MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM DESIGN AND MANAGEMENT PROGRAM

ESD.36J
System and Project Management (SPM)
Syllabus

Units (3-0-9)
Fall 2003

Co-Instructors:
Prof. Olivier de Weck and Dr. James Lyneis

Teaching Assistants:
Christos Sermpetis and Darren Chang

Lectures:
Tuesday and Thursday, 3:00-4:30pm
MIT Room 9-057

Class Schedule (13 Tuesdays, 13 Thursdays)

Tuesday	***Thursday***
	Sept 4 Course Introduction dWo, JL *Project Assignments out*
Sept 9 Network Planning Techniques dWo *HW1 out*	Sept 11 DSM 1: Task-based Models dWo *Project Proposals due*
Sept 16 DSM 2: Iteration Models SE *HW2 out*	Sept 18 Project and Team Organization dWo *HW1 due, Project Approval*
Sept 23 SD1: Introduction to Project System Dynamics JL *HW3 out*	Sept 25 SD2: Feedback Loops and Rework JL *HW2 due*
Sept 30 SD3: Project Dynamics Simulation JL *HW4 out*	Oct 2 SD4: Managing Project Dynamics JL *HW3 due*
Oct 7 SD5: Strategic Issues in Project Planning JL	Oct 9 Product Development Processes dWo *HW4 due*
Oct 14 Integrated Concurrent Engineering Projects dWo *HW5 out*	Oct 16 Case 1: Software Development Projects G *Project Update*
Oct 21 ***Business Trip*** Case 2: Civil Architecture Projects G	Oct 23 ***Business Trip*** Case 3: Aerospace and Naval Projects G
Oct 28 Critical Chain/Path Scheduling dWo/SE	Oct 30 SD6: Risk Management JL *HW6 out*
Nov 4 Resource Consumption and Progress Tracking G *HW5 due*	Nov 6 SD7: Project Change & Adaptation JL
Nov 11 **No Class, Veterans Day**	Nov 13 SD8: Overlapping & Concurrency JL
Nov 18 Project Critical Success Factors dWo	Nov 20 SD9: System Dynamics Summary JL *HW6 due*
Nov 25 **No Class**	Nov 27 **No Class, Thanksgiving**
Dec 2 (3 hr class) Project Presentations dWo	Dec 4 (3 hr class) Project Presentations dWo *Project Assignments due*
Dec 9 Class Summary and Feedback dWo, JL	

Instructors: dWo: Olivier de Weck, JL: Jim Lyneis, SE: Steve Eppinger, G: Guest
(Thick vertical bars indicate module boundaries)

Contact Information:

Prof. Olivier de Weck
Robert N. Noyce Assistant Professor of Aeronautics and Astronautics and Engineering Systems
Room 33-406
Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, Massachusetts, 02139
Phone: (617) 253-0255
E-mail: deweck@mit.edu

Dr. James Lyneis
Professor of the Practice
Atwater Kent 103
Worcester Polytechnic Institute
Worcester, MA 01609
(508) 831-5303
E-mail: JMLyneis@wpi.edu

Prof. Steven Eppinger
Co-Director, LFM/SDM
General Motors LFM Professor of Management Science and Engineering Systems
Massachusetts Institute of Technology
Room E40-439
77 Massachusetts Avenue
Cambridge, Massachusetts, 02139
Phone: (617) 253-0468
E-mail: eppinger@mit.edu

Teaching Assistants :

Class Coordinator, SloanSpace, Cases:
Christos Sermpetis (christos@mit.edu)

Homeworks, Grading and Projects :
Darren Chang (darrenz@mit.edu)

Course Synopsis:

System and Project Management (SPM) is focused on planning and managing product and system development projects. We assume that the enterprise has strategically chosen what product or system to develop, so that the course can focus on the preparation, planning, and execution of product development projects. The course is organized into four main modules. The first module covers traditional and advanced methods and tools of project management such as PERT/CPM, design structure matrices (DSM) and system dynamics (SD). This operational view of project management exposes the capabilities, limitations and complementary nature of SPM methods and tools. The second module builds on the first by considering strategic questions such as preparation and planning, product development process (PDP) selection and concurrent engineering infrastructures. Three case studies, presented by experienced guest speakers, will serve to contrast the challenges of hardware versus software centered development projects. The third module treats project monitoring and change as well as risk management. This includes ways of tracking resource consumption, critical paths and project progress. Corrective actions such as schedule slippage and compression as well as staffing adjustments are simulated by means of system dynamics models. Empirical factors that are known to affect project success and failure will be presented and debated. Finally, student project presentations will round out the course and offer an opportunity to tap into the collective experience and insights of the participants.

Course Learning Objective:

The course is designed for students in the System Design and Management (SDM) program and therefore assumes that you already have a basic knowledge of project management. The objective is to introduce advanced methods and tools of project management in a realistic context such that they can be taken back to the workplace to improve management of development projects. In contrast to traditional courses on the subject we will emphasize scenarios that cannot be fully predicted such as task iterations, unplanned rework, perceived versus actual progress and misalignments between tasks, product architectures and organizations. Each lecture will introduce a subset of these topics (see below).

We plan to include discussion related to your own project management experiences. We hope to accomplish this in several ways:

1. Class discussions will revolve around your experiences in industrial practice.
2. We would like to steer the lecture content and focus on those aspects that interest a majority of the class beyond the standard, planned material. For this purpose the class coordinator will conduct a number of informal polls at several times during the semester.
3. We welcome SDM student contributions to specific aspects of the course where you feel particularly competent or where you wish to share unusual project management experiences with your peers. Such contributions can take the form of short prepared speeches, additional readings or mini-presentations throughout the term. Please contact the course coordinator if you wish to contribute in this manner.
4. The project assignment will allow you to directly apply one of the advanced methods such as DSM or System Dynamics to a development situation at your company. Alternatively, you may want to analyze in-depth the reasons for failure or success of past or ongoing complex product development projects.

Lecture Content:

The main themes of the lectures are given below.

9/4 Project Introduction: Instructor, TA and student introductions, course objectives, course administration, brief history of project management, terms and definitions, course framework

Module 1: Advanced Methods and Tools

9/9 Network Planning Techniques: CPM, PERT, MPM, probabilistic scheduling, critical path identification, focus on parallel and sequential task dependencies

9/11 DSM 1: Task-based Models: Work Breakdown Structures (WBS), introduction to Design Structure Matrices (DSM), sequencing, partitioning and tearing

9/16 DSM 2: Iteration Models: Use of DSM's in a project management context, sequential and parallel iteration models, process analysis and redesign, industrial examples

9/18 Project and Team Organization: Influence, Matrix and dedicated project organizations, alignment of task, product and organizational architectures (DSM overlap), IPTs

9/23 SD1: Project System Dynamics: Introduction to system and project dynamics, causes of project dynamics, key concept: "the rework cycle", notion of feedbacks and knock-on effects

9/25 SD2: Feedback Loops and Rework: SD modeling introduction, "soft" and "hard" tools, causal loop diagrams, cause-effect relationships, stocks and flows, productivity and quality

9/30 SD3: Project Dynamics Simulation: quantitative modeling of project dynamics, model calibration and parameter estimation, simulation execution, industrial examples

10/2 SD4: Managing Project Dynamics: SD simulation application, staff and schedule dynamics, variations on the basic rework cycle, discuss Vensim simulation assignment

Module 2: Strategic Issues in Project Preparation and Planning – Case Studies

10/7 SD5: Strategic Issues in Project Planning: "Strategic" view of project management, project preparation and planning, strategic vs. operational decisions, initiation of dynamics

10/9 Product Development Processes: Classification: phased vs. spiral PDP's, a project management view of the PDP, process selection criteria, milestones, industrial examples

10/14 Integrated Concurrent Engineering: Traditional sequential design versus ICE, computational infrastructures and processes, peer-peer vs. client-server architectures, examples

10/16 Case 1: Software Development Projects: Industrial guest speaker will give examples of past software/IT projects and discuss salient aspects in the context of the class, Q&A session

10/21 Case 2: Civil Architecture Projects: Industrial guest speaker will give examples of past civil infrastructure projects and discuss salient aspects in the context of the class, Q&A session

10/23 Case 3: Aerospace & Naval Projects: Industrial guest speaker will give examples of past aerospace, automotive or naval projects and discuss salient aspects in the context of the class. These projects differ from case 1 and 2 in the sense that both high hardware and software complexity are present, Q&A session

Module 3: Project Execution, Monitoring and Adaptation

10/28 Critical Chain/Path Scheduling: Critical path scheduling, identification and control, project crashing and its consequences, Critical Chain Method, DSM to critical chain linking

10/30 SD6: Risk Management: SD view of risk management, risk identification, risk assessment, risk mitigation, case example: Peace Shield, delay and disruption disputes

11/4 Resource Consumption and Progress Tracking: resource consumption: cost and time, progress monitoring: perceived vs. real, Cost Schedule Status Reporting (CSSR), "earned value"

11/6 SD7: Project Change & Adaptation: Descoping, schedule adjustments, staffing strategies

11/13 SD8: Overlapping & Concurrency: Use of buffers, decoupling task interdependencies, schedule compression strategies, task overlapping framework, SD simulation, cost impact

Module 4: Project Critical Success Factors and Summary

11/18 Project Critical Success Factors: Strategic, tactical and operational factors that have influenced project success and failure in the past, empirical data from Lean Aerospace Initiative

11/20 SD9: System Dynamics Summary: – review and reinforce selected topics from the System Dynamics lectures

12/2 and 12/4 Project Presentations: Formal class presentations by student SPM project teams. Ca. 20 minutes per team, including Q&A session

12/9 Class Summary and Feedback: Review of key concepts in SPM, extension to multi-project environments, discussion of open issues, and quantitative evaluation of class feedback

Administrative Details:

Course Web Site

http://sloanspace.mit.edu

- The class will meet from 3:00 to 4:30pm Tuesdays and Thursdays in 9-057 according to the above schedule. We expect students to either attend on campus or via MIT's video bridge. There is no regularly scheduled recitation.
- As your instructors, we are very anxious to be responsive to your needs. Since many students are off campus, regular office hours may not work well. Based on past experience, e-mail seems to be most effective. Please email the class coordinator first, who will bundle the comments and questions. We can follow up with phone, personal meetings or email as appropriate. We will make every effort to respond within 24 hours. If our schedules require us to be away we will keep you informed and provide alternate contacts.
- Major responsibilities have been partitioned among the instructors and TAs as follows:
    - Overall course responsibility: Olivier de Weck
    - Methods, tools, organizations and ICE: Olivier de Weck
    - System dynamics techniques and strategic issues: Jim Lyneis
    - Design structure matrix methods (DSM): Steven Eppinger (on sabbatical)
    - Aerospace & Naval Case, Resource & Progress monitoring: Patrick Hale
    - Integrating the content: All instructors
    - Bringing your experiences into the discussion: All students
    - SloanSpace, class liaison and attendance, case studies: TA Christos Sermpetis
    - Homeworks, grading and projects : TA Darren Chang
- We will use electronic communications for the class to the maximum extent possible. We plan to use SloanSpace for receiving homework and posting documents for distribution. We will also potentially use software that can be downloaded from the internet.
- Presentation charts for the current lecture will be posted on SloanSpace no later than 9:00am the day of the class.

- Distance learning can be challenging, especially with a large group with many different sites. If you are having difficulty hearing or seeing, please speak up let us know during the class.

Homework Assignments:

There will be a total of six (6) homework assignments throughout the term. The assignments are designed to reinforce some concepts from class and focus on applications of specific methods and tools. Our objective is not to make you an expert user of any particular method (e.g. PERT/CPM, DSM, SD) or particular tool (e.g. Microsoft Office 2000). We are assuming that you will be in a leadership position at your company and that others will carry out the mechanics of maintaining project plans and documents under your supervision. Therefore, it is important that you understand the basic workings of the different methods and tools and grasp their relative advantages and limitations. The homeworks are a pedagogic means of ensuring some uniformity in achieving the learning objectives across the class that would not be guaranteed by the projects alone.

- Homeworks can be solved by pairs of two. These teams can, but don't have to be, remixed for each assignment. It is your decision whether or not to solve homeworks with members of your project team.
- The nominal per person effort for solving a homework problem is nine (9) hours. Please let us know if the homeworks are over-scoped so that we can take corrective measures. We will gather and publish anonymous time-spent statistics for each assignment.
- We do not encourage inter-team cooperation on the homeworks. If you did cooperate, you must explicitly acknowledge and reference other contributions. MIT's standard academic honesty policies and procedures apply: http://web.mit.edu/gso/gpp/index.html
- A master solution will be worked out, posted and discussed for each homework
- The homework topics and due dates are shown in the table below.

HW	Topic	Out	Due
1	Project Network Planning Techniques: PERT, CPM	9/9	9/18
2	Task-based Design Structure Matrix (DSM)	9/16	9/25
3	Design of a Project Organization	9/23	10/2
4	System Dynamics 1: Simulation of the Rework Cycle	9/30	10/9
5	Cases Studies: Comparison of H/W and S/W projects	10/14	11/4
6	System Dynamics 2: Project Adaptation	10/30	11/20

Class Projects Assignment:

The intent of the Class Project Assignment is to allow you to explore one particular aspect of SPM in-depth in the context of your company or a general industrial setting. There is relatively large freedom in the selection of topic, choice of research method and team composition. Some examples of acceptable topics are given below:

- **DSM Project:** Create and analyze a DSM model of a product development project of your choosing. You must identify a project to study, collect the data, conduct the analysis, and suggest ways that the process can be improved based on your findings.

- **SD Project:** Identify the dynamics and drivers of a real or hypothetical project. Build a system dynamics model of the project including causal loop diagrams and governing equations. Quantitatively simulate the evolution of the project and explore "what-if" scenarios. This SD model has to be different from the one used in HW 4 and 6.
- **Survey of Methods and Tools:** Conduct a survey of professed and actually used methods and tools (software) in system project management across a range of organizations. Compare advantages and disadvantages and distill lessons learned.
- **Success and Failure of a Past Project:** Analyze in-depth the preparation, planning and execution of a large-scale past development project. Study historical data and conduct stakeholder interviews. Assess the degree of project success or failure against the original project objectives and identify key factors.

This list is not meant to be comprehensive. We are open to other types of projects, provided that there is a clear link to the class objective and contents.

Project Administration:

- The project is expected to require approximately 60 hours of cumulative work per person over the entire semester.
- The formal project assignment will be handed out during the first class: 9/4
- Two page project proposals are due at the end of the second week: 9/11
- Faculty feedback and approval of the course proposals will occur by: 9/18
- A written (email) progress report is due around mid-term, before the Business Trip: 10/16
- Final project presentations are given during the week of 12/2
- Teams must be formed by the second week and be indicated on the project proposal. The nominal team size is two (2) students. Deviations from this guideline can be approved by the instructors.
- The final project deliverable is the set of annotated viewgraphs used during the final presentation, no written report is required
- This is essentially a two-month assignment (October and November) requiring some project management skills to complete on time.
- Project grades are based on the quality of the proposal, mid-term update, in-class presentation and on the insights presented to the class.

Grading:

The grading will be based on the six homeworks (40%), the project assignment (40%), and the degree of class participation (20%).

Readings:

Required Readings – Packet Available from MIT Copytech

Articles	**Date**
F.K. Levy et al., "The ABCs of Critical Path Method", *Harvard Business Review*, September-October 1963.	Sept. 9
Steven D. Eppinger, Daniel E. Whitney, Robert P. Smith, and David A. Gebala. "A Model-Based Method for Organizing Tasks in Product Development", Research in Engineering Design. vol. 6, no. 1, pp. 1-13, 1994.	Sept. 11
Steven D. Eppinger, Murthy V. Nukala, and Daniel E. Whitney. "Generalised Models of Design Iteration Using Signal Flow Graphs", Research in Engineering Design. vol. 9, no. 2, pp. 112-123, 1997.	Sept. 16
Steven D. Eppinger, "Patterns of Product Development Interactions", Proceedings of ESD Symposium, Cambridge, MA, May, 2002	Sept. 18
John Sterman, "Learning in and About Complex Systems", *System Dynamics Review*, Summer-Fall 1994.	Sept. 23
Soo-Haeng Cho and Steven D. Eppinger. "Product Development Process Modeling using Advanced Simulation", ASME Conference on Design Theory and Methodology, Pittsburgh, PA, September 2001.	Oct. 9
IDEO Product Development case (HBS No.9-600-143).	Oct. 9
Microsoft Office 2000 Case (HBS No.9-600-97).	Oct. 16

Optional Readings – Suggested Texts

Books
Harold Kerzner, *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*, 6th ed., New York: John Wiley & Sons, 1998.
Visualizing Project Management, A Model for Business and Technical Success, Second Edition, Kevin Forsberg, Hal Mooz, and Howard Cotterman, John Wiley & Sons, Inc. 2000.
Highsmith, James, *Adaptive Software Development: a collaborative approach to managing complex systems*, Dorset House Publishing, 1999.
Steve McConnell, *Rapid Development: Taming Wild Software Schedules*, Redmond, WA: Microsoft Press, 1996.
Eliyahu M. Goldratt, *Critical Chain*, Great Barrington, MA: The North River Press, 1997.

Additional readings might be posted as pdf files to SloanSpace as the semester evolves. Student contributions and pointers to relevant references are encouraged and should be routed through the class coordinator (christos@mit.edu).

dWo, August 7, 2003