Leap Cad System Proposal

A HIGH LEVEL KNOWLEDGE SCIENCE ENHANCED, INVESTIGATIVE PARADIGM: THE EVOLUTION OF KNOWLEDGE STRUCTURES

MAY 18, 2009

Proposal

This proposal aligns with the national imperative for energy resilience and the development of green energy technologies. The proposal is to construct a library of meta research energy models and an integrated software environment optimized for the investigation and creation of energy technologies. This creates

- a knowledge infrastructure of leading edge research available in a format of math models that are readily analyzable and can be synthesized with other models.
- It will create immediate jobs for nine researchers,
- and potentially hundreds of jobs from the leverage results of the development of new energy related technologies.

The System Concept

The Leap Cad System Concept consists of an Integrated Software Environment of a Compact Analytic Math Model Library of the leading edge energy research papers, a Virtual Laboratory for math computation and exploration, and a high level multi-disciplinary Knowledge Science Enhanced innovation tool set. The ready-made model library is a powerful advocacy factor for green technology and renewable energy to the scientific community. We proposed to develop such a system optimized for the investigation, creation, facilitation, and optimization of green energy technologies.

Project Management Plan Standards

Because a central part of this system involves software development, The Project Management Plan is structured after IEEE Std 1058-1998, the Program Management Plan standard for software development. This project plan is an amalgamation of the development of the Leap Cad System structure and IEEE Std 1058-1998.

TABLE OF CONTENTS

FIGURES: LCS Network Structure, LCS Methodology Map, and LCS Process Flow

SECTION 1. EXECUTIVE SUMMARY

Energy is the universe's foundational technology. It is related to the growth and cost of other key technologies, the global environment, and national defense and security. Energy enables homes, schools, factories, businesses, airports, hospitals, computers, and the internet to function. It is a prerequisite to human and technical development, and its national usage is correlated to the UN's Human Development Index.

In some arenas, energy limits, usage, and its consequences are approaching the scope of a planetary emergency. There is only a narrow window of opportunity in time to reverse these trends. Energy technologies are of such vital global and national importance that logic dictates that we employ all of the best available tools and research methodologies for its development. If energy technologies are of vital importance, it follows that ***the models that describe the leading edge research in energy are also of great importance.*** These models represent the nucleus of ideas that can be used to investigate and construct new technologies.

The first science research journal (Royal Society of London) was published in March of 1665. The research journal format was basically unchanged for 300 years. IT over the last 25 years technology has provided a wide range of digital access (wireless, online), media (CDs, digital paper), file format (PDF, hypertext), and review process publishing options for journals. However, the basic knowledge structure: text, mathematical equations, and graphics, is unchanged. There has been an explosive growth in knowledge systems, Information Technologies, and innovation research methods since the 1980s. ***Application of these higher level methodologies to facilitate innovation of energy technologies through the development of enhanced knowledge structures should be a priority.***

We propose to develop a prototype of a system optimized for the creation of breakthrough energy technologies. The prototype is a high level Knowledge Science Enhanced innovation system, the Leap Cad System. The system consists of four elements: 1) a select database of models of the leading edge research abstracted from technology journals from a broad spectrum of energy and green technologies and other disciplines. The models are captured/regenerated into a format most readily usable by researchers for innovation, that is, compact analytic math worksheets; 2) a virtual laboratory for the exploration of models related to concepts and ideas; 3) an integrated system for the application of high level Knowledge Science innovation tools; 4) a learning component for the continued collaborative evolution and development of the system. The system also serves as a powerful tool for advocacy of green and renewable technologies to the scientific community. Integrated into the data base are models of product, environmental, and societal costs, to bridge and meld these operational silos for the engineering community.

The intent of the Compact Analytic Model Library is for the development of concepts and ideas, not for detailed product design. Thus, we do not require the precise geometric modeling, provided by finite element programs. The goal is to use math techniques for approximations for detailed material properties and multi-physics to analyze, abstract, and capture the leading edge research papers into compact analytic models.

There has been a rapid evolution of knowledge structures in the last few decades. The establishment of books and libraries took millennia, while that of digitized books and hyperlinked document took just a few decades. A conceptually higher step is to capture models of the leading edge research found in technical journals into electronically reusable math model libraries.

The goal of the system is for application to “low hanging fruit”; that is, those innovations most amenable to the Leap Cad System approach. One potential area of investigation is the methodical investigation of the potential for synergies among different energy technologies. Another is for determining the optimal cost, quality, social, or “green” conditions across the multi-disciplinary domains/factors in the models.

For examples of compact analytic math worksheets, refer to
“Models & Analyses” at the website: http://www.leapcad.com/

1.1 Project Summary

1.1.1 Purpose

The purpose is to facilitate innovation in energy research and reduce the development time of new technologies by application of Knowledge Science Enhanced Methodologies.

1.1.2 Rationale

Knowledge Science research shows that innovation best comes from the synergy of a lateral synthesis of diverse ideas. In general, most traditional innovation springs from an unstructured process, i.e. it does not come from a structured application of Knowledge Science, such as the methodical investigation of possible combination of diverse technologies for a broad synergy. We propose to apply a structured approach of multidisciplinary knowledge methodologies to energy innovation.

1.1.3 Methods and Scope

- Reusable Compact Analytic Model Prototype Database: Abstraction of 100 leading edge research journal papers from a selected energy sector(s) into reusable math worksheets
- Associated materials science properties
- Associated product, environment, and social cost models
- Model properties matrix: An abstraction of model properties that characterizes how different models can be synthesized into new technologies
- Heuristic Model Relationship/Properties Explorer: explores possible solution spaces for model library
- Toolset to provide Knowledge Science Enhanced innovation methodologies
- Toolset to provide mathematical process transformations
- Virtual Laboratory for investigation of models and synthesis

1.1.4 Objectives

- Create bibliography of 100 leading edge compact analytic models from research papers in a selected energy sector(s)
- Analyze, capture/regenerate, abstract, and create compact analytic mathematical model scripts/worksheets of the 100 leading edge energy related research papers

- Bridge operational silos and create associated materials science and product, environment, and social cost models
- Create a Models' Properties Matrix
- Create a Virtual Laboratory for investigation of models
- Develop Knowledge Science Enhanced Methodology Toolkit for innovation
- Develop Mathematical Process Transformations
- Develop a Heuristic Model Properties Matrix Explorer

1.1.5 Project Deliverables

In fulfillment of project requirements, eighteen months after receipt of funding, two copies of compact disks (CDs), delivered by next day USPS mail service, will be provided with the following: 1) A model library of 100 compact analytic math models, based on leading edge research in energy and associated project, environmental, and societal cost models, in the format of Mathcad worksheets, and 2) a Knowledge Science and Process Transformations Toolkit, Model's Property Matrix, and Heuristic Model Properties Matrix Explorer as illustrated in **2.3.6 LCS Network Structure and Transactions** found on page 2-6.

1.1.6 Qualifications of Principle Investigator

My professional experience includes 37 years of working as a Senior Physicist in R & D for World Class Aerospace (AC Electronics) and Automotive Electronics (Delphi Delco Electronics) companies. Additionally, I have managed the successful development of over a dozen high technology products, from concept, design, development, prototype, and manufacturing. I have multidisciplinary Masters degrees in Theoretical Physics and Clinical Psychology, and I have half a dozen patents in advanced technology design. Currently, I am working on the conceptualization of the Leap Cad System as a means of facilitating and optimizing solutions to our global energy related problems.

Patents

Apparatus and Method for Conditioning Polysilicon, Patent # 6,532,568, Mar 3, 2003
Programmable Memory Transistor, Patent # 6,762,453, 2003
Transistor Short Protection, Patent # 4,333,120, June 1, 1982
Power Transistor Protection from Substrate Injection, Patent # 4,496,849, Feb. 4, 1981
H-Switch Short to Plus Protection, Patent # 4,333,129, Feb. 4, 1981
Transistor Protection Circuit, Patent # 4,336,562, Feb. 12, 1980

National Presentations

Ford Conference and Event Center – Windstar PM Motor Analysis, June 2003
Automotive Electronic Council, Dynamic Inductance Characterization of Electro-Mechanical Actuators, Oct. 11, 2002
High Injection Region Analysis and Optimization of Power Transistors, PESC, 1977

Journal Publications

Actuator Saturated Fall Current Characterization Models, IEEE Power Electronics, Submitted for Publication, 2008
High Injection Region Analysis and Optimization of Power Transistors, IEEE Power Electronics Specialists, June 1977

Industry Conference Publications

Safe Operating Area Scaling Laws, Motorola-Delphi Conference, Feb. 2002
Probability of SIDM Bump Fusion Analysis, GM-Delphi Conference, Sept. 2000

1.1.7 Master Schedule and Budget Summary

The Master Schedule is for a 6 quarter or eighteen-month project.

Prototype Leap Cad System: 18 Month Project			
Goals for Grant	**Sources**	**Report Frequency**	**Completion dates**
1. Create 100 Models			
Bibliographies completed	TWK & Contractors: 1-6	Quarterly	1Q
Abstract 6 models per month	TWK & Contractors: 1-6	Quarterly	1Q,2Q,3Q,4Q,5Q,6Q
2. Integrate High Level Breakthrough Strategies			
Define Strategies	TWK	Quarterly	6Q
Develop Math Transformations	Mathematician	Quarterly	6Q
Incorporate in Software Design	TWK	Quarterly	6Q
3. Conceptualize and Develop Integration Software			
Concept Design	TWK	Quarterly	4Q
Development	TWK	2Q	2Q
Testing	TWK	4Q	4Q
Proto Development	TWK	5Q	5Q
4. Website and Software Design			
*Site design parameters defined	TWK & Contractors	Quarterly	1Q
Proto software developed	TWK & Contractors	Quarterly	4Q
Launch to web host	Contractors	4Q	4Q
Update site with last models	Contractors	6Q	6Q
5. Evaluate LCS Prototype			
Run metrics	TWK	5Q, 6Q	5Q, 6Q
Feedback on design	Team and Reviewers	5Q, 6Q	5Q, 6Q
Redesign	Team	5Q, 6Q	5Q, 6Q
5. Develop Collaborative Component			
Integrate	Contractors: 1, 2, 3, 4 ,5 ,6	5Q, 6Q	5Q, 6Q
Feedback on design	Team and Reviewers	5Q, 6Q	5Q, 6Q
Redesign	Team	5Q, 6Q	5Q, 6Q
Team Members			
TWK	Thomas William Kotowski		
SMA1-6, Subject Matter Experts# 1-6	Contractors – Out for bids		
SWE, Software Engineer	Contractors – Out for bids		

Creation of 100 compact analytic model worksheets and development of a Leap Cad System prototype would require 1 project manager, 7 researchers, 1 mathematician, and one software programmer for 18 months. The budget for 7 researchers to create the compact analytic database of 100 leading edge models is $202,500. This portion of the budget will be spread equally across the 18 months. The budget for a software programmer and Chief Architect /principal investigator/project manager for 18 months is $75,000. The total cost for personnel, travel, support resources, etc. is $383,000. For budget details refer to section 5.2.5 Budget Allocation Chart.

SECTION 2: DEVELOPMENT OF THE LEAP CAD SYSTEM

2.1 The Challenge – Expanding the Solution Space for Energy Technology

Ever since the oil embargo of October 1973, every president since Nixon has had a national goal of oil energy independence. However, despite the US government spending over 100 $billion in programs, energy independence is still a distant goal (see Appendix). We clearly need to be more innovative and effective in this pursuit. Because of the global increase in demand and falling energy supplies, this decade may be our last opportunity to turn this around.

Roughly 69% of oil is used in the US is for the transportation sector. The average household spends $4100 annually on gasoline. Some estimates project that the cost for oil in the US over the next ten years will be 10$ trillion. This is close to the total worth of the US Fortune 500.

We have to use every tool and muster every possible advantage available to make certain we back the best technological solutions. If we make the wrong choices there may not be enough crude oil left in the ground for a second chance. These are complex issues – political will is not enough to assure success. And paradoxically, because of global use, we have to make the right technology available for our global competitors. That is, we can achieve national oil resilience, but if global demand from China, India, and Russia is not abated, costs will still skyrocket and carbon will still be pumped into the air.

Most productivity growth comes not by working harder, but by working smarter. Innovation is now responsible for up to one-half of the growth of the US economy. This growth is highly correlated with the amount spent on research. The US has lost the lead in material production, consumer electronics; however, the USA historically and nationally has taken the lead in innovation. Only the US has the unique combination of freedoms and economic opportunity to do achieve breakthrough levels of energy innovation. Our national destiny is to lead the world in the area of creativity and innovation.

To move to the next level of global creativity, we need to systematize and expand the potential solution space in the field of energy innovation. Langdon Morris, in his book "Permanent Innovation," states that, "*Innovation without methodology is just luck.*" We need to add Knowledge Science Enhanced components to the art of innovation to make it a well defined, systematized process.

Meta-Research: the next higher level of research. The area of research that uses a synthesis of research is called Meta-research. Meta-Research is designed to synthesize knowledge arising from existing studies. It seeks to identify, appraise, and aggregate or synthesize existing knowledge on a particular topic.

2.2 The Leap Cad Systems Approach: Apply Higher Level Knowledge and Meta-Research

2.2.1 Research Paper Content as the Written Word versus Reusable Models in a Virtual Laboratory

The results of research are ordinarily communicated by text within technical journals. Oftentimes the journals are highly specialized and results are confined within a relatively small group of researchers. Papers often only show the final results, such as in a graph of the major variables. Page costs and restrictions are such that the actual math models used to generate the results are usually not given. Model details, if given at all, are often sketchy. The Leap Cad System approach is to analyze, recover/regenerate model details that were not recorded in the original journal, abstract the mathematics, and capture into scripts/worksheets the leading edge research models into versatile math scripts/worksheets that can be plotted, edited, combined, contrasted, or synthesized within a framework of an expanded solution space with other models within a Virtual Laboratory. New models can be created from the scripts/worksheets using the computation and symbolic capabilities of the commercial simulation software. This framework provides a method of unlocking and circulating the wealth of intellectual capital with the leading edge research.

2.2.2 Energy Technology Analysis Tools and Metrics

There is a common set of metrics that can be applied for the analysis, valuation, and comparison of energy technologies: energy density, Ragone chart, material breakdown strengths, efficiency, standard functions of Thermodynamics, existing infrastructure capacity, and various cost factors.

2.2.3 Traditional Research Methodology vs. Multidisciplinary, Structured, Lateral Synthesis – Expanded Solution Space

Most research is of the deep silo variety; that is, it is focused on a single topic and may spring from subject matter experts limited to a single area of expertise. Most problem solving uses the direct, single discipline, approach. Generally, innovation springs from these ad hoc, “shoot from the hip” methods. Project, time, and cost pressures do not allow the optimum, multidisciplinary expanded solution space attack of the problem.

However, research shows that innovation best comes from the synergy of a lateral synthesis of diverse ideas. Indeed, a recent article by six leading physicists in Physics World, states that research “traditionally involved finding new sources of energy or discovering new materials, but now the focus of the questions is slowly shifting towards increasingly interdisciplinary problems at the boundary of physics.” In general, most traditional innovation springs from an unstructured process, i.e. it does not come from a structured application of Knowledge Science, such as the methodical investigation of possible combination of diverse technologies for a broad synergy.

2.2.4 A Knowledge Science Enhanced, Structured Solution

The Leap Cad System (LCS) is a structured, expert/model-mining, high level Knowledge Science Enhanced development system that was created to leap beyond these limitations. The LCS has been created to apply a structured approach of multidisciplinary knowledge methodologies to energy innovation. As noted above, one potential area is the methodical investigation of potential technological synergies within the framework of a “Virtual Laboratory.”

The Leap Cad System provides a means to lower the barrier and broaden the base for technical innovation in energy. Barriers often have an exponential type of effect on results. That is, raising the barrier just slightly often causes a huge reduction in results. Conversely, lowering a barrier slightly may provide a tremendous increase to accessibility.

As noted above, there is only a narrow opportunity in time to reverse some global trends with respect to energy. The current recession presents a unique opportunity. Prior to the economic slowdown, there was considerable competition from industry for a researcher's spare time, but because of the recessionary economic situation, there is less competition for a researcher's time.

2.2.5 Prototype Implementation Goal for Model Development

The implementation goal is to develop a prototype Leap Cad System with a library of a total of 100 (refer to Appendix) analytic models. Eighty of the models will be taken from a broad spectrum of leading edge research. Example: http://www.leapcad.com/Results%20of%20Re-Simulation%20of%20Carnegie-Mellon%20Study.pdf. Twenty of the one hundred will be general review models to help "glue" the others together. A library of 100 models would be sufficient to allow evaluation and testing of the software tools of the Leap Cad System concept and investigation of problems within the realm of the selected models in the library. It does not, however, provide the expanded solution space truly needed for breakthrough innovations.

2.2.6 Collaborative Development, Growth and Learning

Our intention is to make the Leap Cad System Prototype available on a website, such that it is open to collaborative development. Vint Cerf, the chief Internet evangelist for Google has stated that "The Internet's ability to enable collaboration will be the key to breakthrough innovation."

Metcalfe's Law states that the value of a network is proportional to the square of number of subscribers. Once a network achieves some "critical mass," it grows explosively. Analogous to the growth of the internet, it is believed that 1000 (refer to Appendix) models would be sufficient to achieve a "critical mass," an amount sufficient to spur the collaborative development, diffusion, and self-sustained growth of the Leap Cad System.

The goal is to abstract the best and leading edge models and use the Virtual Laboratory and Knowledge Science tools as a means to get innovations to the market as quickly as possible. This is a learning process, and faster learning has a potentially exponential payback. To quantify this advantage, achieving "critical mass" could result in a 20% reduction in development time of an area of emerging energy technology.

This methodology is not a panacea. The intent is to apply it to "low hanging fruit" type applications, that is, to those research areas most amenable to the application and success of this system.

2.2.7 Advocacy for Green Tech and Renewable Energy to the Scientific Community

A ready-made model library (green tech and renewable energy models) is a strong magnet for the scientific community. The models will attract great interest from students, educators, and planners. The net effect is to provide powerful advocacy for green and renewable energy technologies.

2.3 New Paradigm for Energy Innovation: The Leap Cad System

The Leap Cad System consists of four elements which form an integrated development system. (For more details refer to the Technical Appendix – "Appendix E: Example of successful application of one LCS technique.") Following, there are three figures which show 1) Figure 2.3.6 LCS Network Structure and Transactions, 2) Figure 2.5.1 LCS Methodology Map, and 3) Figure 2.5.2 LCS Process Flow. The elements of the System are:

2.3.1 An energy related knowledge infrastructure – <u>Compact Analytic Model Library</u>.

This is the most important element. This makes the treasure trove of leading edge research available in a format of math models that are readily analyzable and can be synthesized with other models.

A. Determine the leading edge priority areas of research (See Appendix: I.)
   1. Extensible to other promising areas of research

B. Expert/Model-mining of priority leading edge research
   1. Abstract the essence of the leading edge research analytic models
   2. Analytic closed form model equations

C. Use mathematical scripts/worksheets (Mathcad, MatLab, Mathematica, etc.)
   1. Tutorial format - Pedagogy
   2. Reproduce results of research papers: Tables, graphs
   3. Reusability – apply to novel situations
   4. "Live" Equations – allows generation of new models, conditions, graphs
   5. Models are for conceptual, top level development and not for detailed product Development

D. Construct the models' **<u>Property Matrix</u>** (materials, physics types, energy types, variables). This is then used with the

2.3.2 <u>Virtual Laboratory</u> for the investigation and interplay of models –

Integrated Software Environment

A. Interplay of parameters of model library.

B. Material Science models of material used in energy research
   1. A common database of material science properties
   2. Linkable to external simulation models

C. Incorporate associated product, environmental, societal cost analysis
   1. Database of energy data

D. Venture Capital Analysis/Assessment tools and criteria.
   1. Incorporate live financial and energy sectors data
   2. Database of relevant financial data

The potential solution spaced spanned by a compact analytic process models is enormous. One set of rules for generating the solution space are given by Knowledge Science Enhanced Tools and Process Math Transformations.

2.3.3 Software tools to apply integrated <u>Knowledge Sience Enhanced Tools (KSBT)</u>

and meta-research for product innovation and solution of problems across a spectrum of models – lateral synthesis.

A. Best innovation through broad lateral synthesis of models
B. High Level: Use methodologies for best research, cognition, and innovation
C. Application of inventive thinking methodologies
D. Faster learning
E. Use XML "Smart Tag" concepts for searching database
F. Collaborative growth

2.3.4 Software tools to apply integrated <u>Mathematical Process Transformations (MPT)</u>

This is the place to apply generalized principles: Rules and examples of various process mathematical transformations. First we consider basic physics. Possibilities for generalized transformations are given by the rules of Thermodynamics and dimensional analysis. If applicable, we would consider application of Linear System Control Theory concepts such as network connections and convolution.

2.3.5 Software tools to apply <u>Heuristic Relationship/Properties Matrix Explorer</u>

Black Box: Looks for most promising technology breakthrough relationship/pair matches. Use the TRIZ strategy: analyze historically successful syntheses and discern model properties.

2.3.6 LCS Network Structure and Transactions

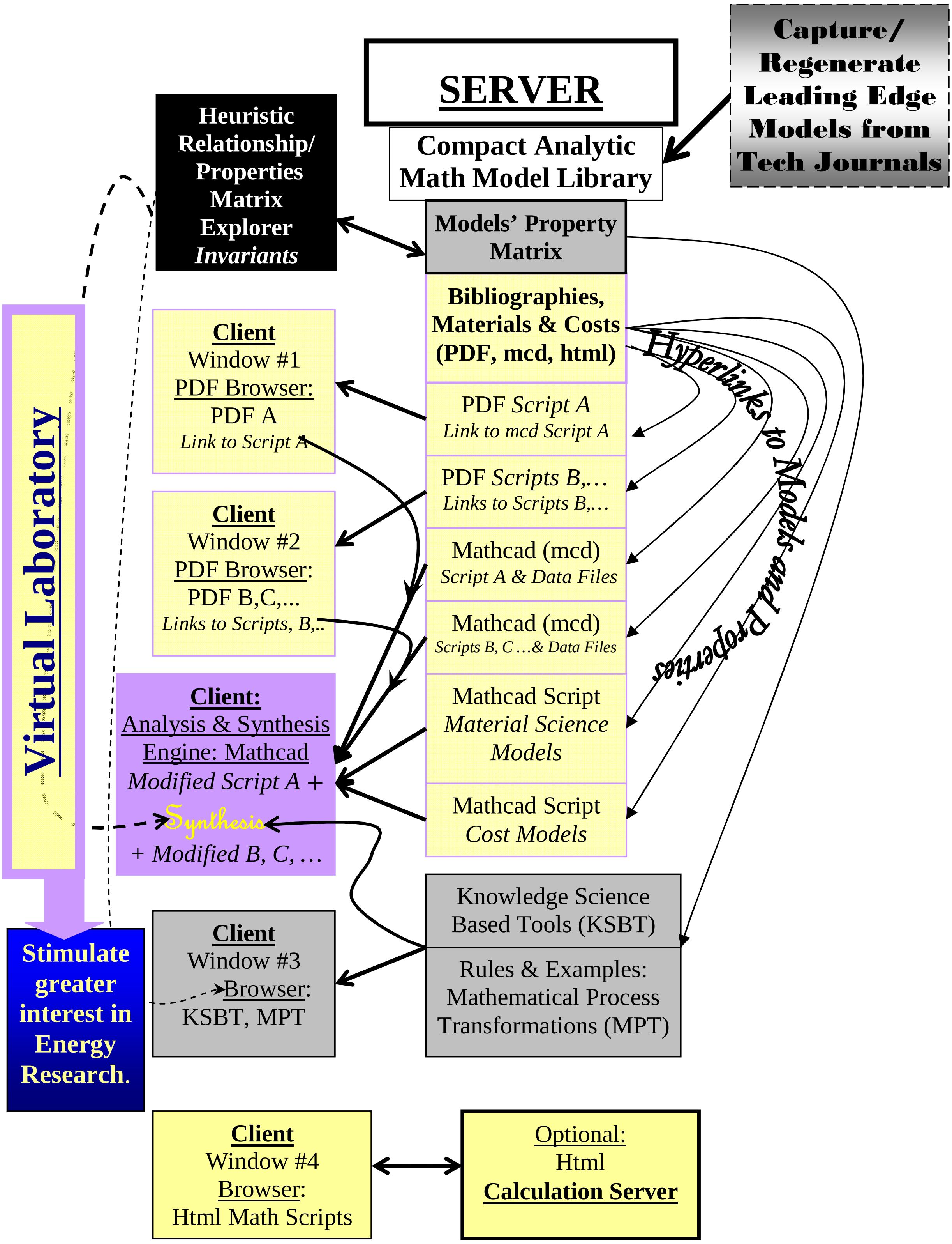

Figure 2.3

2.3.7 Application of Knowledge Science and meta-research into continual evolution of the Leap Cad methodology, pedagogy, and training, NIH factors, collaborative and integrated software tools. Ranganathan's (1931) fifth law of library science states that "A library is a growing organism."

2.3.8 Structured Approaches to Innovation

A Structured Development Approach is being used increasing in areas such as pharmacological and chemical research for enhanced innovation productivity.

2.4 Added Components

An integrated cost model and database makes calculation and comparison of social cost factors easier.

2.4.1 Merge Economic, Environmental, and Social Cost/Benefit Models

One of the limitations of many studies is that the consequences of environmental and social costs are ignored. The Leap Cad System provides a cost database for estimating these important factors in addition to product costs. This presents a structured method for increased awareness of these issues during the concept development stage.

2.4.2 Entrepeneurial, Venture Capital, Business Model, Market Performance Criteria Tests

The success of many projects often depends more on competitive cost and market factors than technical considerations. The LCS integrated environment provides databases on venture capital and entrepreneurial considerations for estimation of product success factors. These considerations can be used to guide development in ensure a viable product.

2.5 LCS Methodology Map and an Elements of Process Flow for Development

The following map and diagram shows the connection and linking of the elements of the Leap Cad System.

2.5.1 LCS Methodology Map

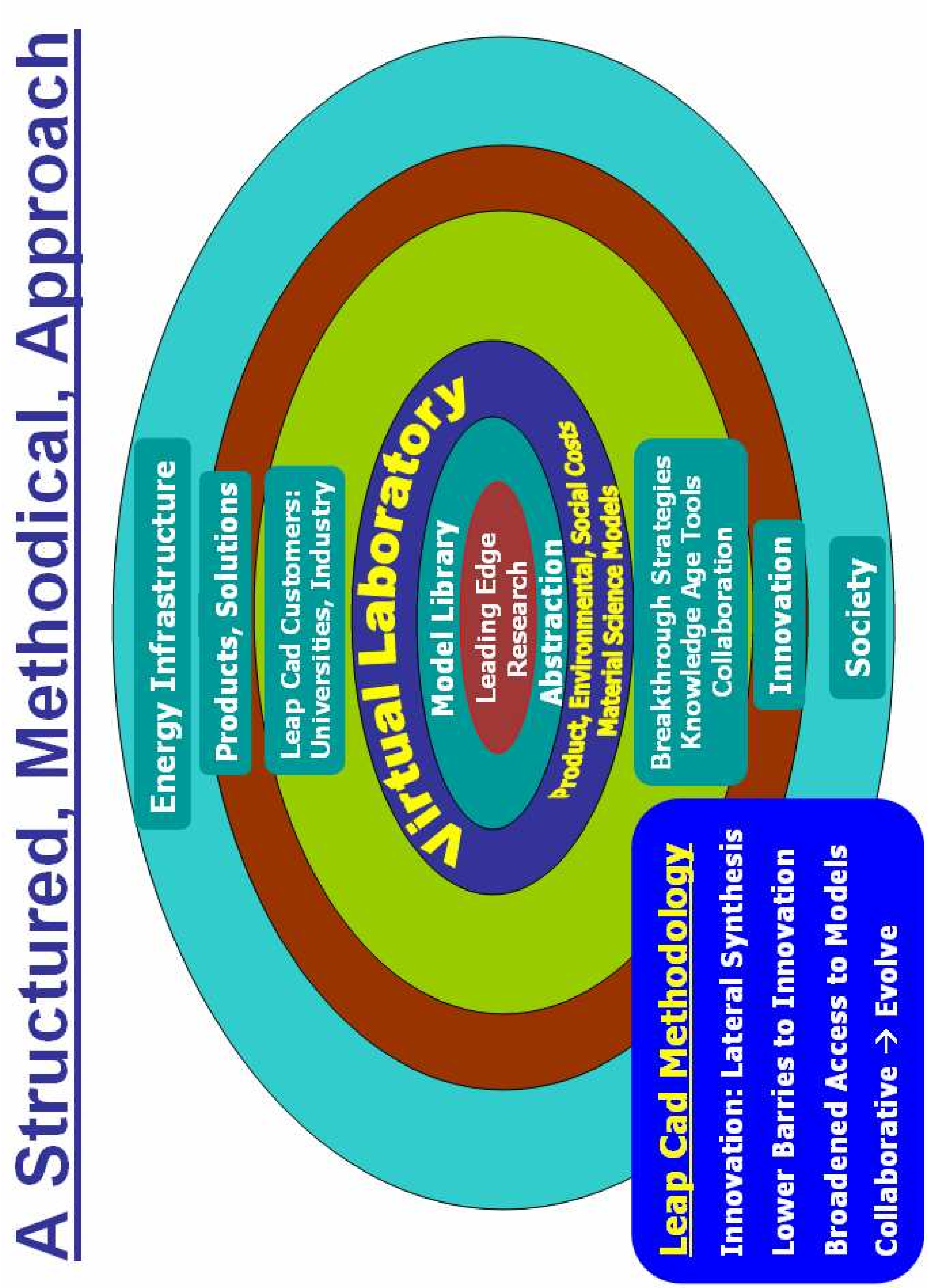

Figure 2.5.1

2.5.2 LCS Process Flow

Moving Energy Development from the Deep Silo Subject Matter to the Knowledge Age

1st Expert and Model Analytic Mining

Models: Mining, abstraction, translation

Create Bibliography of 100 leading edge research papers in multiple energy research areas. Mine Analytic papers.

↓

Analytic/Model Library: Leverage existing math tools like Mathcad, Mathematica, or MatLab to abstract the leading papers into a common framework or script that can be easily edited, understood, discussed, analyzed, shared, and used to jump start innovation and widen interest in the energy & knowledge domains.

- See Example Abstraction

Create Models' Properties Matrix.

2nd Virtual Laboratory, VL

An Integrated Environment

Examine behavior and results.

Common mathematical framework Model Library and databases: Reusable and can be merged with other scripts into new creations.

↑ Entrepreneurial business models

↑ Product, environment, and social cost models and common database

↑ Materials Science
- Materials LCS models
- External Simulation Models
- Proposed model
- Common database

3rd Apply Knowledge Science and PBM to VL

User: Application of higher level thinking

Provide Software Toolset to Implement:
- Model Properties Matrix and Explorer
- Structured, Meta-Innovation Process
- Most innovation from lateral thinking
  - Facilitate lateral cognition styles
  - Expose to variety of information
- Break out of "specialization silos"
- Framework for "What if?" investigation
- Tutorial models
- Detect analogies, patterns, exceptions
- Proven Breakthrough Methods, PBM
  - Edward de Bono's Lateral Thinking
  - Synthesis/Convergence
  - "Physical Process Factorization"
    - See Example PBM
  - General Morphological Analysis
  - TRIZ Principles
  - Concept mapping – Thinker Toys
- Mathematical Process Transformations
  - Thermodynamic transformations
  - Where applicable, Linear Control

4th LCS Meta-Research and Development

Community: Multi-Disciplinary Collaboration

Grow the LCS science and methodologies

- **Promote, Advocate, Advertise LCS**
- **Continued evolution of LCS methods**
- Metcalfe's Law to expand power of tools
- Leap Cad System Training
- Breakthrough Methodology research
- Information Systems research
- XML "Smart tagging" categorization
- Develop new computer tools, e.g.
  - Knowledge systems engineering
  - Concept mapping, Engineering Ontology
- Characteristics of best modeled papers
- Symposia on LCS application, methods

Figure 2.5.2

2.6 Window of Opportunity

2.6.1 Budgetary Constraints: a window of opportunity

Cutting edge researchers have little time left over for outside projects. Every project has some fixed costs associated with it, e.g. new project orientation and a learning curve for the new project. There is often competition for the left-over time and industry can offer lucrative opportunities for top researchers. We would like to contract the greatest number of researcher to get the widest spectrum of technology models. However, if we slice the budgetary pie too narrow, we would not be able to attract talent.

Because of the recessionary environment, industries research budgets have shriveled. This is a good time to engage researchers.

2.6.2 Identifying Arenas of "Low Hanging Fruit"

The LCS method has general applicability; however, the particular techniques used can be more expeditiously applied to some areas of investigation rather than others. The factors that contributed to the success of the LCS will be investigated in tandem with the general LCS prototype development to identify those areas of special promise as targets for LCS innovation.

2.6.3 An open versus a closed system. If there is open global access to this tool set, won't the U.S. lose its competitive advantage?

For the sake of argument, assume new developments in energy technology are kept secret. Furthur assume, this new technology is then used to reduce our energy consumption by 20%. The result is that this will cause the global price of energy to decrease. The Asian market will probably expand to absorb the cheaper surplus, and the world price of oil will remain the same.

Consequently, the cost of energy is not a problem unique to the USA, it is a global problem. As long as India and China continue to grow and consume massive amounts of fuel, the problem of global pollution and tight supplies will not be solved. This is a global problem that demands a global solution.

For the LCS to be successful as a global concept, it must maintain a high level of integrity. It must not be compromised by the hint of secret agendas, national or ideological interests.

2.6.4 LCS Works - General Morphological Analysis (GMA), TRIZ, APPENDIX C and E.

Research (See Appendix C and E and Bibliography) has shown that a multidisciplinary and lateral approach is the most effect strategy for innovation. The LCS includes the concept of continually evolving the methodologies as the latest Leading Edge Energy research, Knowledge Science, Cognitive Psychology, Breakthrough research and Simulation Tools become available. Indeed, the General Morphological Approach has been proven to be successful in energy research.

2.6.5 Target Leap Cad Systems Customers

The target customers are academic and industry researchers and developers in the energy arena. The implementation goal is high level support and facilitation of energy research and innovation. We will provide an integrated environment for energy development in the context of a Virtual Laboratory that has the abstracted scripts/worksheets of the latest research models, the associated economic, environmental, and social costs, material models and common database, and tools to implement structured, knowledge research methodologies. The target is to harvest the low hanging fruit. The ultimate goal is to suggest a new technological approach or to hasten development. There is a potentially huge (40 – 100X) economic payback relative to this investment.

SECTION 3. DESCRIPTION OF PROPOSAL

3.1 Prototype and Outcomes

3.1.1 Create a Leap Cad System Prototype with 100 compact analytic leading edge energy models

I. Goals

Develop a Leap Cad System prototype with 100 models. The prototype will establish the framework to support the addition of models. The Leap Cad System is aligned with the mission of the USA to become energy independent and to develop green technologies.

II. Evaluation and feedback phase at the end of the fourth quarter.

3.1.2 Payback, Outcomes, and Impact of Activities

The LCS will provide jobs for 8 investigators for eighteen-months. It will create an infrastructure of a highway and an integrated shell holding intellectual gold, the best energy analytics models, breakthrough methodologies, and a databank of environmental, social, and material costs. The Leap Cad System offers a huge potential payback in terms of facilitating a jump in solving technological hurdles or in developing new energy technologies. If we meet the goal of shortening development time in achieving energy dependence by 20% of a three year project, this is 7 months less for a roughly $3.5B oil cost avoidance. If it enables the discovery of new technology, the ten year payback from new technology alone could also be in the billions. If we demanded a 10X economic payback, this would then justify the expense of $350M on the Leap Cad Project. Other vital factors, such as security, global warming, energy resilience, and the decreasing window of time to turn the corner on global energy consequences, could justify a LCS development cost equal to direct costs of energy itself.

3.1.3 When

The work will commence when initial project funds become available. Abstracting models will start one month after project funds become available. It is anticipated that eighteen-months would be required for LCS prototype development.

3.1.4 Where

The work will be coordinated from the Chief Architect's office in Cape Coral, Florida and will be subcontracted to subject matter experts located at the appropriate centers of expertise. A software programmer local to Lee County Florida will be employed.

3.1.5 Evaluation

Work Per Model Abstraction.

It is estimated that four papers will have to be reviewed to find one that is suitable for abstraction. Average time to review four papers, study target paper, abstract model, and develop: 5, 10, and 40 hours, respectively, for a total of 55 hours.

SECTION 4. PROJECT ORGANIZATION

4.1 External Interfaces

Both the organizational boundaries between the project and external entities and its internal structure are shown in the organizational chart in the following subclause.

4.2.1 Website http://www.leapcad.com/

A website was developed to work some aspects of the Leap Cad System, to provide an example of some aspects of the LCS for this document, to make the concept and models accessible, and to help in training LCS contractors. Eventually a Forum will be added to the website for the solicitation of models, ideas, and general feedback.

4.2 Internal Structure

This describes the internal structure of the LCS project organization to include the interfaces among the units of the development team. Because the Project Manager is responsible for Administration, Project Management (which requires travel), LCS concept development, some model abstraction, math script translation into Mathcad, some aspects of software development, and LCS advocacy, it may be necessary to employ an assistant during the final two quarters to keep the schedule on track.

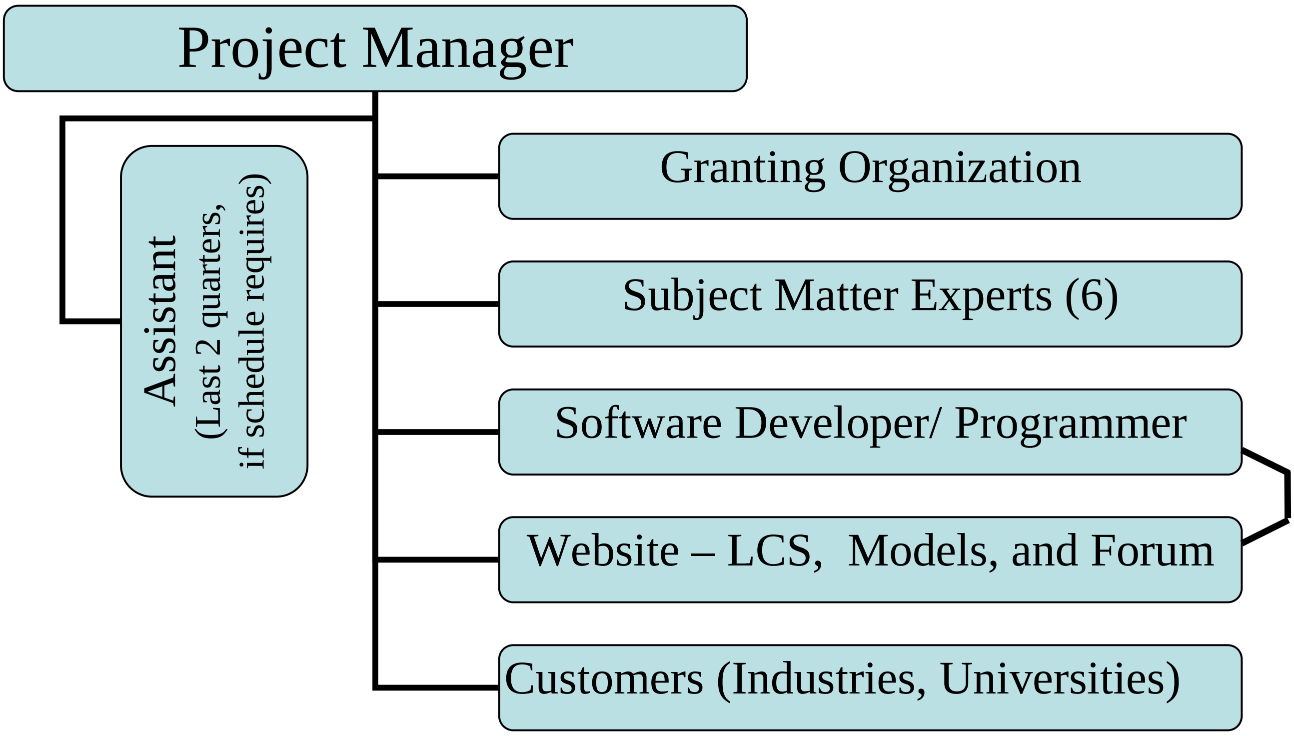

Figure 4.2

4.2.1 The Project Manager

4.2.1.1 Scope of Authority.
All of the subject matter experts and the programmer will report to the project manager.

4.2.1.2 Scope of Responsibility.
The project manager will coordinate all activities among subject matter experts and the programmer. We will be responsible for recruiting staff, dispersing grant monies, coaching staff, training staff, initiating meeting, gathering status reports, generating monthly project reports to the granting agency, assessing quality control of models and software, and writing the final project report.

4.2.1.3 Internal Responsibilities.
Coordinate the LCS team, keep the time, cost , training, and reporting activities monitored and on task

4.2.1.4 External Responsibilities.
Advertise, champion, and advocate the LCS. Interface with the granting institution.

4.3 Project Roles and Responsibilities and Abbreviations
Below is a matrix of work activities and supporting processes vs. organizational units (Chief Architect: CA, PM: Project Manager, CI: Chief Investigator, SMA: Subject Matter Expert, Math: Mathematician, Prgmer: Software Programmer, Revrs: Outside Reviewers) that depicts project roles and responsibilit*y.*

SECTION 5. MANAGEMENT PROCESS

5.1 Start-up

An estimation plan, recruiting and staffing plan, organizational plan, resource acquisition plan, work process flow, and training plan have been developed for LCS and are detailed below.

5.1.1 Estimation

Estimates of the cost and schedule for conducting the LCS project as well as methods, tools, and techniques used to estimate project cost, schedule, resource requirements, and associated confidence levels. In addition, the basis of personnel cost estimation has been the number of required model abstractions, estimate of total abstraction time based on T. Kotowski's work, hourly wages, and a learning curve. Cost of airfare from the average Priceline.com cost of RSW to E coast, W coast, hub-hub, and off hub air travel as of February 2009. These will be re-examined quarterly.

be specified to include techniques such as analogy, rule of thumb, or local history and the sources of data. This subclause shall also specify the methods, tools, and techniques that will be used to periodically re-estimate the cost, schedule, and resources needed to complete the project. Re-estimation may be done on a monthly basis and/or periodically as necessary.

5.1.2 Staffing

This specifies the number of staff required for the LCS project by skill level, the project phases in which the numbers of personnel and types of skills are needed, the source of personnel and the duration of need. Resource Gantt charts, resource histograms, spreadsheets, and tables may be used to depict the staffing plan by skill level, by project phase, and by aggregations of skill levels and project phases.

Graduate students or PhD candidates in Physics or Engineering should have the math and physical science skills needed to do this work. This is the type of work that can be done at any facility with access to a PC. Considering the remuneration, candidates should be readily available from University Physics or Engineering Departments. Candidates may decide to collaborate

Investigator	**Function – Eighteen-months**
Thomas Kotowski	Chief Architect, Project Manager, Modeler, and Lead Investigator
Contractor	If the schedule needs it, an assistant may be needed in the last 2 Qs.
Contractor	Mathematician
Contractor	Subject Matter Expert
Contractor	Subject Matter Expert
Contractor	Subject Matter Expert
Contractor	Subject Matter Expert
Contractor	Subject Matter Expert
Contractor	Subject Matter Expert
Contractor	Software Engineer

Thomas Kotowski has Master degrees in both Theoretical Physics and Industrial Psychology. His professional experience is 36 years doing R&D in semiconductors and sensors for World Class Aerospace and Automotive companies, has successfully developed 12 products from conception, development, design, proto, and production, and holds six patents in semiconductor design.

5.1.3 Resource Acquisition

All of the resource acquisition will be done by the project manager. Other than the project manager and principle investigator, all of the work is to be done by independent contractors (Tax Form 1099 nonemployee compensation). Contractor remuneration is on a per piece (model abstraction or software project) basis. Model remuneration, is based on the degree of difficulty/learning curve formula given in subclause 5.3.3.1, Cost Control. Rubrics for model difficulty are given in the website at www.LeapCad.com. One of the job requirements is that each investigator owns a PC, have Microsoft Word and Excel applications, ready access to the internet, and an email account.

Contract personnel will be acquired by bids. There are numerous bidding websites for software programmers. Requirements will be successful completion of a number of major programming projects and documentation of such. To make collaboration easier, bids from local programmers will be solicited first. The software programmer will be paid on a contract basis at the completion of the project.

It is estimated that about half of the subject matter personnel will be obtained in the first month. Inquires will be made to Physics and Engineering Departments for researchers who may be interested in job contracted, part-time modeling. The only requirement for investigators is that they be able to do the work. If they are successful at creating math models that abstract the work of leading edge energy research they will get paid. Examples of models are posted under “Models and Analyses” at www.LeapCad.com . More examples will be added as they become available. It will be fairly easy for investigators to do modeling within their area of expertise, but more difficult for new areas. A high rate of turn-over is anticipated for investigators.

Office supplies and duplication will be obtained by local businesses (Office Depot, Office Max). Most communication will be by phone and email. Air travel will be contracted through an online service such as Expedia or Priceline.

Commercial software will be acquired during the first quarter. Five copies of Mathcad 14 may be purchased for qualified academicians to create Mathcad scripts/worksheets. It is anticipated that most of the investigators will have access to MatLab. If not, there is an open source MatLab clone (Octave) that is available. With the exception of travel and collaboration, all work by the principal investigator will be at his home office. It is anticipated that some finite element modeling may be required. If finite element analysis is required for some models, the Field Precision Advanced Electrostatics Design Suite ($3690) will be purchased.

5.1.4 Staff Training

Each investigator will be given a copy of this overall plan, a representative bibliography, a description of the compensation learning model, a Gantt chart to see scheduling constraints, and examples of abstracted models. A telephone conference will be held to answer any and all questions related to this project. The website is also available for study. It is anticipated that most of the investigators will be physical science related PhD candidates and thus, already be highly trained in the area of mathematics and science. A weekly transmittal of work-in-progress and monthly telephone Q&A sessions will be held to assess understanding of the job requirements and any need for additional training.

5.2 Work Planning

5.2.1 Work Activities

This subclause shall specify the various work activities to be performed in the project. A work breakdown structure shall be used to depict the work activities and the relationships among work activities. Work activities should be decomposed to a level that exposes all project risk factors and allows accurate estimate of resource requirements and schedule duration for each work activity. Work packages should be used to specify, for each work activity, factors such as the necessary resources, estimated duration, work products to be produced, acceptance criteria for the work products, and predecessor and successor work activities. The level of decomposition for different work activities in the work breakdown structure may be different depending on factors such as the quality of the requirements, familiarity of the work, and novelty of the technology to be used.

5.2.2 Schedule Allocation

Because LCS is a small project, a Gantt chart should adequately monitor project tracking and will be used for scheduling and showing project milestones. Also tracking the percent models completed versus time in a modified Earned Value Management chart will monitor schedule progress.

5.2.3 LCS Project Plan (Note: There is a separate Gantt Chart for tracking)

LCS Project Plan Sequencing and Critical Events

Task #	Activity	Process	Org Unit	Predecessor Task #	Critical	Cycle Time (Week)
1	**Analyze & Verify Project Plan**					
2		Develop Schedule	PM			4
3		Develop Budget	PM			1
4		Develop Processes	PM		✓	6
5	**Assemble Team**					
6		Identify Skills and Availability	PM	4	✓	2
7		Contact Physics & Eng Depts	PM	6	✓	3
8		Advertise & Solicit Team Members	PM	7	✓	6
9		Interview, Chk Refs & Select Team	PM	8	✓	7
10		Train Team	PM	**9**	✓	2
11	**Establish Project Goals**					
12		Review, Develop, Design Tests	PM	10		1
13	**Project Communications**		PM			
14		Publish: Communication Plan, Update Schedule	PM	10		2
15		Status Reporting Rules	PM			
16	**Setup**					
17		Software	Team	10	✓	1
18		Telecom	Team	10		
19	**Create Model Library**					
20		Select Consensus Panel & Revrs	PM	**9**		3
21	Select Energy Sector(s) &Papers for Proto Abstraction		Panel	**20**	✓	10
22		Abstract model into mathematics	SMA	21		2
23		Translate into scripts/worksheets	SMA	22		2
24		Verify that it matches graphs	CI	23		0.2
25		"Electronic Book" Format	SMA	24		0.2
26		Finish One Paper	Team	25		3
27		Put into Website	Prog	26		
28		50th Paper	Team	**49th Paper**	✓	30
29		Create Properties Matrix & Explorer |	CA	28	✓	18
30		100th Paper	Team	99th Paper	✓	65
31	**Create VL Environment**					
32		Identify Methodologies	CA	**4**		10
33		Identify Math Process Rules	CA, Math	**4**	✓	50
34		Define Environment Specs	CA	32		8
35		Design Integrated Environment	Prgmr	34	✓	4
36		Create Integrated Environment	Prgmr	35	✓	40
37		Test	CA	36	✓	2
38		Feedback on Design - Tweak	Prgmr	37	✓	4
39		Finish system documentation	Prgmr,PM	**38**		
40		Upload to website	Prgmr	38		
41	**Acceptance Testing**					
42		Test System, Metrics	CA	36	✓	2
43	**Proj Review**	Assessment by Reviewers	Revrs	42	✓	5

CA: Chief Architect, PM: Project Manager, CI: Chief Model Investigator, SMA: Subject Matter Expert, Math: Mathematician, Prgmer: Software Programmer, Revrs: Outside Reviewers

5.2.4 Resource Allocation

Refer to 5.2.3 for schedule allocation.
About 88% of the financial resource allocations are for personnel. Subject matter experts will be Engineering or Physics PhDs or PhD candidates with the necessary skill levels to abstract mathematical models. This is detailed in the following section: Budget Allocation. The next two major items are for travel expenses and technical journal articles and subscription fees. It is assumed that the subject matter experts have access to PC computers and standard Microsoft desktop applications. The Principal Researcher will code the math models into Mathcad, if necessary. No administration support is required.

Because the Lead is responsible for Administration, Project Management (which requires travel), LCS Architecture/concept development, some model abstraction, math script translation into Mathcad, some aspects of software development, and LCS advocacy, it may be necessary to employ an assistant during the final two quarters of the project to keep the projected schedule on track. Some renegotiation of goals would be required. Extra finances will come by reducing compensation/difficulty level for model abstraction, or reducing the 100 model target for number of models.

5.2.5 Budget Allocation Chart

Prototype LCS Budget Allocation

Description	Quantity	Unit/ Period	Unit Cost	Yearly Cost	18 Mon. Cost
Personnel					
Thomas Kotowski - Chief Architect Project Manager	1	Yearly	$25,000	$25,000	$37,500
Thomas Kotowski - Software Develop	1	Yearly	$5,000	$5,000	$7,500
Mathematician - Math Process Trans	1	1 Year	$50,000	$50,000	$50,000
SE - Software Development	1	Yearly	$30,000	$30,000	$30,000
Thomas Kotowski - Model Abstraction	1	Yearly	$35,000	$35,000	$52,500
SME1 - Model Abstraction	1	Yearly	$20,000	$20,000	$30,000
SME2 - Model Abstraction	1	Yearly	$20,000	$20,000	$30,000
SME3 - Model Abstraction	1	Yearly	$20,000	$20,000	$30,000
SME4 - Model Abstraction	1	Yearly	$20,000	$20,000	$30,000
SME5 - Model Abstraction	1	Yearly	$20,000	$20,000	$30,000
SME6 - Model Abstraction	1	Yearly	$20,000	$20,000	$30,000
Model Abstraction SubTotal 18 Months:	**$202,500**	= 50 hours average/paper @$40/hr			
Assistant to Project Manager	**If needed to keep schedule on track** during last 3 quarters. Funds would come from reallocation of model compensation.				
Travel					
Plane	24	Times	$550		$13,200
Car, gas	28 days	Times	$50		$1,400
Hotel	28 nights	Times	$110		$3,080
Video Telecommunications					
Hardware	5	Pc	$150		$750
Software		Pc	$300		$300
Rental	2	Monthly	$30	$720	$1080
Software					
FE Advanced Electrostatics Design	1	Pc	$3,690		$3,690
Mathcad	5	Pc			$650
Research Paper Purchase	200	Pc	$30		$6,000
Journal Online Subscriptions	10	Yearly	$250	$2,500	$5,000
Duplication Service					
Color	200	pg	$0.50		$100
Black	1000	pg	$0.08		$80
Office Supplies		Monthly	$50	$600	$900
Phone		Monthly	$50	$600	$900
5% Cost Overrun					**$18,000**
Total					**$382,630**

5.3 Project Controls

This subclause specifies the metrics, reporting mechanisms, and control procedures necessary to measure, report, and control the LCS requirements, the project schedule, budget, and resources, and the quality of work processes and work products. All elements of the control plan are consistent with LCS's standards, policies, and procedures for project control as well as with the contractual agreements for project control.

5.3.1 Requirements Control

This document will be used as the control mechanisms for measuring, reporting, and controlling changes to the LCS requirements. Any changes will be dated and made in red and s~~trikethrough~~ will be applied to deleted clauses. The document will be stored at www.LeapCad.com/proposal as a PDF file and titled "Proposal - Leap Cad System.pdf."

5.3.2 Schedule Control

The following lists the control mechanisms to be used to measure the progress of work completed at the major and minor project milestones, to compare actual progress to planned progress, and to implement corrective action when actual progress does not conform to planned progress. The schedule control plan specifies the methods and tools that will be used to measure and control schedule progress. Achievement of schedule milestones should be assessed using objective criteria to measure the scope and quality of work products completed at each milestone.

The following paragraphs define the management approach for schedule control of the Leap Cad System.

5.3.2.1 Schedule Tracking.

The LCS is a small project. Excel spreadsheets have been developed for Gantt charts for time management and Earned Value Management (EVA) charts for cost management.

5.3.2.2 Schedule Performance Reports.

Monthly reports will be generated for updates on the Gantt, EVA, and Section 5.1.2 chart tracking.

5.3.2.3 Schedule Reviews.

Quarterly project reviews are planned. Software milestone will be reviewed and action taken to remain on schedule

5.3.2.4 Progress Variance Monitoring.

After the second quarter, cost deviations of more than 10% will have model compensation adjustments to remain on budget. Schedule lags of more than 10% will be adjusted by recruiting more model investigators.

5.3.2.5 Progress Variance Resolution.

Spending limits and schedule deviations will be resolved monthly. Amount rewarded for each type of model abstraction will be reduced if needed. (Note a learning curve is built into the model reward amounts.)

5.3.2.6 Follow-Up on Corrective Action.

This will be assessed at the next monthly review.

5.3.3 Budget Control

This specifies the control mechanisms to be used to measure the cost of work completed, compare planned cost to budgeted cost, and implement corrective action when actual cost does not conform to budgeted cost. The budget control plan shall specify the intervals at which cost reporting will be done and the methods and tools that will be used to manage the budget. The budget plan includes monthly milestones that can be assessed for achievement using objective indicators to assess the scope and quality of work products completed at those milestones. A modified method of earned value tracking will be used to report the budget and schedule plan, schedule progress, and the cost of work completed. The following paragraphs define the management approach for schedule control of the LCS project.

5.3.3.1 Cost Management and Compensation Rules.

We want an equitable method for compensation. We will use a compensation distribution model based on level of difficulty with a learning curve for number of models abstracted.

Compensation for Complete Models: We have allocated about $200K compensation over 100 models, which gives an average of $2000 per model Assume 50 hrs, on the average are needed for an abstraction. $2000/50hr = $40/hr However, the degree of difficulty and amount of work will differ. To compensate for the degree of difficulty , models are ranked into three degree of difficulty: Easy, Average, and Hard. Examples of these categories are shown on the www.LeapCad.com website. The target allocation numbers are 20, 40, 40 abstractions per each of these category, respectively. This corresponds to $1500, $1800, and $2500 per category, respectively, for a total of $200, 000. As models are developed, development skills should increase, and this is reflected in a learning curve. Consequently, only the first 40 hard abstractions are eligible for $2500/model. After that, average and hard category models are both rewarded $1800.

Finders Fees for Analytic Models that can be easily abstracted: $100 for locating non-trivial, analytic models of "leading edge" renewable energy papers that can be readily abstracted with standard math software. See examples. Model submitted for finders fee must not already be listed in the bibliographies at www.LeapCad.com.

LCS Earned Value Management Tracking Chart

Activity	0	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	PV	% Complete	EV							
Abstract Models												202500									
Activity	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**PV**	**% Complete**	**EV**
Abstract Models																			202500		
Software Design																			30000		
Project Management																			37500		
Software Support																			7500		
Air Travel																			17,680		
Software Purchases																			4340		
Duplication Costs																			180		
Research Paper Costs																			6000		
Subscription Costs																			5000		
Office Supplies																			900		
Telecommunications																			2130		
Phone																			900		
TOTAL																			**314630**		
Monthly PV																					
Cumulative PV																					
Monthly EV																					
Cumulative EV																					
Project EV to date																					
Project PV to date																					
Project AC to date																					
CV = EV - AC																					
SV = EV - PV																					
CPI = EV / AC																					
SPI = EV / PV																					
Est at Completion																					
Est Time to Complete																					

Note: Mathematician will be contracted for one year at a fixed amount.

5.3.4 Quality Control

Quality of models will be determined by the ability to reproduce the graphs and numerical results in the original journal articles. Some software algorithms give different results. For this work, a 1% difference is tolerable. A monthly review will be made with regard to metrics.

5.3.5 Project Reporting and Communication

This specifies the reporting mechanisms, report formats, and information flows to be used in communicating the status of requirements, schedule, budget, quality, and other desired or required status metrics within the project and to entities external to the LCS project. The methods, tools, and techniques of communication are specified. The frequency and detail of communications related to project measurement and control are consistent with the LCS project's scope, criticality, risk, and visibility.
The following paragraphs define the management plan for ensuring the broadest communication of needed information for LCS project coordination.

5.3.5.1 Electronic Media.

Work will be tracked using Microsoft Word, Excel, and the math scripts/worksheets. Copies of email correspondence will be made. Html scripts (for website) will be modified with Macromedia Dreamweaver. Data will be stored to hard drive, CDs, and USB drives.

5.3.5.2 Meetings.

Weekly telephone conferences will be held. The Chief Architect will make one monthly trip to the six different subject matter experts, for a total of 3 trips per investigator for the eighteen-month program.

5.3.5.3 Information Repository.

Information will be stored on the Program Manager's computer. Weekly backups to hard drive and USB drives will be made. A final achieving to a CD and a CD backup will be made. Project material will also be available on the web domain host.

5.3.5.4 Written Status Reporting.

Each staff member will provide a monthly written report giving the number of models completed and proposed bibliographies.

5.3.6 Metrics Collection

Projects metrics are: percent difference between model results and original articles, percent schedule completion, number of articles abstracted, number of breakthrough techniques in software models, and percent of models that have technology, environmental, and social cost models. The evaluation tools will be the math software used for the model scripts/worksheets (Mathcad, MatLab, etc). These metrics will be compiled monthly.

5.4 Risk Management

Risk factors: risks in the model and software contractor relationship, contractual risks, data backup risks, risks in acquisition of investigators and programmer, investigator and programmer skill levels and retention, risks in meeting LCS schedule and budget targets, and risks in achieving the grant providers acceptance of the LCS. These specific "program management" risks will be evaluated monthly, analysis applied, if needed, and appropriate corrective action will be applied as needed. Other risks are that funding may not be adequate to fully develop the LCS concept or that the energy sectors chosen for initial modeling may not be optimal for application of the LCS method. These latter problems could be fatal to the success of LCS.

5.5 Project Closeout

Steps will be taken to ensure an orderly closeout of the project. Each investigator will provide a final report to include lessons learned and analysis of project objectives achieved. There will be a final archiving of project materials.

SECTION 6. TECHNICAL PROCESS

6.1 Process Model

The Project Manager will update all team members and will be the arbiter of all changes, to be recorded by updating this document. Process models are given in sections 2.5.

6.2 Methods, Tools and Techniques

IEEE Std 1058-1998 Guidance (Subclause 6.2) Methods, tools, and techniques is the technical standard to be used in governing development and/or modification of the work products shall be specified. The project will use Microsoft Office (Word, Excel, and PowerPoint) and the UltraEdit programming editor. Mathcad, MatLab (Octave), and Mathematica are the chief analytic programming environment. Web programming will use Java (JaveBeans), JMatlink, and Perl.

6.3 Project Infrastructure

Each investigator has the responsibility of maintaining there own PC, communication facilities, and software backup. The project manager will supply analysis software, if required, and the contract for the web hosting site (BlueHost.com).

6.4 Product Acceptance

Quality of models will be assessed by the ability to reproduce the graphs and numerical results in the original journal articles. Some software algorithms give different results. For this work, a 1% difference is tolerable. A monthly review will be made with regard to metrics. An outside review board will be used to check metrics and ease of use of website. A mock problem will be used to evaluate the LCS facilitation of problem solving. A written evaluation will be solicited and attached to this document.

SECTION 7. SUPPORTING PROCESSES

7.1 Configuration Management

This document will be used to record any changes to procedures, goals, or evaluation procedures.

7.2 Independent Verification and Validation

This A board of independent reviewers (Engineering Professors) will be used for final evaluation.

7.3 Documentation

All changes will be recorded as addendums to this document.

7.4 Quality Assurance

Prior to completion of this project, a quality assurance procedures will be prepared to include analysis, inspections, reviews, audits, and assessments. The quality assurance plan will indicate the relationships among the quality assurance, verification and validation, review, audit, configuration management, system engineering, and assessment processes.

Technical Appendix

APPENDIX A. BRIEF HISTORY OF PRESIDENTIAL ADMINISTRATION ENERGY POLICIES

President Nixon 1970s
Nixon declared war on foreign oil when its price tripled, virtually overnight. He established Project Independence 1980.

President Ford
Established the Energy Policy and Conservation Act in 1985 to set federal standards for energy efficiency in new cars for the first time.

President Carter 1977
"Unless we act, we will spend more than $550 billion for imported oil by 1985 -- more than $2,500 a year for every man, woman, and child in America. Along with that money we will continue losing American jobs and becoming increasingly vulnerable to supply interruptions". Carter proposed a sweeping **$142 billion** energy plan which would achieve *energy independence* by 1990. Part of his plan included the "creation of this nation's first solar bank, which will help us achieve the crucial goal of 20 percent of our energy coming from solar power by the year 2000." Carter imposed an import quota of 8.5 million barrels of oil per day and created the **$20 billion** Synfuels program, which was supposed to produce 2.5 million barrels of synthetic fuels per day by 1990.

President George H.W. Bush 1991
In the prelude to the First Gulf War, he announced a hodgepodge of proposals as a national energy strategy. One of his strategy's guiding principles was "*reducing our dependence on foreign oil.*"

President G.W. Bush 2003:
In his 2003 State of the Union Address, he announced a **$1.2 billion** Hydrogen Fuel Initiative to reverse America's growing *dependence on foreign oil*.

http://www.whitehouse.gov/news/releases/2008/09/20080909-11.html
2006 State of the Union address: Twenty in Ten" challenge in his to increase fuel efficiency and mandate the use of renewable fuels to reduce our dependence on oil. Advanced clean energy technologies;

- Provided nearly **$18 billion** to research, develop, and promote alternative energy technologies;
- Invested more than **$45 billion** for climate-related science, technology, observation, and incentives;
- Signed into law loan guarantee authorities of up to **$42.5 billion** to support innovative energy technologies; and

http://www.whitehouse.gov/stateoftheunion/2006/energy/index.html
President Bush announced in his State of the Union Message in 2007, a goal for Americans to cut their consumption of all gasoline by 20 percent over the next 10 years.
Bush will present the energy plan one year after he told Americans the nation was "addicted to oil." To fulfill solar energy's promise, the President's 2007 Budget proposes a new $148 million Solar America Initiative – an increase of $65 million over FY06.

APPENDIX B. SELECTION CRITERIA OF TECHNOLOGICAL AREAS FOR INVESTIGATION

Identifying low hanging fruit – in general this results from a confluence of four factors. General Guidelines: No crystal ball. Don't know which engineering technologies will be ultimate winners. Assume basic laws of physics hold (e.g., can't violate second law. Equal weight given to short versus long term payback).

I. Identify Areas of National Criticality
One major area is America's Oil Vulnerability. A number of US presidents have stated that "America is addicted to oil, which is often imported from unstable parts of the world."

II. Market Potential
A Present

- Sector Maps – Plot Economic Value Data of Existing Markets

http://online.wsj.com/mdc/public/page/2_3024-sm_utility_map.html

    - Utilities
    - Oil & Gas Producers
    - Equipment Manufacturers

B. Future Markets

- Oil – Transportation
    - Oil
        - Security
        - $700B Annually
    - Transportation: 60% of Oil Use

III. Overcoming Technological Barrier to Adoption of Renewable and Green Technologies
A. Load Balancing Technology for Intermittency (When the Sun doesn't shine and the Wind doesn't blow)

- The Storage Technology Challenge
    - Pumped Hydro
    - Compressed Air Energy
    - Batteries
    - Hydrogen

B. EV

- Cost Effective, High Energy Density Storage – Replacement for gasoline

IV. Model Efficacy for Leading Edge Research
Well defined analytic model
Well defined, non-interacting, geometries
Best suited to generate and evaluate hypotheses

APPENDIX C. PROVEN BREAKTHROUGH METHODOLOGIES

Problem driven approach.
Given a user's problem, then use the model library for the solution. Select leading edge research as best domain for which would contain a sample of the user's problem space. Apply TWK's synthesis

Creativity Space
Use for deBono space. Don't know what are best areas for lateral creative synthesis. Make assumption that areas of leading edge research would be fruitful ground.

Identify fruitful problems

Dr. K..'s
Creative researchers expose themselves (in comparison to their less creative counterparts) to a greater variety of information sources, including those outside their specialities.

Known Breakthrough Methodologies
TRIZ

Knowledge Research, multi-disciplinary (cognitive psychology) in LCS
Facilitating the "Aha" problem solving process.
Application of Knowledge Science to Energy Techological Innovation - environment or circumstance, that supports the development and practice of scientific knowledge creation.

Knowledge science and knowledge systems engineering a computer-based integrated system
Reusability, written in the natural language of mathematics computerized tools for creativity support
Mathematical model is a tool for finding a solution;
Expert mining
information and knowledge are becoming essential economic assets

The latter as the common approach has got more and more attentions from multi-disciplines, such as cognitive psychology, management science, system science, knowledge science, social science and computer science, etc. Also, both the theory and mental models have been involved in the design and operation of the computerized tools. This paper presents a creativity support system

APPENDIX D. MINIMUM NUMBER OF MODELS AND "CRITICAL MASS"

What follows is far from rigorous discussion of the effects of the number of models. We have chosen 100 as the number of models for prototype development. One hundred gives a meaningful statistical sampling from at least five separate model areas, and it keeps budgetary cost for 100 model library within the low six figures for a reasonable grant application.

Obviously, there are no hard rules for what constitutes the "critical mass" with regard to the number of models. *This is a very loose discussion.* Metcalfe's Law states that the value of a network is proportional to the square of number of subscribers. The next order of magnitude beyond 100 is 1000. There were about 1000 hosts when the entire network switched to the TCP/IP system and the Domain Name Server (DNS) was introduced, creating the internet as we know it today. One thousand nodes roughly corresponds to the point where the internet exploded.

APPENDIX E. EXAMPLE OF SUCCESSFUL APPLICATION OF ONE LCS TECHNIQUE

An "Impossible" Problem

I was given an "impossible" assignment by our Director of R&D. It was a problem that involved the time-dependent-dielectric-breakdown, TDDB, of the SiO_2 dielectric in semiconductors. Because, with regard to known technology, the problem seemed "impossible," I had no way to directly attack the problem. What I needed was some structured problem solving methodology to aid in the solution of this problem. The approach I tried was a variant of a structured, general problem solving methodology known as General Morphological Analysis (GMA) applied to the body of TDDB knowledge.

Best-in-Class Innovation Strategies

A study by the Aberdeen Group, "The Innovator's Toolbox, Empowering the Next Wave of Innovation Makers," showed that innovation is improved by the use of idea collection systems, conceptual design tools, digital information capture technologies, improved methods of idea communication, standard procedure for the investigation of existing technologies, use of knowledge research tools, and providing an environment for innovation. As a generalization, these methodologies improved the innovation of companies about 45% over their competitors. The Leap Cad System is the application of these concepts and Knowledge Science with regard to leading edge editable mathematical models.

Model and Expert Mining and Subsequent Mathematical Abstraction

I created a list of the 100 most important papers in this particular area of oxide modeling and development. The emphasis was on papers about models, which give an abstraction of the details of physical processes. These papers came from the following publications: the Journal of Applied Physics, Proceedings of the International Reliability Physics Symposium, Sold State Electronics, Journal of Applied Physics Letters, Proceeding of the Electrochemical Society, IEEE Transactions on Electron Devices, and IEEE Transaction on Solid State Circuits. There were also a few sections of books that deal with the particular area of interest. These papers dealt with the engineering and physics of this problem, and in general, were written in the common language of science, namely, mathematics.

Let me share an example of a small snippet from one of the above "expert" papers on TDDB.

For oxide thickness above 4 nm, the oxide field can be extracted from the Fowler-Nordheim tunneling current and is given by:

$$J_{FN} = AE_{ox}^2 \exp\left(-\frac{C}{E_{ox}}\right) \quad (3)$$

where A and C are constants and given by:

$$A = \frac{q^3}{8\pi\pi}\left(\frac{1}{\Phi_B m^*}\right) \quad (4)$$

and

$$C = \frac{8\pi\sqrt{2}}{3qh}\left(\frac{m^*}{m}\right)^{1/2}\Phi_B^{3/2} \quad (5)$$

As this example shows, the results of the research in this paper are "locked up" either in an Adobe PDF file or on the printed page. The above is simply text and is static, unchangeable, and not easily manipulated. It is not immediately usable to calculate numbers or print graphs. It is not possible to easily re-use the results or re-apply them to a new problem or solution.

The intent of the compact analytic model library is for the development of concepts and ideas, not for detailed product design. Product design usually requires finite element simulation tools to define precise geometries and material properties of the technology or product. Our intent is to examine synergies across a broad range of areas. Thus we use analytic models which offer greater flexibility and ease to integrate with other technology arenas. We use the term compact to mean models that do not require many data points. This is not a precise term, but for our purposes we will define a compact model as one that requires less than 5,000 data or grid points. The models are to be extracted into a common framework of reusable scripts/worksheets such as Mathcad, MatLab,or Mathematica. Mathcad, which uses a natural math notation, and thus displays the logic behind its steps, is preferred. (For examples of models relating to energy development see the models section on the website www.LeapCad.com)

I then abstracted the contents of the papers from the bibliography by rewriting the equations and tutorializing the mathematics into a standard math tool, Mathcad.

Different math software engines have different features and strengths. Mathcad is probably the best tool for easily capturing, tutorialing, documenting, and sharing math models. Other tools have other strengths, but Mathcad with its clarity of presentation and self documentation capabilities is best for this particular application.

- It uses the standard, natural, symbolic notation of mathematics for (Calculus) operators. Thus others can read the content without specialized knowledge.
- Equations, text, tables, and graphics are shown explicitly in same worksheet.
- It does automatic unit checking which both save time and reduces errors.
- It is clear self documenting and it is easy to add descriptive details.
- It explicitly names every function, variable, and vector/matrix length.
- Its functional and symbolic notation matches what is seen in tutorials in text books.
- I t thus has clarity of notation and documentation.
- Its features make collaborative development easier.
- Because of its tutorial value, it is being used to write a number of Science and Engineering textbooks.
- Its documentation features facilitate design reuse.

Creation of a Virtual Laboratory

Next, the goal was to abstract the model dynamics into a tutorial, programmable, editable, format that optimized re-usability of the abstracted model. The goal was that the math abstraction would be able to reproduce the graphs, charts, and tables that were the product of the key concepts in the paper. The result should also be extendable to new data, parameters, materials, or situations.

The abstraction into a common framework of the collection of papers provided a "Virtual Laboratory" to explore the properties, dynamics, and potential synthesis of the models. I was able to view, digest, and experiment with a broad range of models.

Application of Known Breakthrough Methodologies

Once abstracted into this common tutorial framework, it was then possible to apply a multi-disciplined approach and use higher level thinking tools such as the problem solving, and creativity techniques (Delphi, GMA, Lateral Thinking, TRIZ), and higher level abstractions. Within the Virtual Laboratory framework, it was straightforward to compare, contrast, and detect analogies, patterns, exceptions within the models.

This facilitates the process of lateral thinking and synthesis. The solution to my problems was not obvious, but by using a higher level concept of "Physical Process Factorization," I was successful in solving this particular "impossible" problem. The solution was not published in a Journal outside of our organization because our management concluded that, at that point in time, it gave us a proprietary advantage over our competition.

Appendix F. LCS Master Schedule (Microsoft Excel Gantt Chart)

The objective of the LCS Master Schedule is to provide management with the task map and tracking tool needed to guide the LCS Project in the performance of its mission. This will be documented with an Excel Gantt chart. A preliminary example of this is shown in section 4.3   Project Roles and Responsibilities.

Appendix G. LCS Project Training Plan

An LCS Project Training Plan will be developed to enhance the skills and knowledge of the LCS project staff so they can perform their roles effectively and efficiently. A copy of the schedule and project goals will be sent to the staff. Staff will be sent training materials and will then be tested on these materials. See section 5.1.4 Staff Training.

Appendix H. LCS Quality Assurance Plan

Staff will be provided with work product standards for the model format. The model format will conform to the "Electronic Books" format used in Mathcad. A more detailed development of the Appendix E: Example of the Leap Cad Systems approach, will be provided to staff. Each completed model will be inspected to ensure that it complies with this standar

BIBLIOGRAPHY

"Managing Industrial Research Effectively," ICFAI University Press, 2006, Roli Varma

"Smart Material Systems – Model Development", SIAM Frontiers in Applied Mathematics, Ralph C. Smith (Center for Research in Applied Computation)

"Creative Space –Models of Creative Process for the Knowledge Civilization Age," Studies in Computational Intelligence, Volume 10, Andrzej P. Wierzbicki, Yoshiteru Nakamori

"Permanent Innovation," Lulu, 2006, Langdom Morris

"Towards Knowledge Synthesis and Creation," 7th International Symposium on Knowledge and Systems Sciences, Sept. 2006, Expert Mining, Jifa Gu

"Innovation and Institutions – A multidisciplinary Review of the Study of Innovation Systems," Edward Elgar Publishing, 2005, Steven Casper, Frans van Waarden

"Advanced Mathematica Thinking," Kluwer Academic Publishers, 2002, David Tell
Foundations of Cognitive Psychology, Daniel J. Levittin

"Creative Space: Models of Creative Processes for the Knowledge Civilization Age (Studies in Computational Intelligence)," Springer, Andrzej P. Wierzbicki, Yoshiteru Nakamori

"Thinkertoys: A Handbook of Creative-Thinking Techniques (2nd Edition)," Ten Speed Press, 2006, Michael Michalko

"Lateral Thinking: Creativity Step by Step," Harper and Row, 1990, Edward De Bono

"Decision Making in Systems Engineering and Management," Wiley Series in Systems Engineering and Management, 2008, Gregory S. Parnell, Patrick J. Driscoll, Dale L. Henderson

"Innovation Algorithm: TRIZ, systematic innovation and technical creativity," Technical Innovation Center, 1999, Genrich Altshuller

"Energy Supplies, Sustainability, and Costs," Thompson Gale, 2007, S. M. Alters

"Macmillan Encyclopedia of Energy," Macmillian Reference USA, 2001