Status of the Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE^{TM}) Project

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Abstract. The Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE™) project is being established to develop a guide to the Systems Engineering Body of Knowledge (SEBoK) and the Graduate Reference Curriculum for Systems Engineering (GRCSE™). The project, primarily funded by the U.S. Department of Defense, is led by a university partnership between the Stevens Institute of Technology and the U.S. Naval Postgraduate School (NPS) with support from various professional societies, especially the International Council on Systems Engineering (INCOSE) and Institute of Electrical and Electronics Engineers (IEEE), universities and commercial entities, all supporting the core authors from across the globe.

The purpose of the BKCASE project is to provide a reference guide to the Body of Knowledge for Systems Engineering (SE) to assist all interested in understanding the nature of this professional field. The BKCASE project is also developing a reference curriculum to improve the interpretation and comparability of graduate level SE programs. This will assist prospective students and employers of graduates to better understand the differences between individual programs. The BKCASE project, which kicked off in September 2009 with a small core team held its first author workshop in December 2009 at the NPS in Monterey, CA, The effort is scheduled to take three years during which SEBoK and GRCSE products will be delivered incrementally to the public. After 2 years, and eight workshops, the author team has grown to over 60 members from across the globe. Industry and academia are equally represented with approximately 1/3 of the authors based outside the U.S. with representatives primarily from Europe, Asia and Australia. An intermediate draft of both the SEBoK and GRCSE (version 0.5) was issued in September 2011 and December 2011, respectively, for public review by any person interested in submitting comments. In addition, a decision was made by the BKCASE author team to produce a SEBOK (version 0.75) which is scheduled for delivery in March 2012. This paper will focus on the progress of each document (SEBoK and GRCSE) about half a year before their final scheduled delivery to the public scheduled for September and December 2012 respectively.

INTRODUCTION – BKCASE PROJECT BACKGROUND & OVERVIEW

The Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE) project was previously introduced in various publications (see [1] through [4]), and the project has continued to make progress over since inception. Over the past year the guide to the Systems Engineering Body of Knowledge (SEBoK) has transitioned from a paper document to a wiki, officially released in draft form in September 2011. In anticipation of the first full release of the SEBoK, public review comments have been collected both through the general public and by way of focused requests to professional societies such as the International Council on Systems Engineering (INCOSE) and Institute of Electrical and Electronics Engineers (IEEE) and editorial boards including the Journal of Systems Engineering. A Graduate Reference Curriculum for Systems Engineering (GRCSE) was released in December 2011 with an updated curriculum architecture visualization and details on desired levels of cognitive achievement in both core material and concentrations, for systems engineering graduates. Both SEBoK [8] and GRCSE [9] are mature enough for use by early adopters.

History

The BKCASE project was born from a need to develop an internationally accepted authoritative guide to both the knowledge of the systems engineering discipline and the curriculum needed to teach the discipline at the Masters (professional) level. Historical efforts to create a body of knowledge for systems engineering were supported primarily through the International Council on Systems Engineering (INCOSE) [5, 6]. These efforts included the evolution of the INCOSE Systems Engineering Handbook (see INCOSE 2011 Version 3.2.2 [5] for the latest version) as well as a guide to the systems engineering body of knowledge that was published online and described in the April, 2002 edition of INCOSE INSIGHT which remains available to INCOSE members. Systems engineering knowledge has also been documented through various standards bodies, most notably:

- *ISO/IEC/IEEE 15288, Systems Engineering-System Life Cycle Processes, 2008* (see [7]).
- *ANSI/EIA 632, Processes for Engineering a System, (1998)*
- *IEEE 1220, ISO/IEC 26702 Application and Management of the Systems Engineering Process*[1]
- *EIA 731, Systems Engineering Capability Model*[2]
- *CMMI, Capability Maturity Model Integration*
- *United States Defense Acquisition Guidebook, Chapter 4, June 27, 2011*
- *IEEE/EIA 12207, Software Life Cycle Processes, 2008*
- *United States Air Force Weapon System Software Management Guidebook*
- *U. S. Dept of Defense Manual for the Service Development and Delivery Process (SDDP), Version 1.00, 28 Jan 2011*

These efforts were supported by the need to develop a coherent foundation of community accepted systems engineering knowledge as a basis for future workforce development initiatives and advancement of the ability to more effectively horizontally integrate independent functions and activities within an enterprise.

Project Members, Partners, Stakeholders

The desire to create a foundational guide to systems engineering knowledge is a shared vision across the wider international community of systems engineers. As individuals continue to advance interactive communications and the virtual integrated means by which desired end states are attained, the need for a common language for the SE profession is increasingly paramount. This was the primary reason the United States Department of Defense was the foundational sponsor of this effort. For example, in supporting Human Relief efforts around the world, this Department finds itself increasingly partnering with other entities; and all must interact seamlessly to deliver the needed support. To this end, the BKCASE project consists of a core team with members from the lead

[1] IEEE 1220 underwent a minor update that enabled concurrent usage with IEEE 15288. It was then fast-tracked into ISO/IEC as ISO/IEC 26702 and now contains a new project element to enable increased focus on SE management planning.

[2] Although still in use and available, EIA 731 is not considered “current” by many and is viewed as being replaced by CMMI

universities and the funding agency; and a broader author team with over five dozen sponsored and volunteer authors from around the world and across multiple domains. The core team manages the project and members of the core team also serve as co-editors and co-authors on the project.

Two professional societies, INCOSE and IEEE have agreed to become joint stewards of the BKCASE products once they are released in 2012. Both INCOSE and the IEEE are partners in the current project and have provided observers and authors to the BKCASE team. Other partners and sponsoring organizations include the Association for Computing Machinery (ACM) and the Systems Engineering Division (SED) of the National Defense Industrial Organization. Stakeholders in the development and success of the BKCASE project include many institutions too numerous to mention here and include an array of organizations spread across government, industry and academia from around the world.

BKCASE Project Overview

The project was initiated in September of 2009. At the time of this writing the team has completed eight of twelve planned workshops. The initial three workshops preceded the release of the 0.25 version of the guide to the SEBoK (Pyster, et. al, September, 2010) [13] and the fourth workshop was followed by the release of the 0.25 version of GRCSE (Pyster, et. al, December, 2010) [14].

Similarly, SEBoK version 0.5 [8] was released in the fall of 2011 (19th Sep 2011) following the seventh workshop held in July in Denver Colorado, USA. However, one major difference between version 0.25 and version 0.5 of the SEBoK is the format in which the guide is presented. Version 0.25 of the guide to the SEBoK was a document of over 650 pages in length including the front matter as well as references and a glossary. This version was comprised of sixteen chapters. The newer SEBoK version 0.5 has been released in a wiki format and is comprised of over 166 wiki articles ranging up to 2000 words each. These articles are comprised of seven main parts with introductions, about a dozen introductory sections in the initial part (Part 1), 29 knowledge areas, 115 topics, and over a dozen case studies and vignettes. Following the eighth workshop in London (Oct 2011), it was decided to issue an interim version of the SEBoK (version 0.75) in March 2012 with a limited number of article updates, before the SEBoK's first final release (version 1.0) planned in Sep 2012.

For GRCSE, both the version 0.25 and the version 0.5 (issued in Dec 2011) were released in document form with the second release being more international in flavour and more mature in the recommendations for developing graduate programs in systems engineering. GRCSE 0.5 presents a new curriculum architecture visualization and included details on desired levels of cognitive achievement for each non-introductory article of the SEBoK (excluding case studies and vignettes) for all graduates (core) and for graduates in Systems Engineering Management (SEM) and System Design and Development (SDD) concentrations.

More detail on both the SEBoK and GRCSE products are outlined in the next two sections.

SEBOK OVERVIEW AND STATUS

SEBoK Purpose

According to the BKCASE Project Charter as defined when the project was launched in September 2009 [1], the SEBoK claims the following value proposition:

a. There is no authoritative source that defines and organizes the knowledge of the SE discipline, including its methods, processes, practices, and tools. The resulting knowledge gap creates unnecessary inconsistency and confusion in understanding the role of SE in projects and programs; and in defining SE products and processes. SEBOK will fill that gap, becoming the "go to" SE reference.

b. The process of creating the SEBoK will help to build community consensus on the boundaries and context of SE thinking and to use this to help understand and improve the ability of management, science and engineering disciplines to work together.

c. Having a common way to refer to SE knowledge will facilitate communication among systems engineers and provide a baseline for competency models, certification programs, educational programs, and other workforce development initiatives around the world. Having common ways to identify metadata about SE knowledge will facilitate search and other automated actions on SE knowledge.

SEBoK Structure

The initial structure of the SEBoK at the project launch was based on the ISO 15288 processes [7]. Then, the authors adopted an expanded table of contents which was used for the SEBoK 0.25 issued in September 2010 [13]. Many SEBoK 0.25 reviewers recommended changing the overarching structure of the document and provided suggestions. In line with these proposals/comments and following discussions with authors held in the 3 last workshops (Phoenix in Jan 2011, Los Angeles in April 2011 and Denver in June 2011), the structure of SEBoK version 0.5 has finally been decomposed in 7 main "parts". Those main parts are listed and described below.

Part 1: Introduction

This part covers the context, purpose and scope of the SEBoK, its relationship to overlapping communities of interest, the current status and the guidance and plans for progressing to Version 1.0. This section provides the « opening » material of the SEBoK.

SEBoK is not a copy of all SE Knowledge but rather a guide for finding the literature about SE that has been separately published in books, articles, websites and others resources. It includes:

- Scope of the SEBoK
- Structure of the SEBoK
- Systems Engineering: Historic and Future Challenges
- Systems Engineering and Other Disciplines
- SEBoK Users and Uses
- SEBoK Evolution
- Acknowledgements

Part 2: Systems

This part describes the basic characteristics of engineered systems and the languages for describing them. This is the "what" of Systems Engineering: What is engineered? It includes:

- Systems Overview
- System Concepts
- Type of Systems
- Representing Systems with Models
- Systems Approach
- Systems Challenges

Part 3: Systems Engineering and Management

This part covers the actual engineering of systems, how engineering may be performed, how engineering is managed, and the implications of engineering activities throughout the systems life. This will also discuss the different common lifecycle models. This is the "how" of systems engineering: How are systems engineered ? It includes:

- Life Cycle Models
- System Definition
- System Realization
- Deployment and Use
- SE Management
- Product and Service Life Management

- SE Standards

Part 4: Applications of Systems Engineering

This part focuses on the applications of Systems Engineering on various types of Systems and includes:

- Product Systems,
- Service Systems,
- Enterprise Systems
- Systems of System (SoS).

Part 5: Enabling Systems Engineering

This part covers the organizational aspects of systems engineering, who manages and performs systems engineering, as well as organizational considerations such as where systems engineering is housed and competency models for systems engineers. This is the "who" and the "where" of systems engineering: Who is responsible for performing and overseeing systems engineering? It includes:

- SE Organizational Strategy
- Enabling Businesses and Enterprises to perform SE
- Enabling Teams to perform SE
- Enabling Individuals to perform SE

Part 6: Related Disciplines

This part covers how related disciplines interface with Systems Engineering. These related disciplines are:

- Software Engineering
- Project Management
- Specialty Engineering:
  - Reliability, Availability and Maintainability
  - Human System Integration
  - Safety Engineering
  - Security Engineering
  - System Assurance
  - Environmental Analysis
  - Resilience Engineering
  - Manufacturability and Reparability
  - Affordability

Part 7: Systems Engineering Implementation Examples

Part 7 is a collection of implementation examples to illustrate the principles described in the SEBoK. These examples describe the application of systems engineering practices, principles, and concepts in real-life settings. The intent is to provide real examples of the application of SE, in the hope that others will learn from these experiences. These systems engineering examples can be used to improve the practice of systems engineering by illustrating to students or practitioners the benefits of effective practice and the risks and liabilities of poor practice.

A matrix of Implementation Examples is used to map the implementation examples to topics in the SEBoK. To provide a broader set of domains, both formal case studies and shorter vignettes are used as examples. For the case studies, an introduction and analysis of the case is given, with references to the external case study. For the vignettes, the implementation example is described directly. In the literature, a wide variety of examples and formats are considered "case studies." Here, the distinction between a case study and a vignette is that a vignette is a short wiki article written for the BKCASE project and a case study exists externally in the literature. An initial set of examples is included, anticipating that other examples will be added over time to highlight the different aspects and applications of systems engineering.

Present Case Studies are: HST (Hubble Space Telescope), GPS (Global Positioning Systems), FBI Virtual Case File, ISS (International Space Station), Space Shuttle, Korean Rail.

Present Vignettes are: Denver Airport baggage Handling System, GE Birth of IDEF, Virginia Class Submarine, UK West Coast Route Modernisation Project, Singapore Water Management System

GRCSE OVERVIEW AND STATUS

GRCSE Purpose

GRCSE was commenced in March 2010. GRCSE addresses the general concern that there is a wide diversity of Masters level education programs using the name “systems engineering” in their title with such great differences between the programs that prospective students and employers have difficulty understanding what kind of systems engineering education is provided across the range. The purpose of GRCSE is to describe the systems engineering education space in a way which provides a common vocabulary for all stakeholders and which provides a framework for stakeholders to understand what they would receive from particular programs. The second review version, (version 0.5), was provided to any interested person on 15 December 2010. This version incorporated author responses to the over 1300 distinct comments received from well over 100 reviewers of the first review version (version 0.25). The review of version 0.25 closed on 15 March 2011 and the changes described in this paper reflect the progress in GRCSE during the nine months following.

The scope of GRCSE has been deliberately focused on the Masters level professional education of people seeking to advance into systems engineering from other areas with a view to providing holistic perspectives on the engineering work. This scope decision has been made to ensure that GRCSE provides a focused account of the curriculum recommendations for programs designed to support the most common purpose of systems engineering education, that is, enabling students to prepare for entry to systems engineering practice positions following undergraduate education, and possibly experience, which has motivated them to seek education in systems engineering. As such, GRCSE does not address the issues of undergraduate education, in which an educational curriculum must accommodate the lower level of intellectual maturity of students with high school backgrounds. GRCSE is not focused on the particular needs of students whose motivation is to proceed to a PhD with a view to pursuing a research career. A third class of program not explicitly addressed are programs focused on some other discipline which include some systems engineering studies. However, designers of out of scope program types will, most likely, find some significant benefit from GRCSE because it will provide them with the subject matter which has been agreed by leaders in systems engineering education as essential practice knowledge, and also provides a discussion of many curriculum related issues, to be introduced below, relevant to the design of any educational program, although with specific recommendations related to professional Masters programs in systems engineering. The scope constraint choice simplifies GRCSE for the reader.

GRCSE has taken the perspective that curriculum should be broadly interpreted to mean the combination of all the teaching and learning experiences and the context in which they are provided with a view to creating the educational results of the program [10, 11, 12].This theoretical position is important in informing the design of GRCSE. The choice has been made to include GRCSE topics which address the lifecycle of the student and the program in addition to outlining the intended content of a systems engineering program. The topics include entrance criteria, program content, program outcomes, program objectives, assessment of students and evaluation of programs. GRCSE is unusual, also, in including both the cognitive and affective domains of student education as parts of the curriculum planning. The material which has been added beyond the topics normally addressed in similar documents is intended to provide the reader with a richer description of the educational situation, and to provide all the discussions in a single source.

GRCSE has also deliberately focussed on providing a reference which will be useful globally. This presents a combination of educational regulatory and cultural issues concerning educational design and sequencing and issues associated with the definition of qualifications, and also issues such as the expectation of credit granting and the expectations of students with respect to progress from undergraduate to Master’s level studies. The deliberate intention of the GRCSE authors has been to develop a reference curriculum with is cognisant of the impact of these issues, and so provides useful advice for use in all places.

The goal of GRCSE™ is to provide useful guidance to several groups of stakeholders, as follow:

1. University program developers, to assist the development of professionally oriented systems-centric masters level programs in systems engineering. The guidance provided includes characteristics of the people who progress through the program in the form of objectives, the capabilities that graduates are expected to demonstrate 3 to 5 years after graduation, outcomes, the knowledge and capabilities graduates are expected to have at the time of graduation, entrance expectations which enable a program to expect to achieve the desired objectives and outcomes.
2. University program maintainers, who can use GRCSE to compare their program with the considered view of the systems engineering community as to what master's level systems engineering education should be like.
3. Prospective students, who will better understand the program options available to them through having access to a general discussion of the various kinds of programs available, and the expected outcomes of those programs, written without the vested interest of promoting any particular program.
4. Employers of systems engineers, who benefit in the same way as prospective students, by having a basis to determine the match between particular programs and their specific needs.

A set of use cases is provided in GRCSE, Appendix F, which will provide guidance for each of these stakeholder classes in the use of GRCSE for their purpose.

GRCSE Structure and successive evolutions

We now outline the contents of GRCSE and discuss changes made between versions 0.25 and 0.5, both of which were released for review purposes.

GRCSE is divided into front matter (title page, preface, acknowledgements, executive summary and content lists), nine chapters and six appendices.

The front matter includes a general preface explaining the purpose of the project, and GRCSE in particular, a list of authors contributing to the BKCASE project, acknowledgments and an executive summary. The executive summary is extended by providing the project purposes and copying the principal recommendations from the later chapters. The intention is to provide an executive summary of the whole, although a reader reading straight through may find repetition.

Chapter 1 is a general introduction describing the purpose of GRCSE and guiding the reader through the remainder. A number of changes have been made to this chapter to tighten the discussion. We have explained the relationship of GRCSE to contexts in which students study packaged bachelor and master's programs as a first qualification in engineering, and the situation in which students complete a first qualification followed by an unrelated master's program in systems engineering. This clarifies some issues associated with the international applicability of GRCSE.

Chapter 2 defines objectives and explains the rationale for the development of objectives in a systems engineering program and provides a set of generically expressed objectives for a systems engineering Master's program.

Chapter 3 defines outcomes and describes the outcomes expected to be achieved by graduates of a Master's program in systems engineering.

Chapter 4 discusses the rationale of entrance expectations and provides a generic set of recommended entrance expectations for a Master's program in systems engineering.

Chapter 5 presents the curriculum architecture model upon which GRCSE is based. This model divides program into four primary areas: foundation topics which are essential for all graduates of any systems engineering program; concentration topics which extend the knowledge of the graduate in a particular professional subarea of systems engineering; domain and program specific topics which are distinctive to the particular university; and a capstone experience which binds the program together. The foundation and concentration topics are intended to occupy approximately 50% of the degree, providing considerable opportunity for universities to provide teaching which responds to their context and therefore adds value to the regional stakeholders surrounding the university. The authors of GRCSE have deliberately chosen not to specify particular courses, allowing freedom to universities to design programs which are suitable in the context.

Chapter 6 presents the core body of knowledge itemised as the set of topics addressed by articles in the SEBOK product of BKCASE with levels of achievement expressed by levels in Bloom's taxonomy for the cognitive domain. The tables provided show the level of achievement expected for the foundation topics and four each of the concentration areas for which the GRCSE authors have developed the table. In version 0.5 these concentration areas are system design and development, addressing the needs of prospective systems engineers intending to proceed to system design activities, and systems engineering management addressing the needs of those intending to proceed to the system management roles. The authors envisage that other concentration areas will be identified in the future and equivalent level of attainment information provided.

Chapter 7 integrates the preceding chapters with information about the work required to implement a program, binding together the content of the earlier chapters.

Chapter 8 discusses the processes of assessment, including the achievement of learning objectives by students, the effectiveness of courses at promoting the intended learning and the effectiveness of the program as a whole in developing the intended outcomes and objectives in its students.

Chapter 9 discusses the intentions for the future maintenance of GRCSE. This discussion is contingent on finalisation of agreements with the intended long-term sponsoring organisations, INCOSE and IEEE.

Appendix A contains a set of contextual premises and a set of guiding principles for the authorship of GRCSE, and intended for the future maintenance of the document. These have been groups as contextual premises and guiding principles, which in turn have been grouped according to topic, to simplify reading. The statements have been presented together and the rationales have been consolidated as the rationales for each group, to shorten and simplify the discussion.

Appendix B provides the results of a survey of existing Masters level programs in systems engineering which was conducted at the beginning of the GRCSE project. This survey provided the authors with an understanding of the state-of-the-art as it was at the time the project commenced.

Appendix C provides a detailed discussion of Bloom's taxonomy in the cognitive and affective domains and a discussion of the rationale for using this approach to describing the levels of achievement expected of students. The tables in this appendix also provide information about the kind of evidence that a student may provide of attainment the particular level of knowledge.

Appendix D provides a mapping of the CorBoK to the program outcomes, thinking chapters 3 and 6.

Appendix E provides significant additional information concerning the assessment processes and the kinds of tools and methods that can be used to assess students, courses and programs.

Appendix F discusses the relationship of systems engineering education as described in GRCSE and competency frameworks used in many systems engineering employer contexts. This appendix also indicates why the development of the student in the affective domain with respect to systems engineering content areas has a significant bearing on the later achievement by that person of the appropriate competencies for successful practice of systems engineering.

Appendix D provides several use cases describing how particular stakeholder groups could use GRCSE and the kind of benefit that GRCSE could provide for them.

CONCLUSION

Practitioner’s Need to Fill the Gap Between the Classroom and the Workplace

When examined through the eyes of those who design, develop, field and sustain systems, that must increasingly rely on each of these separate systems ability to be an integral part of the other, yet also remain autonomous for potentially different pairings, the BKCASE initiative is long overdue.

For example the United States Department of Defense in the mid 1990’s found itself under ever increasing pressure to dramatically change the way it developed, acquired, fielded, and sustained systems. It was widely believed at the time that the unbridling of contractors from the need to comply with military standards and specifications would reduce costs while simultaneously fostering innovation. Contractors were strongly advocating that if they were free of these inhibitors, they could deliver better products at lower costs. The dual onslaught from the media, who highlighted cost overruns on major projects, and contractor’s advocacy, resulted in sweeping changes that included the rescinding of a large number of the military specifications and standards, slashing program documentation requirements, and greatly reducing the size of acquisition program offices.

The language of contracts was changed to specify the desired "capability" and allowed contractors the freedom to determine "how" to best deliver this capability. This action effectively transferred systems engineering to the sole purview of the contractors who were producing separate systems, that the Department would later need to integrate. The contractors were being relied upon to deliver, while the responsibility for the delivery of viable solutions remained squarely with the buyer.

What resulted was a vacuum in which neither the buyer nor the contractors accomplished the necessary systems engineering and further the presence of any semblance of a common language was lost. Over the following decade, the externally focused integration of SE capabilities within many large entities virtually disappeared. This absence of SE capability became increasingly apparent on multiple-system (systems-of-systems) programs in which more than one contractor was involved where the lack of a standard language, which supported standard common methods models and tools, was most apparent.

Faced with increasingly complex systems that relied on other complex systems and a barrage of failures and miss-starts, companies/governments began re-focusing their attention on external integration requirements. This re-focusing demand mutually agreed upon standards that are based on a common language. As was highlighted earlier in this paper numerous different entities initiated efforts to develop such SE process standards, however, after almost 20 years no single common language yet exists, hence the critical importance of the BKCASE initiative. The practitioner community must increasingly assure that their products/services effectively integrate with those products and services provided by others to deliver the outcome desired by the customer. To effectively achieve this desired end-state companies and governments are increasingly seeking systems engineers who can communicate horizontally beyond traditional boundaries. To do so, these engineers must be educated in a manner that instils a common set of knowledge.

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Dr Alice F. Squires has nearly 30 years of technical leadership experience. She is currently an industry and research professor in systems engineering at the Stevens Institute of Technology, School of Systems and Enterprises. She is a Senior Researcher for the Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE) and Systems Engineering Experience Accelerator (EXPACC) projects. Alice is a lifetime member of Beta Gamma Sigma, Tau Beta Pi, and Eta Kappa Nu Honorary Societies; and is a member of American Society of Engineering Education (ASEE), Institute of Electrical and Electronics Engineers (IEEE), National Defense Industrial Association (NDIA), and International Council of Systems Engineering (INCOSE), and Past Chair of the Systems Engineering Division of the ASEE. She is an INCOSE Certified Systems Engineering Professional (CSEP) including in Acquisition (CSEP-Acq). Alice received the Stevens Institute of Technology Provost's Online Teaching Excellence Award in 2007.

George Richard Freeman: Mr. Freeman is the Technical Director, Air Force's Center for Systems Engineering (SE) located at the AF Institute of Technology. Over 30 years experience in systems and process engineering and has held numerous positions in civilian industry and government including; AF MAJCOM Chief, Concept Development & Process Engineering, Senior Executive VP and Board Member - EICON Inc, and numerous positions with General Electric (GE), United Nuclear and UNC Aerospace, including Director Expansion Programs (Manufacturing Plant Manager), Materials Manager, Manufacturing Systems Manager, Engineering Systems Manager, & retired from the USAFR in the grade of Colonel. Mr. Freeman was responsible for bringing the first GE robotic assembly system into production, led the design and successful start-up of a new precision aircraft engine parts and sub-assembly manufacturing plant, design & implementation of two Enterprise Resource Planning (ERP) systems for GE & UNC Aerospace, and the web-based AF enterprise-wide Reduction of Total Ownership Cost Decision Support System; all based upon service-oriented architectures and employing shared authoritative data. He also led the successful development & fielding of the AF's first SE process assessment model now in use across the entire enterprise. His published models include the; Freeman 6-phase strategy development and execution process model, and the Integrated Product, Enterprise, Customer Service Systems Engineering model. He is a graduate of the Air Force Squadron Officer School, Air Command and Staff College, Air War College and Naval War College and also selected and served as a Mahan Scholar. He holds a BS-Computer Science and Aviation (cum-laude), MS-Engineering/Industrial Management (summa-cum-laude), and MA-National Security Strategy (highest distinction) and is Defense Acquisition Workforce Improvement Act Systems Planning, Research, Development& Engineering (SPRDE) Level III (Systems Engineering) and Program Management Level III certified. He is also a Registered Environmental Manger (REM) and Certified Systems Engineering Professional (CSEP & CSEP-Acq).