (e.g. seminar and wargaming; complexity modelling; swarming and agent-based simulations (Such as used by the QinetiQ HiLOCA model, see [6 Richardson & Dodd]) etc).

In general, metrics will be developed based on the principles and structures detailed in the "Code of Best Practice for Experimentation" [7] and the "NATO Code of Best Practice for C2 Assessment" [8] and the NCW Conceptual Framework [9]. The design of a metrics framework will follow aspects of the relationships of measures of merit presented in the "Code of Best Practice for C2 Assessment":

- Dimensional Parameters – organizational parameters defining interactions.
- Measures of Performance – organizational agility, controllability and 'commandability' (ability to morph and transform, levels of achievable accuracy, precision, range and reach in terms of time and space), operability and usability (maintainability, manipulatability, interoperability, etc).
- Measures of Combat Effectiveness - C2 tempo (i.e. decision-making and planning times), degree of knowledge shared (neg-entropy changes due to different distribution of information), increases in weight of evidence (eg, metrics based on the effective distribution of information etc), changes in morale and leadership factors<sup>5</sup>, ease of strategic integration (matching power distances with interacting organizations to integrate means, ways and ends).
- The experimental campaign will also produce 'cost models'<sup>6</sup> relating to organization power distribution and agility.

An important aspect to bear in mind when designing the Experimental Campaigns for Edge Organisations is that they operate in a very different manner to constrained organisations. This means that appropriate tools, simulations and metrics must be chosen which are less about outcome and more about assessing the ability to support dynamic change.

#### **Theme 4 - Issues related to Acquisition, Implementation and Employment**

Part of the research work will need to indicate issues related to acquiring, implementing and employing Edge Organisations such that these challenges can begin to be scoped. The concept of Military Capability Packages will need to be changed to support the deployment of Edge Organisations and it is already possible to see that some basic principles will have to be followed.

It may not be possible to evolve from current systems [PTTE acknowledges that 'disruptive transformation' may be required] to the kind of fully agile organisation that is espoused. For example, when you move from road transport to flight, some things just have to be different.

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<sup>5</sup> Following Leavitt "Managerial Psychology".

<sup>6</sup> Cost in this sense relates to the effort or resources that the organization must expend to effect a change relative to the benefits that the change might accrue.

This disruptive change in MCPs will be partly because some of the mechanisms and interactions cannot be supported within current organisational arrangements and partly because retaining 'backwards compatibility' will eventually be too constraining and costly.

Recent work in the UK on Capability Architectures [10 Lloyd & Markham] is concerned with *structures*, in the form of Deployed Operational Groups (DOGs) and the higher command organisation, the relationship between these structures (in terms of both their *command relationships* and *the integration of common functions* described by the components of the UK Defence Capability Framework (DCF)<sup>7</sup> [11] ) and the rules that allow this to happen in manner that that accords with doctrinal concepts. It argues that forces will continue to be provided in environmentally based context-specific groups since the organisations that currently exist, such as Task Groups, already fill many needs (particularly in terms of human issues) and, as a result, provide an organisation that is utilitarian and stable. These groups result from a deliberate process that task-organises resources to create specific effects and these groups are described as 'built organisations'.

The ability of a DOG to access a wider range of resources will increase its capability to undertake diverse and demanding missions. Functional integration is achieved through 'capability networking' and can be valued in terms of responsiveness and availability. This is reflected in the Capability Architecture where the provision, sharing, reinforcement or substitution of functional capability across DOGs is a key part of functional integration, but the dynamic networking of capability has to be placed in a sound context of command and organisation.

The doctrinal driver is the need to empower commanders so that they can deal with rapidly changing situations using opportunistic, innovative and creative solutions. However, the freedom of command given a DOG commander to create such novel actions is meaningless unless he can access the wider range of capabilities offered by functional integration [12 Dodd]. To deal with complexity, commanders must be given the freedom to form the relationships they understand will allow them to deal with the situation and its inherent unpredictability; that is, to exercise choice over the appropriate degree of mission command and the associated command and control arrangements. Their ability to do this is expressed in the form of a 'command space' within which the commander can move and act, and this ability to vary command freedom as appropriate to the nature of the operational setting must be considered as a value in its own right. Edge Organisations are aggregations of DOGs and there is a relationship between the notion of DOGs and MCPs which needs to be clarified.

Next it is worth noting that some of the acquisition principles involved will apply to the static, 'design-time' properties of the components of Edge Organisations (such as DOGs) and some of the principles will apply to the dynamic run-time capabilities. Acquisition tends to concern itself with the former, leaving the latter to be dealt with through training or design reviews. In the future, Edge Organisations will need to be able to adapt their capabilities dynamically, during the execution of operations, **without** recourse back to the acquisition community - this will require considerable changes of emphasis in acquisition procedures and attitudes as well as in the way that 'requirements' are expressed. [13 Beutement]. It may be more appropriate to move to threat-based acquisition - rather than capability-based acquisition - on the basis of needing to be able to cater for the 'unexpected'.

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<sup>7</sup> The Defence Capability Framework comprises seven components of capability: Command, Inform, Protect, Operate, Sustain, Project and Prepare.

Hence, it can be seen that, in future, parts of the military enterprise will need to be very agile and other parts (eg: support services) may continue to be relatively static in their arrangements. The key will be to enable all these different types of MCPs to interoperate without putting undue constraints on each other. Suitable mechanisms have already been identified which support this kind of flexible behaviour and they will be investigated further as part of the experimental campaign.

### **Summary**

This paper has described some of the initial outputs from a DoD-sponsored programme of work being carried out by QinetiQ in the UK to look into Edge Organisations which are, according to the "Power to the Edge" book, structures which would display exceptional agility. Key to implementing and employing Edge Organisations is achieving an understanding of the types of 'mechanisms' required to enable Edge Organisations to work in this manner. This paper has contended that Edge Organisations follow a highly-extended, totally unconstrained, organisational concept that enables power to be dynamically distributed away from the centre to those involved in execution. To this end, Edge Organisations will have to have (effectively unlimited) degrees of freedom available to them that non-edge organisations do not have.

The paper has briefly reviewed the challenges to be addressed through the discussion of four themes. Firstly, the paper looked at why Edge Organisations would be important in the future and considered the capabilities that they would need to have. The paper went on to consider the arrangements that would need to be in place for Edge Organisations to operate and then considered the kinds of degrees of freedom and features that they would need to have. Next, the paper provided a strawman which characterised Edge Organisations and their environments in such a way that this would begin to provide a 'language' for reasoning about them. In the next theme, the paper outlined the kind of experimental campaigns that would be appropriate for Edge Organisations so that studies could indicate the circumstances under which they will and wont work. Finally, the paper indicated how the concept of Military Capability Packages might be changed by Edge Organisations and used this to comment on issues relating to acquisition, implementation and employment.

In summary, this work provides initial thoughts on how to improve our understanding of the arrangements that will be required for Edge Organisations to operate successfully. Some of our opponents already operate in the manner of an Edge Organisation and their inherent agility and small footprint is a real problem for us. Learning how to change our operational systems at will to exert a decisive effect against all types of opponents in all types of 'challenge spaces' is the goal of this work. We invite feedback and comment from interested parties.

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