



**Prof. Daniel Roos**

**ESD 10**



# Engineering Systems Development At MIT Technology and The Civil Sector 1975-1985

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- Post Vietnam Era
  - End of Apollo
  - Reductions in NASA and DOD Programs
  - War on Poverty
- Social Awareness
  - Silent Spring – Rachel Carson
  - Unsafe At Any Speed – Ralph Nader
- Dean Alfred Kiel Focuses Engineering School on Socio-Economic Systems
  - Center For Policy Alternatives - 1971
  - Center For Transportation Studies - 1973
  - Technology and Policy Program - 1975



# CTS – Center For Transportation Studies 1973

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- Holistic Problem Perspective - From Highway Engineering To Transportation Systems
- Different Analysis Approaches - Operations Research, Systems Analysis, Econometric Modeling, Supply/Demand Equilibrium Models, Organizational Theory
- Interdisciplinary Academic Program - Master of Science In Transportation



# U.S. Industrial Competitiveness 1985-1996

- Three Converging Forces
  - Sloan School of Management - Technology Is A Strategic Advantage
  - Engineering School – Back To Basics (i.e. Design, Manufacturing)
  - Industry – Educate Students In Manufacturing to Compete With Japan
- MIT Responds
  - International Motor Vehicle Program (1985) – “The Machine That Changed The World”
  - Commission on Industrial Productivity (1987) – “Made In America”
  - Committee on Large Scale Systems (1987) – Open and Closed Systems
  - Leaders For Manufacturing (1988) – “Big M” Manufacturing
  - System Design and Management (1996) – Product Development



# MIT International Motor Vehicle Program (1985-1990)

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- What Determines Competitive Advantage In The Auto Sector
- Comparative Research and Benchmarking—Researchers From Around The World, Coordinated by MIT
- Policy Forums For Senior Officials – Involving Stakeholders In Research Has High Payoff, MIT As Objective Neutral Party
- “Machine That Changed The World” – Data Based Book, Focused On Senior Executives And Government Officials



# Take Aways - Lean Production As An Engineering System

- Intuition Is Often Wrong - Western Auto Companies Misunderstood The Reasons For Japanese Success
- System Thinking Makes A Difference - Lean Changed Dynamics of International Competition - Superior Productivity, Improved Quality, Rapid Product Development, Production Flexibility
- Implementing Lean Requires Structural Change – Changes In Human Behavior Are Complex and Time Consuming, Denial and Opposition, But Change Is Possible
- Lean System Architecture - Holistic Framework, Foundation, Complete Logic, Fundamentally Different From Mass Production
- The Need For An Enterprise Wide Perspective – Everything Changes – Corporate Culture, Processes, Organizational Structure and Relationships, Information Systems, Incentives and Rewards
- The “Illities” Matter – Quality, Flexibility, Adaptability



# Planning For The Future

- **Professional Masters Programs**

**TPP** Technology and Policy Programs (1975)

**LFM** Leaders For Manufacturing (1988)

**SDM** System Design and Management (1996)

**MLOG** Master of Engineering in Logistics (1998)  
(and Supply Chain Management)

- **Constraints**

- Only Departments Admit Students and Hire Faculty
- Programs Needed Additional Faculty to Lead and Teach
- Decentralized Systems, Faculty Below Critical Size
- New SOE Unit Recommended But Not Implemented

**No Institutional Home for Engineering Systems Programs**

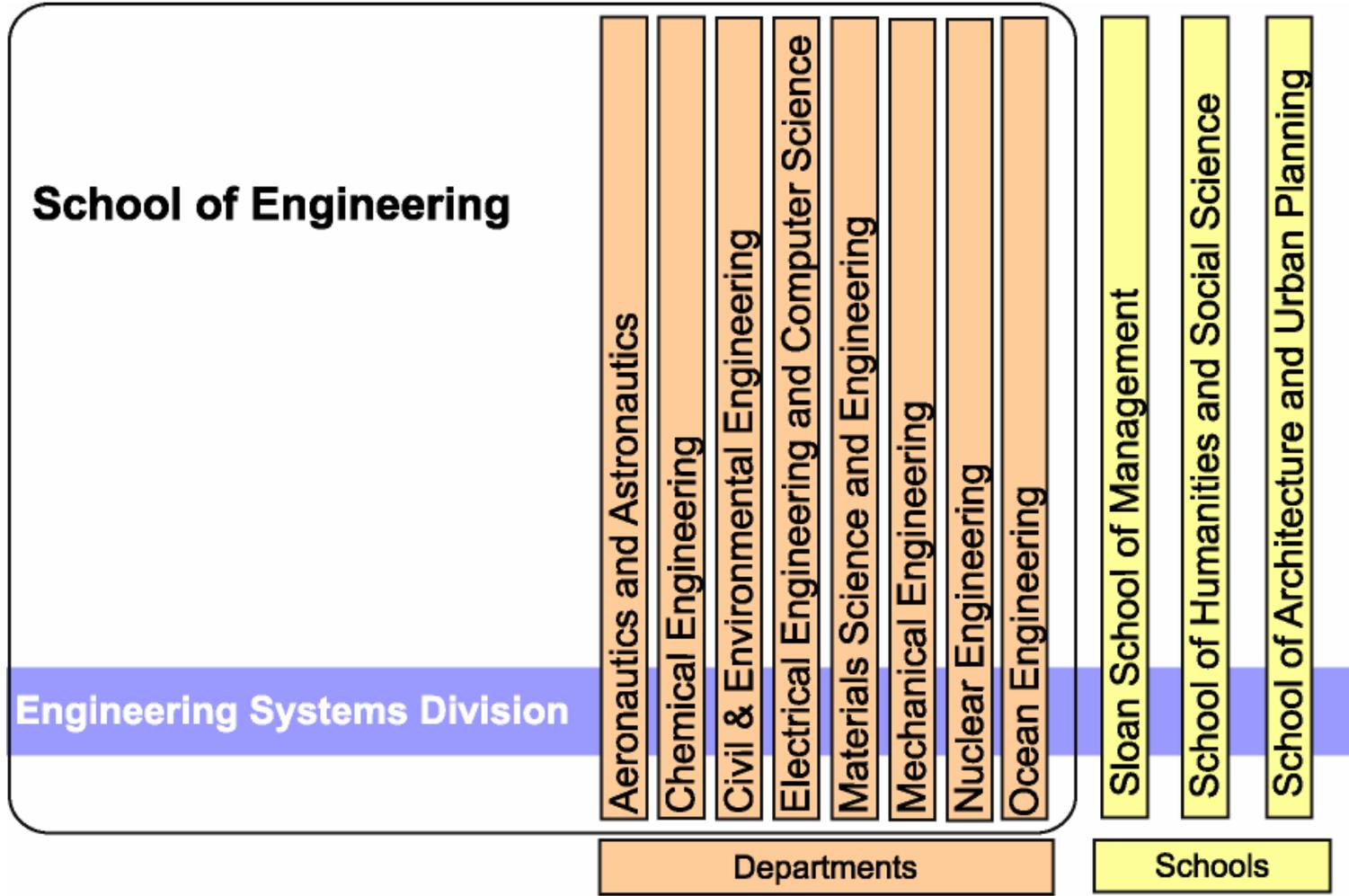


# ESD Formation

- Big “E” Engineering Committee (1995)
  - MIT Needs Leadership in Both Engineering Science and Engineering Systems
  - Develop Curriculum in Engineering Systems
  - Hire Additional Faculty in Engineering Systems
  - New Unit Proposed – Engineering Systems Division
- Opposition to ESD Formation
  - Too Soft - Not Real Engineering
  - Lacks Intellectual Content – Not a Discipline
  - Departments Already Doing Systems – Different Systems Perspectives
  - Use of Scarce Resources



# ESD Works With The MIT Academic Units





## ESD Mission

Establish engineering systems as a field of study focusing on complex engineered systems and products viewed in a broad human, social and industrial context. Use the new knowledge gained to improve engineering education and practice.



# ESD Goals & Objectives

- Create An Intellectual Home for Faculty From Engineering, Management, and the Social Sciences, Committed to Integrative, Interdisciplinary Engineering Systems Programs.
- Develop Concepts, Frameworks, and Methodologies That Codify Knowledge and Define Engineering Systems As A Field Of Study.
- Educate Engineering Students To Be Tomorrow's Leaders, Via Innovative Academic and Research Programs. These Leaders Will Plan, Design and Develop Systems That are Technically Excellent, Socially Responsive and Are Implemented On Time and Budget.
- Introduce Engineering Systems Into The Mainstream of Engineering Education, By Working With the MIT Engineering Departments, the Institute As a Whole, and Other Engineering Schools Worldwide.
- Initiate Research on Engineering Systems of National and International Importance, Working in Partnership With Government and Industry.



# Engineering Systems Scope

product

Automobile schematic removed  
due to copyright restrictions.

infrastructure

urban environment

sustainability

society

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# Engineering Systems Characteristics and Perspectives

- Multidimensional Complexity/Emergent Properties
  - Technical Complexity – “Illities” – Quality, Flexibility, Sustainability, Maintainability, Robustness, etc.
  - Organizational Complexity – The Extended Enterprise
  - Contextual Complexity – Societal Perspective, Qualitative As Well As Quantitative Analysis
  - Evaluative Complexity – Multiple Stakeholders, Life Cycle Analysis
- System Architecture is the Starting Point – Holistic, Enterprise Perspective
- Context in the Design Process – Internalize the Externalities
- Uncertainty Management of Design

**Engineering Systems Requires a Different Way of Thinking**



# Engineering System Symposium Conclusions

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- Call To Arms – Confirming the Importance of Engineering Systems
- A Community Is Forming - Big Tent
- Engineering is Broadening – Leadership Opportunities For Engineering Profession In Engineering Systems
- Industry Will Not Lead In Developing Engineering Systems
- Universities Must Respond and Change, Change Will Be Difficult
- MIT Thanked for Engineering System Leadership
- External Acceptance, Internal Challenges At MIT
- System Engineering Is Part of Engineering Systems
- Numerous Intellectual Opportunities – Illities, Enterprise, Uncertainty, Architecture



# The Future of Engineering Systems The Realities

- Engineering Systems Will Continue To Increase in Size, Scope and Complexity
- Engineering Systems Thinking Is Necessary to Address the Realities of the 21st Century - “Messy Complexity”, Unanticipated Events, Globalization, Rapid Rate of Change, Societal Concerns, International Competition, Overcapacity, Rising Consumer Expectations
- Information Technology Advances Enable New Engineering Systems Problem Solving Frameworks



# Engineering Systems and The Engineering Profession

- Developing Engineering Systems Requires Leaders that Understand Technology.
- New Opportunities for Engineers Developing Engineering Systems
- Those Engineering Leaders Need More Than Technical Knowledge – Broader Understanding of Organizations and Context.
- The Challenge for Engineering Schools – Offer Engineering Systems Programs to Educate Future Engineering Leaders
- A Ten Year Mission To Develop Engineering Systems As A Field of Study –The Journey Has Just Begun