The Truth and Delta of Preparing a Journal Paper

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The road to writing a journal paper is tough because it is riddled with hard work and work that will be reviewed and criticized by your "peers." The nice thing is that it is an incredibly rewarding road when it is done successfully. It is a feeling of great pleasure to see your work published in a journal after it has been critiqued and accepted by your "peers." Also, your ability to interpret, discuss, evaluate, and write scholarly literature is foundational to you making it or not in your Ph.D. process.

This document serves to enlighten you on what it means to produce a scholarly paper, and to understand the delta that exists between a class paper or industry report and a scholarly journal publication. Enclosed you will find a few documents so you can get a handle on the scope and end objectives of producing a journal paper and some tribal knowledge on doing a literature search.

Enclosure descriptions

1. Preparing a Technical Paper for Possible Publication in a Journal - This is a general template/description prepared by Drs. Jose Emmanuel Ramirez-Marquez and Dinesh Verma of what should be contained in a journal paper. The format is not the case for all papers, but a general guidance. Most papers submitted for consideration to a journal are 25-32 double spaced pages (including exhibits and references). Ultimately, you have to write for the audience (the journal and reviewers). Therefore, determining the journal you want to publish in can be critical to how you write the paper and the language you use. It is also important to review other papers written in this journal to see what an acceptable paper looks like for this journal. Which brings me to the next document...

2. Systems Engineering (and related) Journals - This is a listing of potential journals to publish in. Before you start writing a paper, you should narrow the list of potential publications to about 2-3, maybe even 1, depending on the topic. This will impact the way you present the concepts and depending on the quality of the journal the probability of its acceptance. This can range from 10% to 50%. Some of your research you may want to make sure gets published or is not yet to the quality of a top journal, so you can send it to one of the journals with a higher acceptance rate. Some of your research you want to make sure is published in a "top" journal because of its intellectual caliber so you can enhance your academic credibility, you would send to one of the lower acceptance rate journals with a higher credibility. Managing your publication portfolio is like managing any portfolio. There is another reason for deciding which journal that is never spelled out but unfortunately will impact potential revisions to your paper. That is references that include papers from that journal. Sadly, there are rating systems for journals and one of the metrics that determines a journal's rating is citations. Therefore, it is not uncommon for a review to come back from a journal which states, "This reviewer strongly encourages the authors to include some references from Journal ####," which just so happens to be the journal you have submitted your paper to. This has happened to us many times. We recently got a review back in which the reviewer suggested we include 15-20 more references. Then they suggested 15 specific references which were all from that journal.

Note: The Truth and Delta of Preparing a Journal Paper is a statement of perspective from Brian Sauser and John Boardman which may or may not be a statement of verity.
3. **Systems Thinking and Network Enabled Capability (NEC)** - This is an original project assignment submitted to Dr. Boardman for SDOE 775 by Donnie Blair (a sample of an “A” class project). We are sharing this with you because this student was offered the opportunity to continue to work on this paper under our guidance to submit it to a journal for publication. He turned this assignment into the next document...

4. **Communicating Strategic Intent with Systemigrams: Application to the Network-Enabled Challenge** - This paper was based on the assignment previously mentioned and recently published in the *Journal of Systems Engineering*. Comparing the two will help you see the delta between a class assignment and a journal paper. This entire process took about 18 months, which is typical for getting a paper published in a journal. Most of that time you spend waiting. It is also not uncommon for the paper to go through 2-3 revisions with the reviewers/editor before going to print. Most journals list the number of revisions the paper went through on the first page of the paper.

**Techniques in Performing a Literature Review**

One of the sections of a journal paper that you will put the most time into is the literature review (or intellectual justification). The purpose of a literature review and supporting citations in a paper is to demonstrate to the reader that you have an *in-depth* understanding of the current state of knowledge on the subject you are writing about and thus where your research addresses the unknown. Rarely do people over cite… the rule of thumb is that if a statement (no matter how much you paraphrase it) is not your original thought, the source should be cited… else it is PLAGIARISM!

With that said, there is a quality dimension to references based on the rigor by which the information was peer reviewed before being published. This hierarchy is:

1. Scholarly Journals
2. Conference Proceedings (peer reviewed)
4. Internet/Mass Media (magazines, newspapers)

This list also represents the order in which you should perform your search and the number of reference you have should be weighted to the top end of this list. While there is no requirement or standard for numbers of references, you will be able to see from other journal publications the number of references that is considered adequate.

Where to search...
- Stevens Library Databases (e.g. ABI/Informs; ScienceDirect; IEEE; Engineering Village 2)
- References of other papers published on similar topic
- Internet
- Review articles. Many journals will publish article that review the scholarly literature on a subject of relevance to their readers.

**General Parting Comments**

- There is no better way to train yourself to be a better writer of scholarly publications than to read publications from QUALITY journals, and read, and read, and...

*Note: The Truth and Delta of Preparing a Journal Paper* is a statement of perspective from Brian Sauser and John Boardman which may or may not be a statement of verity.
• Ask your mentors and faculty what they are reading now; what journals they publish in and strive to publish in; what do they consider as the “top” journals in their field.

• Learn the difference of writing at length and with brevity; Practice writing, even if it is about something unrelated to your research but something you are passionate about… ultimately you need to be passionate about your research; in the end, just write as much as you can. We are always writing and sharing short pieces with each other that eventually become “feed stock” for journal papers. Keep these on file as provocations. See the Provocations section under Words on our web page, and you will find documents that contain some of our original thoughts that later were published in journals.

• Read history (of science, life, engineering...); Know what has been written in the past; Some concepts may have been discussed 100 years ago that you think are new. Also, read from the great scientist or scientific writers (e.g. Jacob Bronowski, Ascent of Man; Alan Lightman, The Discoveries; John Simmons, The Scientific 100)

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Preparing a Technical Paper for Possible Publication in a Journal

Jose E. Ramírez-Márquez, Dinesh Verma & Author See*

Department of Systems Engineering and Engineering Management, Stevens Institute of Technology,
Castle Point on Hudson, Hoboken, NJ, USA

Type correct affiliation for authors: Name of their organization, Address, City, State, Country

Abstract – Every journal requires that authors submit an abstract of their manuscript. As in this paper you should always include a separate page with the title and manuscript abstract. The abstract is a concise discussion about the paper. In general terms, an abstract should address the following five points:

1. Clearly introduce the problem that the manuscript is discussing/addressing,

2. Discuss the problem background. That is, discuss the research that has been previously conducted by you or others in the field (or related fields) to solve/address the same or similar problem,

3. Develop a succinct argument for the methods or ideas proposed in your manuscript,

4. Present a clear and understandable justification of why the proposed methods or ideas contribute to a superior or different solution to the problem. A clear statement of your contributions is often crucial to reviewers. Clear specify this when possible. And finally,

5. Discuss the likely future directions of the research being conducted by you (your group).

* Contributing author: include Fax # and E-mail address
Preparing a Technical Paper for Possible Publication in a Refereed Journal

1Jose E. Ramírez-Márquez*, 1Dinesh Verma & 2Author See

1Department of Systems Engineering and Engineering Management, Stevens Institute of Technology,
Castle Point on Hudson, Hoboken, NJ, USA

2Type the correct affiliation for authors: Name of the organization, Address, City, State, Country

Abstract – Same as the previous page.

1 Introduction

This section presents a general guide for preparing a technical manuscript. As a pre-requisite, you must define the correct editing format. Instructions on manuscript editing and formatting can usually be found in the “information for contributors” section on the back cover of any issue of the journal being targeted for submission or on the information for authors’ link at the web page of the journal. If the journal is Systems Engineering, the authors can consult the back cover of any issue or the URL http://www.interscience.wiley.com/jpages/1098-1241/authors.html for the required editing and formatting information. If you are not certain of your target journal, we recommend that you use the Systems Engineering Journal guidelines as your default guidelines. It is important to strictly follow the journal guidelines or the manuscript may be returned without consideration. While each journal has a different set of editing and formatting guidelines, all manuscripts should follow a set of established conventions.

1.1 Text and Indenting

Text is usually set in one justified column with top, bottom left and right margins of at least 1”.

All text should be in the same font (usually Times New Roman), 11pt and double spaced except for the manuscript title (14 pt) and text in tables, figures and comments (10pt). Never add any lines space between lines or paragraphs. Finally, first lines of paragraphs are usually indented.

1.2 Equations
Equations are not indented. They should be numbered consecutively and the corresponding number should be placed at the end of the line between parentheses. Equations are called by these numbers within the manuscript. It is important to remember that only equations that are called should have a number. As an example of equation editing and formatting consider Equation (1):

\[
R = 1 - P\left( \bigcup_{h=1}^{l} C_h \right) = 1 - \sum_{h=1}^{l} P(C_h) + \sum_{h<k} P(C_h \cap C_k) - \ldots + (-1)^{l} P(C_1 \cap C_2 \cap \ldots \cap C_l) \tag{1}
\]

where \( l \) = number of minimal cut sets and \( C_h \) = minimal cut set \( h \).

1.3 Tables

Tables should be located close to their referring text. They should be numbered consecutively and centered within the text column. All text contained in the tables should be typed in 10pt. Explanations regarding table data should be placed at the foot of the table. The table number and corresponding caption should be typed above the table in 11pt. As an illustration of these guidelines consider Table 1.

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*See note on cycle handling Section 4.1.1

1.4 Figures

Similar to the tables’ guidelines, figures should be placed centered within the column text, consecutively numbered and close to their referring text. However, the figure number and the corresponding caption must be typed below the figure in 11pt. As an illustration of these guidelines consider Figure 1.
2 Technical Content

This section presents a general structure and organization. Although it is not a convention, most technical manuscripts are structured around six sections: Introduction, Background, Body of Work, Results, Conclusions & Future Research and References.

2.1 Introduction

In this section the author should clearly communicate the motivation of the work to be presented in Section 2.3 Body of Work. This section is often the most important from a reviewer’s perspective. A good introduction can provide a good context for the reviewer, allowing better understanding of your research contributions.

2.1.1 Problem Statement

The first paragraph of the introductory section should discuss the problem being addressed. This paragraph should be concise. Usually, it provides a general explanation of the problem.

2.1.2 Problem Motivation

In this paragraph the problem being analyzed should be put in context. The discussion should be focused on why the problem is important. If possible it should explain how solving the problem is likely to have a beneficial impact. In general, this paragraph of the manuscript should make a case for the technical material to follow.

2.1.3 Problem Background

From a very general perspective, these paragraphs present the related research in the permanent literature, and its contributions to the problem area defined in the manuscript. Furthermore, you should
also address any drawbacks or restrictions of previously proposed approaches in this “body of knowledge”. Similarly, it should communicate how your proposal is unique or different.

2.1.4 Technical Introduction

The last paragraphs should briefly and clearly illustrate the technical material that the manuscript contains. Mathematical content should be avoided within this section. The author should remember that this part of the manuscript can be regarded be as an introduction on how the problem was solved and improvements obtained. Finally, within these paragraphs the remaining sections must be introduced.

Assumptions

Immediately after the last paragraph of the introductory section the manuscript must state all relevant assumptions that you made while conducting your research.

Notation

After all assumptions have been stated the manuscript should introduce the important notations used throughout the paper.

2.2 Background

In this section the manuscript should discuss the most relevant research in the permanent literature related to the problem being analyzed/addressed in the manuscript. As a general rule each area related to the problem should have a separate subsection. Previous work reviewed should be relatively recent and relevant. You should be able to summarize other research efforts targeting the problem space defined by you, illustrate the methods used by other authors, their results and contributions. This is an important section that reflects your familiarity with the research area. Literature review is not only intended to provide a collection of previous research relating to your research area, but also to shed light on key links and motivations of the current research and this manuscript. The last section of this manuscript presents general reference guidelines.

2.3 Body of Work

This section should describe the research conducted by you. The section can be divided into two interrelated subsections.
2.3.1 Discussion of Proposed Methods

This subsection should elaborate on what and how the methods or techniques proposed contribute to the general area of research. Moreover, the discussion should include a description of how the existing research or “body of knowledge” is complemented by your research. Finally, a paragraph justifying the proposed approach should be included.

2.3.2 Proposed Methods

The subsection should start with a detailed description of how the method was developed. Immediately following the methods, techniques or approaches developed should be presented. This section should contain all mathematical expressions and models developed. Usually, this section can be complemented with diagrams that help illustrate the analysis techniques.

2.4 Results

Results and examples are usually used to provide the reviewers with evidence about the effectiveness of the methods presented in Section 2.3. A detailed description of the example must be given followed by the results or findings obtained from the proposed method. If the manuscript builds upon previous work, the results or findings obtained should be compared with these other methods. Each example should be followed by comments regarding the implications of the results.

2.5 Conclusion & Future Research

This section allows reviewers to understand implications of proposed methods. In general, this part of the manuscript should communicate improvements accomplished and future directions of this research.

2.5.1 Conclusions

The conclusion of a manuscript usually initiates with a paragraph discussing the problem that has been solved. Then, it should discuss what the proposed method accomplishes and a general discussion about the results.

2.5.2 Future Research
Manuscripts are usually concluded with future directives that the work proposed may take. The discussion should be centered on how the current methods could be used to solve more difficult problems.

2.6 References

Guidelines on how to reference previous work can usually be found in the “information for contributors” section in the back cover of any issue of the journal being targeted for submission or on the information for authors’ link at the web page of the journal. However, at the end of the manuscript references usually appear in the order they were refer underneath the heading REFERENCES. An Example on the typography for references is given in [1] while examples of actual references [2-3] have been obtained from Ramirez-Marquez et al [4].

2.6.1 On the Importance of References

The main purpose of references is to show that the authors are up-to-date with the latest research central to the manuscript subject, and aware of the relevance of any related research. Also, it shows that the authors have an understanding of any existing drawbacks in the research, and aware of possible avenues of advancing the body of knowledge in this regard.

The manuscript should include articles that contribute to the contextual setting, understanding, and advancement of the manuscript topic.

From an editorial perspective, it is better to have an excess of references rather than having a shortage of references. However, if a manuscript has a small set of references it must make a strong case regarding the lack of research on the proposed topic. If more references related to the manuscript’s topic are available and reviewers know it, they will get the impression that the author is not familiar with the topic. The manuscript may be rejected if important references are omitted.

Acknowledgements:
In this section, you can briefly acknowledge any support or suggestions that you might have received from someone who is not one of the co-authors of this technical paper. This is a graceful way to show gratitude for “informal” help and suggestions that you might have received, a clarifying data or viewpoint shared by someone, or any editorial support received from someone.
REFERENCES

1. Last name, First name or Initials. (year) “Title of article” Title of Journal Volume number, Issue Number and Page numbers.


### Systems Engineering

#### Systems Engineering

- **Chinese Journal of Systems Engineering and Electronics**
  - Issued Quarterly by Ministry of Aero-Space Industry, Beijing, China
  - ISSN: 1004-4132

- **Distributed Systems Engineering**
  - Issued Quarterly by Institution of Electrical Engineers & British Computer Society, UK
  - ISSN: 0967-1846

- **Industrial Process Systems Engineering**
  - Issued Semi-annually by SBEQ, Brazil
  - ISSN: 1519-9118

- **Intelligent Systems Engineering**
  - Issued Quarterly by Institution of Electrical Engineers & British Computer Society, UK
  - ISSN: 0963-9640

- **International Journal of Industrial and Systems Engineering**
  - Issued Quarterly by Inderscience Publishers
  - [http://www.inderscience.com/ijise](http://www.inderscience.com/ijise)
  - ISSN: 1748-5045 (Online); 1748-5037 (Print)
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<td><strong>Systems Research Forum</strong>&lt;br&gt;Issued Annually by Stevens Institute of Technology&lt;br&gt;ISSN: 0-9787122-0-X</td>
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## Education

24. **IEEE Transactions on Education**  
   Issued Quarterly by IEEE Education Society  
   ISSN: 0018-9359

25. **Journal of Engineering Education**  
   Issued Quarterly by American Society for Engineering Education  
   ISSN: 1069-4730

## General Management

26. **Harvard Business Review**  
   Issued Monthly by Harvard Business School Publishing  
   ISSN: 0017-8012

27. **International Journal of Project Management**  
   Issued 8 times a year by International Project Management Association  
   ISSN: 0263-7863

28. **Management Science**  
   Issued Monthly by Institute for Operations Research and the Management Sciences (INFORMS)  
   ISSN: 1526-5501 (Online); 0025-1909 (Print)

29. **MIT Sloan Management Review**  
   Issued Quarterly by Massachusetts Institute of Technology  
   ISSN: 1532-9194

30. **Project Management Journal**  
   Issued Quarterly by Project Management Institute  
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Issued Quarterly by American Society for Engineering Management  
http://www.asem.org/publications/index.html |
| 32. | **International Journal of Technology Management**  
Issued 16 times a year by Inderscience Publishers  
ISSN: 1741-5276 (Online); 0267-5730 (Print) |
| 33. | **Journal of Engineering and Technology Management**  
Issued Quarterly by Elsevier  
http://www.elsevier.com/wps/find/journaldescription.cws_home/505648/description?navopenmenu=1  
ISSN: 0923-4748 |
| 34. | **Journal of High Technology Management**  
Issued Biannually by Elsevier  
http://www.elsevier.com/wps/find/journaldescription.cws_home/620219/description?navopenmenu=1  
ISSN: 1047-8310 |
| 35. | **Journal of Product Innovation Management**  
Issued Bimonthly by Product Development and Management Association  
http://www.blackwellpublishing.com/journal.asp?ref=0737-6782&site=1  
ISSN: 1540-5885 (Online); 0737-6782 (Print) |
| 36. | **IEEE Transactions on Engineering Management**  
Issued Quarterly by IEEE Engineering Management Society  
http://www.andromeda.rutgers.edu/%7Eieeetem/index.html  
ISSN: 0018-9391 |
| 37. | **Leadership and Management in Engineering**  
Issued Quarterly by Committee of Professional Practice  
http://scitation.aip.org/leo  
ISSN: 1532-6748 |
| 38. | **Technovation - The International Journal of Technological Innovation, Entrepreneurship and Technology Management**  
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Systems Thinking and Network Enabled Capability (NEC)

Donny Blair
SDOE 775 Project

30 April 2006
Abstract

This paper addresses Network Enabled Capability (NEC) as a human activity system. The author employs systems thinking concepts, to include the Boardman Soft-Systems Methodology (BSSM) to develop and elucidate key NEC issues. A systemic diagram, or “systemigram”, process representation is developed as a formal NEC system model. The model is compared against the author’s real-world experience with network-centric systems to identify and evaluate three key issues of debate: coherent acquisition strategy, systems engineering reform, and information management. The author offers evidence that fundamental change in the key issues is required to realize a successful NEC capability.

Introduction

To date, much attention and no small amount of funding has been paid to the concept of network centric warfare (NCW) as envisioned by the U.S. Department of Defense (DoD). The counterpart in the United Kingdom Ministry of Defense (UK MoD) is referred to as Network Enabled Capability (NEC). Often used interchangeably, the two concepts are in fact different in approach. NEC, as opposed to NCW, is a capability enabled by networking of systems rather than the more network-centric doctrine espoused by the DoD. NEC is an “enabler” of UK military effects-based concepts.

MoD Joint Doctrine Note 1/05, “The UK Military Effects-Based Approach”¹, states:

“Today, across Government, a new ‘Comprehensive Approach’ to the formulation of responses to crisis and threats to international security is emerging and, within the MoD, a complementary ‘Effects-Based Approach’ (EBA) to complex scenarios is enhancing existing doctrine.”

The author’s research into various open-source UK material on NEC shows a propensity on the part of the writers for an “ends, ways, means” approach to analysis. In such an approach, analysis is sequential starting with the desired end state, through a statement of how this will be achieved, and ending with a statement of what equipment is required. This approach represents classic goal-oriented thinking, as one usually finds in traditional hard-systems engineering. In the case of available NEC literature, the author found himself awash in reams of analyses employing such reductionist processes, some seemingly contradictory, replete with scores of mysterious government acronyms. This is not a condemnation of such well-intentioned methods; however, of interest in this
paper are what insights may be gained by applying systems thinking concepts to the NEC complex problem.

It is important to understand that proponents within the UK Ministry of Defense (MoD) advocate that NEC transcends the technical; indeed, there are strong human and social components to be considered beyond the technical. The view generally held is that NEC is a complex socio-technical capability that must be considered holistically across all defense Lines of Development (LoD). Checkland would classify NEC as a human activity system by virtue of its heavy human influence and interaction. The author sees NEC as a concept ripe for address with proper systems thinking and soft-systems methodologies. Such methodologies using rich text and illustration facilitate a holistic view of NEC from the outset, leading to a clearer elucidation of important issues to be engaged.

In this paper, the author will examine NEC using the Boardman Soft-Systems Methodology (BSSM). The overall problem situation is addressed by developing a rich text formulation of NEC. This structured text is then modeled using a systemigram software tool. The author applies some other systems thinking in a broader discussion on the acquisition of NEC taken from his readings of Vicker, Buchanan, and Senge. Given the idealized model and adjustments from other systems thinking, a comparison is made between the model and the real world based on the author’s experience on a current project. The result of this analysis is a set of key issues to be addressed.

The Problem Situation (BSSM 1, 2)

Following the attacks on September 11, 2001, the UK revisited the standing Strategic Defense Review (SDR) of 1998 and published the SDR New Chapter (SDR-NC) in 2002 to address the changing security environment brought on by the global war on terror. The Defense White Paper, “Delivering Security in a Changing World”, built on the SDR-NC by laying out the policies for NEC, realizing that operations against international terrorism require increased precision and rapid delivery of military effect, capabilities achieved only through a networked force employing shared situational awareness. A number of policy and guidance initiatives have spun off from the SDR-NC, all feeding the future UK Operational Concepts for Space, Air, Land, Maritime, and Logistics, setting the operational context for NEC. These various operational concepts must adopt NEC as an enabling capability crossing all Defense Lines of Development to remain coherent with the overall UK Defense Strategy. This is no small order indeed and represents an unstructured view of the problem situation.

Given Checkland’s advice that “the function of (SSM) stages 1 and 2 is to display the situation so that a range of possible and, hopefully, relevant choices can be revealed, and that is the only function of those stages”, we are then faced with how best to display the problem situation to this end. In this stage of the problem, the author found it tempting to simply take the various writings (viewpoints) on NEC as sufficiently representative and proceed to combine the writings into a rich picture forthwith. Care was exercised, however, to ensure a neutral display of the problem, uncontaminated by real-world
experiences to the extent possible (author’s own project, for example) to avoid invalidating the comparison stage of the methodology, which is the whole point. This required no small amount of restraint on the author’s part, the result being a number of “false-starts” in generating the NEC problem picture used to feed the formal system model.

To summarize, the problem expressed is thus: we have a complex NEC system of systems, mandated by MoD defense policy, guided and informed by UK joint visions and emerging concepts (the inputs), achieving military and non-military effects (the output), development of which is constrained by stove-piped acquisition, ill-defined information management, technical complexity, and an overall lack of systems thinking. Let us now move on to generate a rich, structured textual representation of this problem which we will find useful in building a formal system model.

**Structured Text (BSSM 3)**

The following structured text, or root definition, was developed from the author’s research from various open-sources representing the views of senior level policy makers, MoD General Staff level, joint committee chairs, and industry consultants. Therefore, it constitutes a single combined text representing a number of views of an NEC human activity system. (Note: the author’s original intent was to address each view separately and explicitly but this approach was prohibitive due to the project’s constraint on length) The official MoD sources analyzed and used to build the structured text are included as references 1, 4, 5, and 6.

**Structured Text**

*UK Defense policy directs the development of future UK Operational Concepts for Land, Air, Space, Maritime, and Logistics. These operational concepts are guided by the UK Joint Vision, Joint High-Level Operational Concept (HLOC), Effects-Based Operations Concept, and Defense White Paper 03/04. The operational concepts are informed by emerging concepts such as NEC, to achieve the overall UK Defense Aim: “to deliver security for the people of the United Kingdom (Customers) and the Overseas Territories by defending them, including against terrorism; and to act as a force for good by strengthening international peace and stability.” NEC enables a flexible acquisition strategy to establish coherent acquisition programs (Environment). These programs adopt an incremental approach to realize rapid technology insertion to achieve a net-ready force. This net-ready force exploits a network infrastructure to enable shared awareness. Shared awareness underpins flexible working, which depends on shared awareness, to deliver synchronized effects which address the dynamic mission which is undertaking the defined UK military tasks to achieve military (Actors) and non-military effects (Transformation). NEC requires an information infrastructure to provide secure and assured information access to support the network infrastructure and facilitate shared awareness. NEC also employs Effects Based Planning across Government (Owner) which requires a dynamic planning system supported by distributed tools and models to manage Agile Mission Groups, thus enabling Flexible Working. NEC*
improves equipment integration of weapon systems, intelligence, surveillance, target acquisition and reconnaissance systems (ISTAR), and command and control (C²) nodes to facilitate the Agile Mission Groups. NEC also enables Networked Support across public and industry to sustain Agile Mission Groups used to enable Flexible Working.

The author utilized Checkland’s CATWOE mnemonic to ensure a well-formulated Structured Text. These characteristics are indicated in parentheses in the body of the structured text above.

**Systemigram Design(BSSM 4,5)**

The above root definition is reflected below in Figures 1 and 2. Figure 1 represents a high-level systemigram model of the NEC context discussed above, showing how NEC informs the operational concept development used to achieve the overall UK Defense Aim.

![Systemigram Diagram](image-url)

Figure 1. NEC in Context

The systemigram in Figure 2 represents a magnified version of the NEC Emerging Concepts node of Figure 1. Figure 2 shows five main "strands" taken from the structured text. The blue nodes represent the core NEC themes as defined in the NEC Conceptual Framework. Eight of the core themes cover equipment capability and one the
acquisition process. A story-boarding technique should be used in which a sytemigram slide show (available as part of the sytemigram software tool) is utilized together with color coding to engage the audience in a meaningful process discussion.

Strand 1 develops the Flexible Acquisition core theme of NEC. Inclusive Flexible Acquisition is a coordinating process across the MoD, industry, and other government departments (OGDs) to establish coherent acquisition programs. This is the most pressing and difficult issue of NEC to overcome as it directly addresses the legacy “stovepiped” organization and funding of various program offices in the Defense Procurement Agency (DPA) and Defense Logistics Organization (DLO). An incremental acquisition approach is necessary to minimize risk and realize rapid technology insertion at the same time. This equipment is necessary to achieve a net-ready force which may exploit a network ready infrastructure consisting of C4ISR systems such as the Defense Network-Enabled Capability.
Information Infrastructure (DII), Listener, SKYNET 5, Cormorant, Watchkeeper UAV, Joint Operational Picture (JOP), Bowman, and the Joint C\(^2\) Support System (JC2SS) to enable Shared Awareness. In turn, Shared Awareness underpins Flexible Working, the ability for assets to rapidly reconfigure to meet changing mission needs. Through Flexible Working, Synchronized Effects between mission groups may be delivered to address the very dynamic nature of asymmetric warfare. Thus, the UK military may undertake defined Military Tasks to achieve both military and non-military (political, economic) effects.

Clearly, an information infrastructure is required to provide secure and assured information. The Global Information Infrastructure (GII) initiative is the integration and interaction of networks, information appliances, information resources, applications and people. This infrastructure will provide information sharing between ISTAR, OGD, and Civil entities at varying levels of security and compartmentalization, a non-trivial challenge in itself. This information is required, indeed is the foundation for, the net-ready infrastructure discussed previously as well as a key enabler of Shared Awareness.

NEC forces will have access to many effectors within the battlespace that go beyond the traditional “attrition” effectors. Information operations is a large part of Effects Based Planning (EBP) and provides operational scope to the battlespace commander. Therefore, NEC will take a planning approach that focuses on the use of military and non-military effects (as opposed to attrition based) required against an enemy. EBP must be integrated with other planning processes in the battlespace, operational through all levels in the MoD and in all government departments with impact on political, military, and economic aims. To do this will require dynamic, distributed planning systems to manage Agile Mission Groups. These planning systems must consist of distributed tools and models to allow prediction and “what-if” analyses across the operational domain to include interactions between military, diplomatic and financial effects.

The formation of an NEC force cannot be limited by equipment configurations based on existing organizational structures. The NEC force will consist of capability components (weapon systems, ISTAR systems, and C\(^2\) systems) integrated together to facilitate formation of Agile Mission Groups to enable Flexible Working. These agile groups are brought together for specific operational tasks which may be long-term. Once complete, elements of the agile groups return to their host organization. The Shared Awareness within an Agile Mission Group must be very high to facilitate understanding and achievement of its common goal. However, Shared Awareness would be lower between different Agile Mission Groups.

NEC enables the concept of fully networked support. This support is not restricted to in-theatre forces but includes non-operational entities such as government bodies, industry, academia, and public services. Through networking, all of these disparate entities may be brought to bear in support of in-theater capability. This includes support such as logistics, data/image analysis, and medical. These support “forces” are necessary to sustain the Agile Mission Groups.
Other Systems Thinking (BSSM 4b)

NEC and Scale-Free Network Theory

Buchanan discusses egalitarian and aristocratic network topologies. The author hypothesizes that such topologies may in fact exist in the same network, differentiated only by their respective state of evolution. Egalitarian networks may represent the relaxed, or low-energy state, while aristocratic networks represent a state of higher energy evolution which may eventually “settle” to the lower state, the dynamics of the evolution determined by variables such as automation or human-in-the-loop level of interaction. Although such evolutionary characteristics of networks may only be perceived at certain levels of abstraction, there may be utility nonetheless in such a view. In terms of NEC, one might imagine in the future a reconfigurable network (dynamic network morphology) that purposefully takes on an egalitarian or aristocratic topology, based on purpose or perceived threat to the network, the inherent distributed nature of sensitive information offering more protection in an egalitarian topology, for example.

Continuing, of potential interest in this case might be whether or not particular stages of topological evolution exhibit vulnerability. Furthermore, do desirable architecture attributes such as Openness and Flexibility relate to or affect this evolutionary state (vulnerability)? Control of the evolution would be the ultimate aim. In Senge’s Chicago O’Hare airport study, which in fact revealed a relationship between these two network topologies, the network grows exhibiting emergence of hubs (aristocratic), followed by weakening of hubs, finally settling into an egalitarian state. This is somewhat similar to Senge’s Limits to Growth Archetype. This being the case, Senge’s studies have already proven that one must address the balancing loop, or slowing action, of the limits to growth archetype rather than the growth loop. This may give us some hint as to how one might control an evolutionary NEC network. An Agile Mission Group forms to accomplish a particular military task, for example. The establishment of the network and the dynamics inherent in the unfolding operation as entities join and leave the networked group, are likely to exhibit similar modes of evolution. Perhaps there is an equivalent high-leverage balancing mechanisms to effect control.

NEC and the Command and Control Paradox

A core theme of NEC is Shared Awareness. The very essence of the concept is secure and accessible information at all levels of command. This will be facilitated in the future through service oriented architectures (SOA). This, of course, is paradoxical to classic command and control. How does one execute effective C2 in the context of so much shared information available to so many? Both stronger leadership and increased information sharing is critical, hence the paradox. Effects Based Planning and Operations must account for this dilemma in C2. Effective use of multiple security level software access and role access will be necessary while maintaining the full benefit of Shared Awareness.
NEC and Acquisition Reform

The author is firmly convinced that reform in acquisition to transform stove-piped organizations and, more importantly, *thinking*, is fundamental to addressing the complexity of NEC. This extends to systems engineering reform as well. The author found Vicker’s Appreciative System Model useful in both describing the rationale for the current state of industry and as a *learning system* for developing a future state suitable for addressing NEC acquisition. Figure 3 below shows Vicker’s Appreciative System Model (see Reference 2, pp. A51-A52), the key point being that the source of the standards feeding perception and judgment (appreciation) is the *previous history of the system itself*. The process is therefore recursive in the sense that both Appreciation and Action feed the flux of events and ideas over time. The standards are the existing practices and the appreciation is based on existing points of view, both of which feed a continuation of events and ideas. For long-standing engineering organizations deeply ingrained in traditional reductionist thinking, breaking this process may be extremely difficult. Both Vickers and Checkland propose that meaningful change via Action should be approached from the standpoint of *managing relationships*. This is necessary because, only through relationships, rather than goals and objectives, can we break out of ill-suited mental models to effect change. The uniquely human characteristic of self-consciousness makes such change possible, and therefore apropos, for addressing complex human activity systems such as NEC. The author proposes that relationship management through effective leadership is the key to meaningful acquisition reform.

Figure 3. Appreciative System Dynamics

Feasible, Desirable Changes (BSSM 6)

A comparison of the author’s experiences and the system model reveals the following three major issues with respect to the realization of NEC:
Coherent Acquisition Strategy  
Systems Engineering Reform  
Information Management

A coherent acquisition strategy is the single most important issue facing NEC. The issue is far-reaching and goes beyond simple structural re-organization. Integrated offices, such as DEC(ISTAR), for example, while possessing funding empowerment, are constantly in a state of contention with the acquisition program offices. The separation between user and buyer is remarkably large. Clearly, a new approach is in order, with integrated program offices the first step of a larger cultural change.

One must look hard to find a more challenging environment than that facing the modern systems engineering (SE) organization of the 21st century. The discipline of systems engineering similarly finds itself in a state of unpreparedness for the world of NEC. Beset with challenges of funding uncertainty, technological complexity, and modern culture, the need for systemic inquiry into the engineering of complex systems such as NEC has never been greater. Unfortunately, systems engineering remains firmly embedded in a process culture born out of reductionist thinking, its roots deeply ingrained in Western thought reaching back as far as Descartes. Not surprising, the lion’s share of modern SE processes and tools are founded upon this intellectual tradition of analytical reduction (e.g., functional decomposition). The realization must occur that systems thinking is a core competency for all systems engineers. Figure 4 puts this in the context of Senge’s Growth & Underinvestment System Archetype, where instead of production capacity, investment is made in SE competency “capacity”. The author is convinced the same fundamental law applies as in production capacity whereby strategic investment must be made in the balancing loop (B2) of SE competency (and the urge to concentrate exclusively on accelerating growth at the expense of strategic investment) to achieve long-term, enduring business benefit. NEC cannot be built upon existing paradigms.

The shear quantity of data and information together with extremely demanding requirements of throughput, storage, and retrieval to support near-real time processes places Information Management in the top three of key NEC issues. A strategy that ensures secure and assured information/data access must be adopted. The author recommends a joint government and academic working group be formed and empowered to undertake development of this strategy. Certainly this is underway with the development of the GII; however, the author feels the thrust so far is too heavily technology focused and requires more emphasis on information processes and software requirements. The joint working group could ensure a more balanced address of this critical issue.
Conclusion

While there are viable NEC initiatives on-going, the author sees too little progress due to lack of a unified strategy within the MoD acquisition community. While committees and organizations are stood up and empowered in the MoD Customer 1 User domain (e.g., Director of Equipment Capability, Integrated Surveillance, Target Acquisition, and Reconnaissance), the acquisition community itself remains re-trenched in old ways and remarkably NEC illiterate. Meanwhile industry, in particular the systems engineering community responsible for designing and delivering NEC, continues to embrace tools and processes built upon the reductionist paradigm; suitable certainly for some level of the engineering of systems, yet completely anti-thetical to the systems thinking necessary to address a complex network of networks such as NEC. The defense establishment of both UK and US seems “hamstrung” by its own NEC beaurocracy, a paradox in itself. Sadly, we seem only capable of meaningful progress following events such as 11 September. While not part of this paper, it would be an interesting study in systems thinking to examine this unfortunate emergent property of the government “network” system.

This paper constitutes the author’s initial exposure to the world of systems thinking and soft-systems methodology in particular. While the ideas put forward in this paper may seem to connote a cursory treatment, the intent was otherwise, limited only by the
requirements of the project’s duration. In a real-world scenario, the systems thinking
points (4b) and three key NEC issues would be fed-back into an improvement of the
systemigram, iterating the story until the richest possible picture is available to elucidate
and “tease out” the important issues at hand.

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Communicating Strategic Intent with Systemigrams: Application to the Network-Enabled Challenge

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Received 27 March 2007; Revised 27 June 2007; Accepted 27 June 2007, after one or more revisions
Published online in Wiley InterScience (www.interscience.wiley.com).
DOI 10.1002/sys.20079

ABSTRACT

The U.K. Ministry of Defense (MoD) has mandated the development of a network enabled capability (NEC) across all of defense, aimed at producing agile military and nonmilitary effects via a network of networks. This paper provides an overview of NEC, representing it as a complex human activity system of systems (SoS), analysis of which cannot rely on purely traditional reductionist engineering approaches, requiring instead a soft-systems engineering approach. A literature review is then provided, covering nontraditional systems methodologies of the past 25 years, highlighting the more recent trend towards multimethodological practice. The paper introduces the systemic diagram, or systemigram, conceptual model, explaining its evolution from a form of visual language to its use as an appreciative learning system in a soft-systems methodology. Using the written prose of MoD policy makers, a systemigram model is constructed which represents the NEC concept, providing a systemic visualization of its complexity and an elucidation of the key SoS attributes of emergence, hierarchy, and boundary. Finally, the NEC systemigram is used in an example storyboarding technique, demonstrating its utility as a platform for stakeholder dialog leading towards a refined model that reflects a deeper understanding of NEC strategy. © 2007 Wiley Periodicals, Inc. Syst Eng 10:309–322, 2007

Key words: BSSM; multimethodology; NEC; SoS; SSM; systemigram

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1. INTRODUCTION

To date, much attention and no small amount of funding has been paid to the study and development of Network Enabled Capability (NEC). However, there appears to be no single definition for the concept. In describing NEC, U.K. Ministry of Defense (MoD) Joint Service Publication (JSP) 777 [2005b] states:

... Our understanding of NEC will continue to develop, so it is important not to constrain the future direction of NEC by an overly-restrictive definition. ... Networked Enabled Capability offers decisive advantage through the timely provision and exploitation of information and intelligence to enable effective decision-making and agile actions. NEC will be implemented through the coherent and progressive development of Defence equipment, software, processes, structures, and individual and collective training, underpinned by the development of a secure, robust, and extensive network of networks.

Unlike the more network-centric approach as embodied in the U.S. DoD Network Centric Warfare (NCW), NEC is described as a complex sociotechnical capability that should be considered holistically across all defense Lines of Development (Training, Equipment, Personnel, Information, Doctrine & Concepts, Organization, Infrastructure, and Logistics). Checkland [1993] would classify NEC as a human activity system (HAS) by virtue of its heavy human influence and social interaction. JSP 777 [2005b] describes NEC development as centered around seven high-level goals which in turn are broken down into specific objectives, each with an owner "... responsible for delivering, in conjunction with other stakeholders, the outputs required to achieve their objectives." In specifying NEC requirements, Alston [2003] proposes an "ends, ways, means" approach wherein analysis proceeds sequentially starting with the desired end state, through a statement of how this will be achieved, and ending with a statement of what equipment is required. The language of each of these approaches points to reductionist, goal-oriented thinking, the hallmark of a traditional positivist paradigm (a philosophical world view that objective knowledge can always be achieved; see Mingers [2004]). The philosophical assumptions associated with the positivist paradigm and its weakness in the treatment of complex systems have been covered extensively in the literature of the past 25 years. Checkland [1993] reiterates the inadequacy of a traditional positivist approach in addressing soft problems based on a number of case studies. Mingers [2004] discusses the move away from a positivist paradigm in the practice of management science/operational research (MS/OR). The positivist paradigm is particularly ill-suited for the large HAS. Checkland [1993, p. 256] writes: "... We were driven to conclude that there is a large class of soft problems for which the language of 'ends' and 'means' is inappropriate, problems concerned not with achieving goals but with managing on-going relationships through time." In the early system definition phases of a project, strategic vision and user needs must be captured and accurately translated into requirements, establishing the operational context for system development. In the case of NEC, feeding this translation process are competing social elements arising from the multitude of stakeholder views to be collected, analyzed, understood, and integrated into a set of coherent requirements faithful to the perceived intent of the original strategy. Within this dynamic and complex NEC SoS, what Senge [1990] calls "dynamic complexity" and Ackoff [1981] politely calls a "mess," one strives to understand and effectively communicate NEC strategy to project teams.

This paper contends that communication of NEC strategy begins with a proper visualization of its complexity using a systemic diagram, or systemigram conceptual model. Following a literature review of existing nontraditional systems methodologies, the paper discusses the evolution of the systemigram technique and provides justification for its application to NEC. A conceptual model of NEC strategy is then developed using the systemigram as part of a broader soft-systems methodology. The paper concludes with a storyboarding technique in which the systemigram is decomposed into several major themes, or strands, intended for use in a stakeholder dialog to elucidate key issues for debate resulting in a refined systemigram model to be used in communicating NEC strategy.

2. REVIEW OF THE LITERATURE

The number of nontraditional systems methodologies (defined herein as methodologies founded on other than a positivist/reductionist paradigm) in the literature appears to have stabilized following a period of rapid growth from the mid-1980s through the 1990s. Mingers and Rosenhead [2004] provide a summary of such methodologies, also known as "problem structuring methodologies" in MS/OR circles, in practice. Several of these methodologies are summarized in Table I with references. These methodologies are in contrast to the more positivist techniques currently employed in systems engineering practice and discussed primarily in the U.S. literature such as: Needs Analysis, Hierarchy of Objectives, or Strategies to Tasks (see Thaler [1993]; Kent and Thaler [1993]).
In other writings, Gu and Tang [2005] discuss a methodology of “meta-synthesis” founded on Eastern philosophy. The meta-synthesis approach is designed to address unstructured problems using a combination of soft and decision support methods attempting to synthesize experts, knowledge databases, and computers via networking. Meta-synthesis along with many of the approaches in Table I bring with them considerable

### Table I. Example Nontraditional Systems Methodologies in Practice

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<td>Collaborative decision making approach iterating about 4 modes: shaping, designing, comparing, choosing</td>
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<td>Soft Systems Methodology (SSM)</td>
<td>Approach to address complex human activity systems by modeling of interpretive, appreciative learning systems</td>
<td>Checkland [1993]</td>
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<tr>
<td>Robustness Analysis</td>
<td>Problem structuring technique focused on incremental decision making and planning so as to maintain maximum flexibility</td>
<td>Rosenhead and Mingers [2001]</td>
</tr>
<tr>
<td>Drama Theory (Meta-games, Hyper-games)</td>
<td>Method based on game theory using acting to resolve conflict and/or identify actions</td>
<td>Rosenhead and Mingers [2001]</td>
</tr>
<tr>
<td>Dialog Mapping Methodology (DMM)</td>
<td>Technique using hypertext diagramming to capture group communications</td>
<td>Conklin [2006]</td>
</tr>
<tr>
<td>Viable Systems Model (VSM)</td>
<td>Descriptive, diagnostic modeling technique based on cybernetic principles used to promote organizational viability</td>
<td>Beer [1989]</td>
</tr>
<tr>
<td>Interpretive Structural Modeling/Interactive Management (ISM/IM)</td>
<td>Digraph modeling technique used to form interpretable patterns for complex problem structuring</td>
<td>Warfield [1974]</td>
</tr>
<tr>
<td>Interactive Planning</td>
<td>Five-phase systemic process for the planning of desirable futures based on participation, continuity, and holism</td>
<td>Ackoff [1981]</td>
</tr>
<tr>
<td>Strategic Assumptions Surfacing and Testing (SAST)</td>
<td>A 5-phase group-oriented decision making process based on intra- and inter-group dialectical debate</td>
<td>Mason and Mitroff [1981]</td>
</tr>
<tr>
<td>Strengths, Weaknesses, Opportunities, and Threats (SWOT)</td>
<td>A process for determining internal and external factors key to achieving a chosen objective</td>
<td>Weirich [1982]</td>
</tr>
<tr>
<td>Scenario Planning</td>
<td>Method using scenario thinking and simulations for strategic planning</td>
<td>Schoemaker [1998]</td>
</tr>
<tr>
<td>Socio-Technical Systems Approach</td>
<td>Joint optimization of social and technical dimensions of open systems (organizations)</td>
<td>Trist and Murray [1993]</td>
</tr>
<tr>
<td>System Dynamics</td>
<td>Approach to understanding complex systems through causal loop diagramming</td>
<td>Forrester [1969]</td>
</tr>
<tr>
<td>Decision Conferencing</td>
<td>Working group modeling and analysis of participant judgements to develop shared understanding and agreement on problem approach</td>
<td>Phillips [1989]</td>
</tr>
<tr>
<td>Total Systems Intervention (TSI)</td>
<td>A metamethodology used to select appropriate methodologies for a problem intervention</td>
<td>Midgley [1997]</td>
</tr>
<tr>
<td>System of Systems Methodology (SoSM)</td>
<td>A metamethodology linking problem contexts to systems methodologies; often used as a tool in the creativity phase of TSI</td>
<td>Jackson and Keys [1984]</td>
</tr>
</tbody>
</table>
process “overhead” in terms of facilitator knowledge, required infrastructure support, special equipment, and format. SSM (depending on its design) offers the least overhead cost. Of interest in this paper towards our need to address NEC is a methodology that minimizes such overhead yet offers flexibility in terms of customer interaction while still meeting the need for problem visualization and strategic knowledge capture. Realizing that large SoS such as NEC reflect a continuum of complexity we also seek an approach which can be adapted to a multimethodological treatment. In a survey, Munro and Mingers [2002] show SSM to be the predominant approach used in combination with other methods in multi-methodological practice. This is reflected in the literature in the plethora of examples showing successful adaptation/extension of SSM across a range of engineering disciplines. Fillery, Rusli, and James [1996] describe several rich picture techniques to supplement the problem situation structuring phase of SSM to include caricature, problematic diagramming (rich picture technique to capture problem causal relationships), SWOT, results grouping/ranking, cognitive maps, and Ishikawa (fish-bone) diagrams. Sagoo and Boardman [1998] developed a translation algorithm to convert the SSM conceptual model descriptions into Petri models, thus permitting analysis and verification of the models using Petri net theory. Bustard et al. [2005] present a complementary application of SSM and Viable Systems Modeling in the design of autonomic systems. Patel [2002] augmented SSM with the TELOS knowledge representation language to provide knowledge capture in a complex office environment. Sinha and Chaczko [2005] extend SSM through the integration of a Systemic Analysis through Familiar Entities (SAFE) model into the Checkland’s [1993] CATWOE technique to capture the feedback behavior of changing World views in the analysis of IS systems. Keenan and Bustard [2006] proposed a contiguous use of SSM and eXtreme Programming (XP) in support of agile software development.

3. SYSTEMIGRAMS—EVOLUTION AND RELEVANCE TO NEC

The evolution of systemigrams may be considered in three phases: its development as a form of visual language, its adaptation as a methodology for business architecting, and its refinement as an appreciative learning system. In Phase 1, development of the technique concentrated on the graphical portrayal of structured prose. The first application of the method involved support to a European R&D project [Boardman, 2005]. In this instance, the systemigram was employed to communicate business strategy to a project team using written prose found in a project notebook whose sole author had left the company. Inspired by Checkland’s formal HAS model [1993], Boardman proposed that diagrams, which could be regarded as systems in their own right, were the way forward, and that the components of these systemic diagrams, or systemigrams, would come directly from the author via his/her writings. Diagrams that capture concepts are not new (e.g., concept diagrams, concept mapping, fishbone diagrams, influence diagrams, and even the original flow charts). However, these other diagram types are largely memoryless, capturing the immediacy of prose but then forgetting and moving on to the next local piece of knowledge, making it more difficult to find longer thought threads since they concentrate on linear thinking rather than holistic thinking. Senge’s diagrams [Senge, 1990] are a possible exception to this, but these are usually kept deliberately small with the totality of the language conveyed by the diagram difficult to comprehend. As they are assembled in the spirit of systems (e.g., parts, relationships, wholes, emergence, flows, inputs, outputs, transformations, process, and networks), and used as appreciative learning systems within a soft systems methodology, systemigrams are a powerful medium for systems thinking and systems practice.

The systemigram was intended to convey a synergy of prose and pictures, thus embodying the best features of each. A scientific basis for such synergy exists in the field of neuropsychology [Paivio, 1991; Mazoyer et al., 2002]. Critically, the systemigram must be faithful to the text whence it came; recovery of the original prose by inspection of the diagram a key requirement. This imposes certain rules upon both prose and diagram as follows:

Rules for Prose
1. Address strategic intent, not procedural tactics.
2. Be well-crafted, searching the mind of reader and author.
3. Facilitation and dialogue with stakeholders (owner/originator of strategic intent) may be required to create structured text.
4. Length variable but less than 2000 words; scope of prose must fit scope of resulting systemigram

Rules for Graphic
1. Required entities are nodes, links, inputs, outputs, beginning, end (similar in purpose to Horn’s [1998] morphological primitives).
2. Sized for a single page.
3. Nodes represent key concepts, noun phrases specifying people, organizations, groups, artifacts, and conditions.
4. Links represent relationships and flow between nodes, verb phrases (occasional prepositional phrases) indicating transformation, belonging, and being.

5. Nodes may contain other nodes (to indicate break-out of a document or an organizational/product/process structure.

6. For clarity, the systemigram should contain no crossover of links.

7. Based on experience, to maintain reasonable size for presentation purposes, the ratio of nodes to links should be approximately 1.5.

8. Main flow of systemigram is from top left to bottom right.

9. Geography of systemigram may be exploited to elucidate the “why,” “what,” “how” in order to validate the Transformational aspect of the systemic model.

10. Color may be used to draw attention to sub-families of concepts and transformations.

Phase 2 involved the adaptation of systemigrams by Alison Boardman [Boardman, 2005] to a business architecting approach called the Boardman Soft Systems Methodology (BSSM). Like SSM from which it was inspired, BSSM is firmly rooted in practical application. Unlike SSM, however, BSSM is more narrowly focused on those practicalities of project management associated with concurrent engineering (CE) in the modern extended enterprise. Boardman [1994] describes the use of the systemigram in developing a process model unifying engineering and project management activities. Boardman and Cole [1996] used the BSSM approach for the representation and analysis of process knowledge as a platform for process improvement in capital goods manufacture. The essence of BSSM is threefold.

First, taking a business or technical process approach has considerable virtue:

- It relates powerfully and compellingly to what people do.
- It yields a business process architecture (BPA) of the enterprise.
- It can accommodate an extended enterprise perspective, integrating the component BPAs into a system of systems (SoS) view.
- It can provide a baseline from which to launch development projects.
- It animates an otherwise sterile library of processes into an active and adaptive portfolio of competence.
- It provides a benchmark for demonstrating and maturing competence of the enterprise.
- It affords a profile by which human skills, knowledge and aptitudes can be successfully aligned with tasks.

Second, the BPA can be treated in exactly the same manner as a product architecture, relevant to lifecycles, reviews, tradeoffs, and simulation. It is important to emphasize that systemigrams are not architectures themselves, but rather they can provide a neutral and common environment for comparing and aligning enterprise architectures.

The following case studies [Boardman, 2006] in which systemigrams have sought to capture “system” architectures include: UK Rail Industry Economic Architecture, UK Digital Terrestrial TV Strategy, and Daily Mail and General Trust plc Enterprise portfolio strategy. Systemigrams have also been employed in the analysis of SoS complexity in the USAF 2020 Combat Strategy [Boardman and Wilson, 2005]. Having established BSSM as a viable methodology for the modeling and improvement of business processes, Phase 3 shifted emphasis to refinement of systemigrams as a learning system facilitated through the technique of storyboarding. In this method, the composer of the systemigram creates a storyboard using carefully selected scenes which are subnets of the systemigram. The storyboarding helps to convey the message of the systemigram, together with the message that the author of the original text intended, to a wider audience. In the systemigram, advantage is taken of color, flow, and texture to create scenes (another connection may be made here with Horn’s [1998] use of Gestalt principles of perception and topologies to convey meaning) which represent key parts of the message which can only be amplified by having the right people (stakeholders) listen to the systemigram story. This drilling down can be continued for as long as required or until the messages begin to fail the original top-level requirements for the original text’s systemigram interpretation. In principle, this drill down technique can be part of a requirements management approach in which the key concepts (nodes) are now increasingly circumscribed by relationships with peers, parents, and “offspring.” Such an approach was used in the case study for the BBC in the subject of digital television [Boardman, 2006].

The use of BSSM systemigrams to address NEC may be justified in terms of its validity, relevance, and pragmatic merit. Validity is established in the proper consideration of NEC as a complex sociotechnical HAS requiring a soft-systems treatment. Its relevance lies in the fact that BSSM was specifically designed to address issues associated with ill-structured problems in concurrent engineering, extended enterprise, and project management domains [Ramsay, Cole, and Boardman,
1996; Sherman, Cole, and Boardman, 1996], domains mapping directly to the acquisition of NEC. NEC represents problems covering the spectrum from soft (HAS) to hard (network design). While this paper addresses the soft problem of strategy capture, BSSM offers versatility when used as a multimethodology in those problem interventions requiring a multi-paradigm approach [Clegg and Boardman, 1997]. Systemigrams facilitate the efficient capture and communication of strategic intent to project teams, establishing a framework for comprehensive NEC requirements definition and understanding. The pragmatic merit of BSSM/systemigrams is established by virtue of its successful employment in a variety of interventions [Boardman, 1994, 1995, 2005, 2006; Boardman and Cole, 1996; Boardman and Wilson, 2005].

4. APPLICATION OF BSSM AND SYSTEMIGRAMS TO NEC

4.1. The Problem Situation

Following the attacks on September 11, 2001, the UK revisited the standing Strategic Defense Review (SDR) of 1998 and published the SDR New Chapter (SDR-NC) in 2002 [UK MoD, 2003b] to address the changing security environment brought on by the global war on terror. The Defense White Paper, “Delivering Security in a Changing World” [UK MoD, 2003a], built on the SDR-NC by laying out the policies for NEC, realizing that operations against international terrorism require increased precision and rapid delivery of military effect, capabilities achieved only through a networked force employing shared situational awareness. A number of policy and guidance initiatives have spun off from the SDR-NC, all feeding the future UK Operational Concepts for Space, Air, Land, Maritime, and Logistics, setting the operational context for NEC. These various operational concepts must adopt NEC as an enabling capability crossing all Defense Lines of Development (Training, Equipment, People, Infrastructure, Doctrine, Organization, Information, and Logistics) to remain coherent with the overall UK Defense Strategy. This is no small order indeed and represents an unstructured view of the problem situation.

4.2. Structured Text

The following structured text was developed from the authors’ review of the writings found within the following open-source publications: Defence White Paper [UK MoD, 2003], Joint Doctrine Note 1/05 [UK MoD, 2005a], JSP 777 [UK MoD, 2005b], and Alston [2003]. The structured text constitutes an integrated rich text formulation of stakeholder world views of NEC strategy embodied in these papers.

Structured Text

UK Defense policy directs the development of future UK Operational Concepts for Land, Air, Space, Maritime, and Logistics. These operational concepts are guided by the UK Joint Vision, Joint High-Level Operational Concept, Effects-Based Operations Concept, and the Defense White Paper. The operational concepts are informed by emerging concepts such as NEC, to achieve the overall UK Defense Aim: “to deliver security for the people of the United Kingdom and the Overseas Territories by defending them, including against terrorism; and to act as a force for good by strengthening international peace and stability.” NEC enables a flexible acquisition strategy to establish coherent acquisition programs, these programs adopting an incremental approach to realize rapid technology insertion to achieve a net-ready force which exploits a network infrastructure to enable shared awareness. Shared awareness underpins flexible working to deliver synchronized effects that address the dynamic mission which is undertaking the defined UK military tasks to achieve military and non-military effects. NEC requires an information infrastructure to provide secure and assured information access to support the network infrastructure and facilitate shared awareness. NEC also employs Effects Based Planning across Government which requires a dynamic planning system supported by distributed tools and models to manage Agile Mission Groups, thus enabling Flexible Working. NEC improves equipment integration of weapon systems, intelligence, surveillance, target acquisition and reconnaissance systems, and command and control nodes to facilitate the Agile Mission Groups. NEC also enables Networked Support across public and industry to sustain Agile Mission Groups used to enable Flexible Working.

4.3. Systemigram Design

The above structured text is reflected in Figures 1 and 2. Figure 1 represents the higher-level systemigram model of the NEC context discussed above, showing how NEC informs the operational concept development used to achieve the overall UK Defense Aim.

The systemigram in Figure 2 represents a magnified version of the NEC Emerging Concepts node of Figure 1. Five main strategy “strands” derived from the structured text are indicated by numbers in Figure 2, although one is encouraged to take advantage of color as well to highlight the strands. The following core NEC themes as defined in the NEC Conceptual Framework [Alston, 2003] are included in the systemigram: Flexible Acquisition, Information Infrastructure, Secure and
Figure 1. NEC context.

Figure 2. NEC Systemigram.
Assured Information, Effects-Based Planning, Networked Support, Shared Awareness, Agile Mission Groups, Flexible Working, and Synchronized Effects. Eight of the core themes cover equipment capability and one the acquisition process.

A story-boarding technique should now be used in which a systemigram slide show is utilized to engage the stakeholder audience in an iterative process of meaningful dialogue/debate by walking through each of the strategy strands. This activity of stakeholder interaction via storyboarding is at the heart of the systemigram technique, reflecting its power as a conceptual, appreciative learning system. This also places no small amount of responsibility on the facilitator as the technique itself involves a prudent application of artful communications (both passive and active), acknowledging the cultures of the intended audience. For this reason there are no strict rules to storyboarding; the story can be told in a variety of ways but all have the same generic format: to create a storyboard using carefully selected scenes which are subnets of the systemigram. Storyboarding helps convey the message of the systemigram, together with the message that the author(s) of the original text intended, to a wider audience. The following paragraphs provide one potential story-boarding technique for the NEC systemigram in which advantage is taken of specific strategy strands highlighted numerically.

Strand 1, shown in Figure 3, develops the Flexible Acquisition core theme of NEC. Inclusive Flexible Acquisition is a coordinating process across the MoD, industry, and other government departments (OGDs) to establish coherent acquisition programs. This is the most pressing and difficult issue of NEC to overcome as it directly addresses the legacy “stovepiped” organization and thinking of various program offices within the MoD procurement organization. An incremental acquisition approach is necessary to minimize risk and realize rapid technology insertion in an unpredictable funding environment. This equipment is necessary to achieve a net-ready force which may exploit a network ready infrastructure consisting of C4ISR systems such as the Defense Information Infrastructure (DII), SKYNET 5, Cormorant, Joint Operational Picture (JOP), Bowman, and the Joint C² Support System (JC2SS) to enable Shared Awareness, with secure and assured information providing the underpinning support. In turn, Shared Awareness underpins Flexible

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**Figure 3.** Flexible acquisition strand.
Working, the ability for assets to rapidly reconfigure to meet changing mission needs. Through Flexible Working, Synchronized Effects between mission groups may be delivered to address the very dynamic nature of asymmetric warfare. Thus, the UK military may undertake defined Military Tasks to achieve both military and nonmilitary (political, economic) effects.

Strand 2 in Figure 4 shows an information infrastructure is required to provide secure and assured information. The Global Information Infrastructure (GII) initiative is the integration and interaction of networks, information appliances, information resources, applications, and people. This infrastructure will provide information sharing between ISTAR, OGD, and Civil entities at varying levels of security and compartmentalization, a nontrivial challenge in itself. This information is required, indeed is the foundation for, the net-ready infrastructure discussed previously as well as a key enabler of Shared Awareness.

NEC forces will have access to many effectors within the battlespace that go beyond the traditional “attrition” effectors. Strand 3 in Figure 5 highlights that information operations is a large part of Effects Based Planning (EBP), providing the commander with operational flexibility. NEC will take a planning approach that focuses on the use of military and nonmilitary effects against an enemy. EBP must be integrated with other planning processes in the battlespace, operational through all levels in the MoD and in all government departments with impact on political, military, and economic aims. To do this will require dynamic, distributed planning systems to manage Agile Mission Groups. These planning systems consist of distributed tools and models to allow analyses across the operational domain to include interactions between military, diplomatic, and financial effects.

The formation of a net-ready force cannot be limited by equipment configurations based on existing organizational structures. Strand 4 in Figure 6 shows that an NEC force will consist of integrated capability components (weapon systems, ISTAR systems, and C² systems) to facilitate formation of Agile Mission Groups to enable Flexible Working. These agile groups are brought together for specific operational tasks, each with its own set of unique support requirements. Once complete, elements of the agile groups return to their host organization. The Shared Awareness within an Agile Mission Group must be very high to facilitate understanding and achievement of its common goal.

As Strand 5 in Figure 7 indicates, NEC enables the concept of fully networked enterprise support. This support is not restricted to in-theatre forces but includes

Figure 4. Information infrastructure strand.
Figure 5. Effects-based planning strand.

Figure 6. Integrated capability components strand.
nonoperational entities such as government bodies, industry, academia, and public services. Through networking, all of these disparate entities may be brought to bear in support of in-theater capability. This includes support such as logistics, data/image analysis, and medical. These support “forces” are necessary to sustain the Agile Mission Groups, support Flexible Working, and, like all other strands, ultimately underpin the delivery of military and non-military effects.

5. CONCLUSION

This paper has shown a methodology that transforms the complexity of the NEC SoS into a systemic visualization using the systemigram conceptual modeling technique. As one analyzes each of the NEC strategy strands in the model, elements of communication, holism, hierarchy, and boundary emerge in the context of the core NEC themes. Such a perspective would not be evident from strict prose or any single architecture framework view. Whereas traditional words and pictures represent a positivist ontology of objective systems in the real world, systemigrams represent a phenomenologist ontology, in this case the various stakeholder world views of NEC which provides the catalyst for meaningful dialog. The systemigram model should be refined through storyboarding, working with the stakeholders in an iterative process of refinement until a comprehensive, coherent understanding of NEC strategy emerges.

6. GLOSSARY

- BBC British Broadcasting Corporation
- BPA Business Process Architecture
- BSSM Boardman Soft Systems Methodology
- CATWOE Mnemonic for Customers, Actors, Transformation, Weltanschauung, Owners, Environment
- C2 Command and Control
- C4ISR Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
- CE Concurrent Engineering
- CSH Critical Systems Heuristics
- CST Critical Systems Thinking
- DII Defense Information Infrastructure
- DLO Defense Logistics Organization
- DMM Dialog Mapping Methodology
- DoD Department of Defense

Figure 7. Networked enterprise strand.
DoDAF  Department of Defense Architecture Framework
DPA  Defense Procurement Agency
EBO  Effects Based Operations
EBP  Effects Based Planning
GII  Global Information Infrastructure
HAS  Human Activity System
HLOC  High Level Operational Concept
IM  Interactive Management
ISM  Interpretive Structural Modeling
ISTAR  Intelligence, Surveillance, Target Acquisition, and Reconnaissance
JC2SS  Joint C2 Support System
JOP  Joint Operational Picture
JSP  Joint Service Publication
MoD  Ministry of Defense
MoDAF  Ministry of Defense Architecture Framework
MS  Management Science
NEC  Network Enabled Capability
OGD  Other Government Department
OR  Operational Research
R&D  Research and Development
SAFE  Systemic Analysis through Familiar Entities
SAST  Strategic Assumptions Surfacing and Testing
SCA  Strategic Choice Approach
SDR  Strategic Defense Review
SDR-NC  Strategic Defense Review – New Chapter
SODA  Strategic Options Development and Analysis
SoS  System of Systems
SoSM  System of Systems Methodology
SSM  Soft Systems Methodology
SWOT  Strengths, Weaknesses, Opportunities, and Threats
TSI  Total Systems Intervention
XP  Extreme Programming

J.T. Boardman, Communications with the author, 2006.

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