Introduction to Technological Leadership & Management: Assessing Emerging & Pivotal Technologies Management of Technology (MOT) 5224

COURSE OBJECTIVES

Develops an understanding of the fundamentals of management of technology with a focus on selected technologies, including energy, security and nanotechnology, expected to play pivotal roles in future industrial development. Current state-of the-art status for each technology, together with barriers and opportunities for commercialization will be addressed.

Discussions by two guest experts and student group analyses of potential applications of the technologies to industry will be conducted. More specifically we shall investigate selected pivotal technologies from energy (generation and transmission), security (critical infrastructure protection and sensor networks), and nanotechnology.

Security challenges of protecting critical infrastructure in the United States have been highlighted during the last two decades. In the aftermath of the tragic events of September 11th, our critical infrastructures are facing new scrutiny. Virtually every crucial economic and social function depends on the secure and reliable operation of our national infrastructures. Critical infrastructures such as electric power, oil/gas/water pipelines, transportation, and telecommunications networks including the Internet and digital systems become increasingly interdependent, critical and complex. From an asset management and strategic R & D viewpoint, the security, *agility* and *robustness/survivability* of large-scale critical infrastructure that face *new* threats and *unanticipated* conditions will be presented.

We will draw upon the technological innovations, fields of systems risk analysis, engineering, and economics to investigate infrastructure security, and to support design and management of complex infrastructure systems today and through the full life cycle. This course reviews and builds upon strategic technology assessment, technology foresight and forecasting, energy systems, sensor networks, critical infrastructure, systems' vulnerability assessment, asset and risk management, investigation of infrastructure interdependencies and couplings, along with judicious analyses of pertinent technologies coupled with potential for market impact, and their contribution to strategically enhance our security and quality of life.

This course has also been designed to serve as a bridge between introduction to MOT, pivotal and emerging technologies, technology assessment, foresight and forecasting, S&T policy, and the strategic management of technology. Reading all of the references will be overwhelming to many in the class. Please decide who in your group will be reading which ones ("divide and conquer") and read the subset that is of most interest to you individually (say about 20%-25% per student). The faculty members provide summaries and discuss selections from the reading list together in class.

INSTRUCTOR

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Text Books and Supplemental Material

Required reading is posted on the course website in Moodle (please log in at moodle.umn.edu), two zipped files contain the reading material and references, as well as samples of past final projects and reports.

Supplementary Books:
Cornish, Edward, *Futuring- The Exploration of the Future*, World Future Society (2004).

Arthur, W. Brian, *The Nature of Technology*, Free Press (2009). (This text will also be used in MOT 8232 Innovation in the 2011 Spring semester.)

Articles:

- Albright, Richard, "The Process: How to use roadmapping for global platform products," Visions Magazine, Oct. 2002.
- Brin, David, "Prediction a Faith, Prediction as a Tool: Peering into Tomorrow's World," Futures Research Quarterly, Summer 2006, pp. 16-24
- Coates, Joseph, "Normative Forecasting," in Futures Research Methodology, v. 2, edited by Jerome Glenn
- Coates, Joseph, "Why Study the Future?" Research Technology Management, May-June 2003.
- Coates, Joseph, "Scenario Planning," Technological Forecasting and Social Change 65, 115-123 (2000).
- Kostoff, Ronald and Schaller, Robert, "Science and Technology Roadmaps," IEEE Trans. On Eng. Mgmt., 48, p. 132 (May 2001).
- Popper, Steven, et al., "Shaping the Future," Scientific American, p.66, April 2005
- "Innovation, the attackers advantage"- *Richard N Foster* . Summit Books. 1986
- "Technology in the National Interest" - *National Science and Technology Council*. OSTP 1994. Washington DC 50502
- "Managing R&D as a Strategic Option" – *G.R.Mitchell ,W.F.Hamilton.* Research Technology Management. May/June 1998
- "A Perspective on Entrepreneurship"- *Stevenson, Howard H.* Harvard Business School, case 384-1 3. 1983

The following supplementary Internet resources are also recommended:

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- **www.battelle.org/aboutus/rd/2011.pdf**

- Energy, Materials/Nanotech, Security/Communications, and Biomedicine: *http://www.technologyreview.com*

- For a related discussion of a subset of exciting Emerging Technologies please see the May 2005 issue of MIT Technology Review. *F*or details on each please search subject word:

Airborne Networks	Quantum Wires	Silicon Photonics	Metabolomics	Magnetic-Resonance Force Microscopy
Universal Memory	Bacterial Factories	Enviromatics	Cell-Phone Viruses	Biomechatronics

- In addition, please search your pertinent areas of interest in the development, application and use of distributed sensor technologies in the management, monitoring, and maintenance of infrastructure systems. Assess the state of the art on current technologies and on-going

projects and assemble this information into a web page as a class project. For example, there are existing projects in use of sensor networks to monitor the quality of upstream Mississippi water and relay this information to automatically reconfigure the operation of the Minneapolis water treatment plant. RPI in New York State has had similar work on the way. We'll identify technology and business opportunities in this area.

TECHNOLOGY EVALUATION PROCESS

This process takes a very different perspective by looking into the future (2 to 10, or even to 20 years out) in Pivotal Technology areas totally outside of the electricity and security sectors. Once the key questions and issues are defined and the scope of the process is determined, the participants are divided into study groups.

The teams then look for interactions between electricity energy service trends or CIP areas and technology dynamics to develop a portfolio of science and technology opportunities in various categories pertinent to highest societal and business impacts. The whole group then reconvenes to share, integrate, and analyze the outputs of the sector teams. These overall opportunities are then mapped against the Assets of the system (taken in the broadest sense).

The outputs of this step are then mapped back to the current technology strengths from the insight phase. This overlay yields three types of opportunities and actions:

1. Strategic enhancement of the ***Technology Power Zone™***. This extrapolates current S&T, society and business needs with incremental opportunities.
2. Extension of the ***Technology Power Zone™***. The extension builds the strategic future based on today's foundation.
3. ***New Pivotal Technology Opportunities.*** Developed within current units, this identifies new development or alliance partnering prospects not currently in the planning horizon.

Outcomes

The expectations and anticipated outcomes of the process are to further:

Discover the pivotal science and technology strengths in the current technology profile, as they relate to future trends. The teams will identify and map those key science and technologies that are essential to the Consumer Needs, Technology Potential and Technology Scanning tracks.

Target major new growth platforms. The teams will sort existing science and technology strengths and new opportunities to characterize platforms.

Identify emerging Customer Needs and Technology development opportunities. These opportunities can be applicable to core stakeholders or involve new ventures based on science and technology strengths.

Gain insight for R&D prioritization and strategy. Prioritization is a key problem for most R&D organizations. There are always too many paths to take and jobs to do within resource allocation.

Integrate input for the strategic planning and optimization process. The results of the foresight process provide a business view of science and technology developments and opportunities that can be integrated into the strategic plan, rather than tacked on as the "contribution" from R&D.

Leverage existing technology strengths. The process can lead to clearer insight on current science and technology assets when looked at from a future perspective, rather than just incremental contributions to today's system and products.

Drive innovation through interconnecting the S&T community. By using the expertise of technical and business professionals in the process, new relationships across disciplines and businesses are created. These can be a major source of innovation for years to come. We have also seen the re-energizing of key sectors and technical personnel through participation in these activities with their peers.

In taking the lead in this endeavor, Dr. Amin will help you to identify a few (less than 10) critically important highest priority Innovation Nodes. While not an exhaustive list of the challenges that must be overcome, these are crucial to success, and thus, may ultimately become the focus of future efforts. The highest priority Nodes will create a unified picture of critical goals and challenges for meeting 21st Century service expectations. At this Residency, we shall:

1. Each study group will identify a few (2-4) key pivotal technologies per group that make the highest impact.
2. Expand the list (12+) with related technologies that drive, use, or synergize with these.
3. Map these onto the Technology Space Map™
4. Circle size for Leading (large), Strong (medium), or Capable (small)
5. Shape the Technology Power Zone™
6. Where do the market, policy and technology trends move the power zone in the next 2-4, 5-7, 10 or 20 years?
7. Share results with all participants.

Using examples of technology opportunities drawn directly from the energy and security sectors, study groups will be divided into parallel breakout sessions where they will systematically address each step. Specific technology areas to be addressed are tentatively planned as:

- *Materials and devices—including nanotechnology, microfabrication, advanced materials and smart devices*
- *Meso- and Micro- scale devices and sensors and networks*
- *Advances in information science: algorithms, AI, systems dynamics, network theory, complexity theory*
- *Bioinformatics,biomimetics, biomechatronics, systems biology*
- *Enviromatics*
- *Other industries— moving to a wireless world—transportation, telecommunications, digital technologies, sensing and control*
- *Markets, economics, policy and environment*
- *End-to-end Infrastructure-- from fuel supply to end use*
- *Other areas*

ASSIGMENTS and GRADING

You are free to select from a list of possible topics provided by the instructor or, with the prior consent of the instructor, to choose your own topic. Grades will be assigned based on:

- Participation in class discussions (10%)
- Each study group will prepare detailed analyses of selected pivotal technologies and their summary business cases. A brief executive summary report along with a class presentation investigating and discussing pertinent technology, potential business impact and policy issues and debates, along with your analyses and recommendations, and provide a final presentation on the technology(ies), pros/cons, cost/benefit, articulate urgent/tactical/strategic priorities, all findings and recommendations (70%).
- As always, please be mindful of balanced individual contributions and accountability; peer reviews (20%)

COURSE SYLLABUS AND SCHEDULE

Class Date	Time	Content
Session 1: 1:30-4:30 p.m. 9/9/2011 In person at TLI Room: WBOB, 5th floor, room 538	3 hours	2.5 hours: Introduction to the course and Pivotal Technologies Overview: Framework and Assessment Methodology Context and case studies for energy, cyber, telecommunications and information systems, nanotechnology, and security challenges Pivotal Technologies in energy, cyber/telecom/information systems, Nano 30 minutes: Ideation on course projects and team assignments
Session 2	4 hours	1 hour: Leadership Excellence 2.5 hours: Global R&D/market dimensions: Understanding emergent and accelerated global trends/shifts in energy, education, population/workforce, R&D centers and Innovation; 30 minutes: Discussion & share results-- identify additional needs and final project preparations
Session 3 Live/On-line: 10/14/2011 1-3 p.m.	4 hours	45 minutes: Project Plan Presentations (5 min. per team) 1 hour: Understanding Local vs. Global — Examples include China/India and global dimensions Scanning, Mapping and Evaluation Activity 2 Hours: Nanotechnology continues to be a vibrant and emerging area for science, engineering, and business. Focus on basic nanotechnology principles and applications including the science of dimensional scaling (in the electrical, mechanical, optical, chemical, and biological domains); nanodevices and components; nano-materials, nanostructuring, and nanofabrication; integrated nanosystems; and considerations for interfacing nanotechnologies with the micro-, meso-, and macroscopic worlds. Several case examples in nanobiotechnology, nanoelectromechanical systems, or

		NEMS, and nano-optics will be presented to expose both the multi-disciplinary science of nanotechnology and considerations needed for the development of new business opportunities. Breakout groups: Identify Opportunities and fuse with nano, IT, and global dimensions Discussion and Opportunities for synthesis Identify additional needs and preparations for course projects and preparation for group presentations
Session 4	4 hours	Workshop: Expanding your view of the pivotal technologies, global MOT, investigating and discussing immediate to short/mid-term as well as longer-term collaboration and innovation opportunities in the above areas, along with pros/cons, associated risks, cost/benefit, and strategic/tactical/urgent issues. Discussion & share results: Identify additional needs and final project preparations
Session 5 10/28/2011 Live/On-line: 10/14/2011 1-3 p.m.	4 hours	Midterm progress report group presentations with Short-term and long-term moves (20 minutes per team) Review: Framework & Assessment Methodology, followed by Workshop: Opportunities for synthesis, New Product Development (NPD) and New Business development (NBD) Recursion on identified opportunities and convergence of pivotal technology opportunities Case studies: IT, Energy, biosciences, IP and other selected areas Assessing opportunities in the above technological/business sectors (combined with economic, policy and cultural interests/goals)
Session 6-7	8 hours	Analyzing opportunities that organizations/companies can lead as new business development or forming global alliances. Marketing analyses-- How do the market factors look? Infrastructure for telecom. power/energy and transportation Work force retention and escalating salaries Cost factors vs. emphasis on expertise Lessons learned, time lines, surprises, threats and opportunities Blockers, Accelerators, and the Next Steps: Possible road ahead for innovations in global technology environment
Session 8 12/1/2011 1:30-4:30 p.m. In person at TLI Room: WBOB, 1st floor, room 160	3 hours	Final Project Presentations report back & share results: 20 minutes/project team Opportunities for synthesis, next steps and wrap-up Adjournment