

Advanced Design Methods I

(3-3-4)

COURSE OUTLINE

I. Textbook and Class Materials

A. Primary Text (PT):

Implementing Six Sigma: Smarter Solutions Using Statistical Methods, Breyfogle, F.W., Wiley & Sons, 1999.

Reading assignments will be provided in class

B. Course Notes (CN):

Numerous handouts will be given out in class or referenced to the web to complement the text materials

II. Professors/Instructors

A. Primary Instructor:

Dr. Dimitri N. Mavris, Room 301A SST Bldg, e-mail: dimitri.mavris@aerospace.gatech.edu, tel. (404) 894-1557

B. Other Instructors:

Dr. Michelle R. Kirby, Room 306A SST Bldg.
email: michelle.kirby@aerospace.gatech.edu, tel. (404) 385-2780

III. Grading

A. Exams

1) Two Exams will be given worth 50% (25% each).

Exam #1: October 28th (Subject to change)

Exam #2: November 25th (Subject to change)

2) Team Project (including presentations and written reports) will be included throughout the course worth 45%. Details regarding the projects and due dates will be given at a later time and will be given in increments.

Application of TIES to a commercial fixed wing vehicle, formal report and presentation

3) Homework assignments worth 5%

IV. Class Topic

1. Traditional development process: performance driven
 - a. Definition of the process and the components
 - b. Why this doesn't work: shortcomings of the traditional approach
 - i. Unforeseen design flaws
 - ii. Historical data reliance doesn't work for new innovative systems
 - iii. Throw it over the wall mentality of engineer's to manufacturing
2. Establishing the need for a paradigm shift in Design:
 - a. Comparison of Toyota and Ford and the number of design changes into the design cycle and the cost to do those changes (supplemental notes)
 - b. Introduction to Taguchi methods and Design for quality (supplemental notes)
 - c. Motorola's Six Sigma Process (Chap 1)
3. Paradigm Shift: quality and affordability driven to make the right decisions early on (supplemental notes)

- i. Phases in the Acquisition process
 - b. Distribution of knowledge between the disciplines as a function of time into design/acquisition process
 - c. Define Affordability: Commercial and Military (in terms of weapon's systems effectiveness) example
 - i. Balancing multiple and conflicting objectives; which requirement is more important
 - ii. Defining important metrics
 - iii. Roadmap to Affordability
 - 1. Physics based design through sizing and synthesis
 - 2. Importance of level of fidelity: how to increase the level of fidelity: direct linking, offline integration, or RSEs
 - 3. Rationale for an integrated Virtual, Stochastic, Life Cycle Design Environment (VSLCDE)
 - 4. Description of needed elements
4. Introduction to the Taguchi Approach and Design of Experiments (Chaps 27,28,29,30,31)
 - a. Taguchi approach:
 - i. Control variables, Noise variables, Signal to noise ratios, Robust design
 - ii. Analysis of Variance: single factor (Chap 24 - p 374-393); two factor (Chap 25 - p 394-401); multiple regressions (Chap 26 - p402-406)
 - b. Screening Test
 - i. Pareto Analysis (supplemental notes)
 - c. Response Surface Methodology (Chap 33 - p493-516)
 - i. Fundamentals for execution:
 - 1. Types of DoE's
 - 2. Correlation and Simple Regression (Chap 23 - p360-p372)
 - a. Residuals, Sum of Squares, R^2 , etc.
 - 3. Resolution of DoEs (p 434)
 - ii. HSCT Example (supplementary notes)

Test #1

- 5. Introduction to Uncertainty and Risk in Design: reiterate the paradigm shift and how uncertainty fits into the paradigm shift and Design for Affordability (Background statistical info in Chap 6, 7, 8 – excluding 8.5,8.6)
 - a. Robust Design Simulation (supplementary notes): include responses as a function of requirements, design, techs, and noise): analogy to early phases of design
 - b. Types of uncertainty
 - c. Fundamentals of uncertainty analysis
 - i. Random or noise variables:
 - ii. Results of probabilistic analysis (PDF and CDF) – review Chap 8 info
 - iii. Process capability (C_p and C_{pk}) (Chap 11 p186-221)
- 6. Approaches for probabilistic design (supplemental notes)
 - a. MC+Analysis tool; Analysis tool+RSM+MC; Analysis tool+FPI
 - b. Sampling methods
- 7. Using probabilistic techniques in Systems Design (supplemental notes)
 - a. Economic uncertainty
 - b. System feasibility through design space exploration
- 8. Infusion of new technologies: Technology Push v. Technology Pull
 - a. Forecasting methods (Normative and exploratory)
 - b. Technology development trends: the S-curve
 - i. Physics driven (rise), programmatic (run)
 - ii. Evolutionary versus revolutionary
 - iii. Disruptive versus continuous

- a. Technology Impact Forecasting (TIF)
- b. Technology TIES
- 10. Decision Making techniques (supplemental notes)
 - a. Subjectivity in decision making
 - b. Qualitative techniques: Pugh matrix
 - c. Quantitative techniques: MCDM: MODM, MADM; AHP, GA, MDO, Pareto Optimality, JPDM
- 11. Requirement Space Exploration
 - a. Unified tradeoff environment
- 12. Capturing/Matching Stochastic Requirements
 - a. Game theory
 - b. Real options

Test #2

V. Miscellaneous

Text readings and homework will be given in class
 Tutorial labs on tools and programs will be announced in class

VI. Suggested Readings

All papers can be found at <http://www.asdl.gatech.edu/>

1. Kirby, M.R., Mavris, D.N., "A Method for Technology Selection Based on Benefit, Available Schedule and Budget Resources," Presented at the 5th World Aviation Congress and Exposition, San Diego, CA, October 10-12, 2000, SAE 2000-01-5563.
2. McDonald, R. A., Mavris, D. N., "Formulation, Realization, and Demonstration of a Process to Generate Aerodynamic Metamodels for Hypersonic Cruise Vehicle Design," Presented at the 5th World Aviation Congress and Exposition, San Diego, CA, October 10-12, 2000, SAE/AIAA-2000-01-5559.
3. Mavris, D.N., DeLaurentis, D.A., "Methodology for Examining the Simultaneous Impact of Requirements, Vehicle Characteristics, and Technologies on Military Aircraft Design," Presented at the 22nd Congress of the International Council on the Aeronautical Sciences (ICAS), Harrogate, England, August 27-31, 2000. ICAS-2000-1.4.4.
4. Mavris, D.N., Baker, A.P., Schrage, D.P., "Simultaneous Assessment of Requirements and Technologies in Rotorcraft Design," Proceedings of the 56th Annual Forum of the American Helicopter Society, Virginia Beach, VA, May 2-4, 2000.
5. Bandte, O., Mavris, D.N., DeLaurentis, D.A., "Viable Designs Through a Joint Probabilistic Estimation Technique," 1999 AIAA/SAE World Aviation Congress, San Francisco, CA, Oct 19-21, 1999.
6. Mavris, D.N., Baker, A.P., Schrage, D.P., "Technology Infusion and Resource Allocation for a Civil Tiltrotor," Proceedings of the AHS Vertical Lift Aircraft Design Conference, San Francisco, CA, January 19-21, 2000.
7. Kirby, M. R. and D. N. Mavris, "Forecasting Technology Uncertainty in Preliminary Aircraft Design," 4th World Aviation Congress and Exposition, San Francisco, CA, October 19-21, 1999. SAE paper no. 1999-01-5631.
8. Mavris, D.N., DeLaurentis, D.A., Hale, M.A., Tai, J.C., "Elements of an Emerging Virtual Stochastic life Cycle Design Environment," Presented at the 4th World Aviation Congress and Exposition, San Francisco, CA, October 19-21, 1999, SAE/AIAA-1999-01-5638.
9. Mavris, D.N., Kirby, M.R., "Technology Identification, Evaluation, and Selection for Commercial Transport Aircraft," 58th Annual Conference Of Society of Allied Weight Engineers, San Jose, California 24-26 May, 1999.
10. Schrage, D.P., "Technology for Rotorcraft Affordability Through Integrated Product/Process Development (IPRD)," 1999 Alexander A. Nikol'sky Lecture, Proceedings of the 55th National Forum

- Employing a Joint Probabilistic Formulation," 37th Aerospace Sciences Meeting & Exhibit, Reno, NV, January 11-14, 1999. AIAA 99-0183.
12. Kirby, M.R., Mavris, D.N., "Forecasting the Impact of Technology Infusion on Subsonic Transport Affordability," World Aviation Congress and Exposition, Anaheim, CA, September 28-30, 1998. SAE-985576.
 13. Mavris, D.N., Kirby, M.R., Qiu, S., "Technology Impact Forecasting for a High Speed Civil Transport," World Aviation Congress and Exposition, Anaheim, CA, September 28-30, 1998. SAE-985547.
 14. Mavris, D.N., Macsotai, N.I., Roth, B.R., "A Probabilistic Design Methodology for Commercial Aircraft Engine Cycle Selection," Presented at the 3rd World Aviation Congress and Exposition, Anaheim, CA, September 28-30, 1998, SAE-985510.
 15. Tejtel, D., Mavris, D.N., Hale, M.A., "Conceptual Aircraft Design Environment: Case Study Evaluation of Computing Architecture Technologies," 7th AIAA/USAF/NASA/ISSMO Symposium on Multidisciplinary Analysis and Optimization, St. Louis, MO, September 2-4, 1998. AIAA-98-4844.
 16. Roth, B., Mavris, D., and Elliott, D., "A Probabilistic Approach to UCAV Engine Sizing," 34th Joint Propulsion Conference, July 13-15, 1998, Cleveland, OH, AIAA98-3264.
 17. Mavris, D.N., Nottingham, C.R., Bandte, O., "The Impact of Supportability on the Economic Viability of a High Speed Civil Transport," International Society of Parametric Analysts and the Society of Cost Estimating and Analysis, Toronto, Canada, June, 1998.
 18. Mavris, D.N., DeLaurentis, D.A., Bandte, O., Hale, M.A., "A Stochastic Approach to Multi-disciplinary Aircraft Analysis and Design," 36th Aerospace Sciences Meeting & Exhibit, Reno, NV, January 12-15, 1998. AIAA 98-0912.
 19. Mavris, D.N., Bandte, O., "A Probabilistic Approach to Multivariate Constrained Robust Design Simulation," World Aviation Congress and Exposition, Anaheim, CA, October, 1997. AIAA-975508.
 20. Mavris, D.N., Bandte, O., "Comparison of Two Probabilistic Techniques for the Assessment of Economic Uncertainty," 19th Annual International Society of Parametric Analysts, New Orleans, LA, May, 1997.
 21. Mavris, D.N., Bandte, O., Schrage, D.P., "Application of Probabilistic Methods for the Determination of an Economically Robust HSCT Configuration," 6th AIAA/USAF/NASA/ISSMO Multidisciplinary Analysis and Optimization Conference, Bellevue, WA, September 4-6, 1996. AIAA-96-4090.
 22. Mavris, D.N., Bandte, O., Schrage, D.P., "Effect of Mission Requirements on the Economic Robustness of an HSCT Concept," 18th Annual Conference of the International Society of Parametric Analysts, Cannes, France, June 1996.
 23. Mavris, D.N., DeLaurentis, D.A., "An Integrated Approach to Military Aircraft Selection and Concept Evaluation," 1st AIAA Aircraft Engineering, Technology, and Operations Congress, Los Angeles, CA, September 19-21, 1995. AIAA-95-3921.
 24. Mavris, D.N., Bandte, O., "Economic Uncertainty Assessment Using a Combined Design of Experiments/Monte Carlo Simulation Approach with Application to an HSCT," 17th Annual International Society of Parametric Analysts, San Diego, CA, May, 1995.
 25. Marx, W.J., Mavris, D.N., and Schrage, D. P., "A Hierarchical Aircraft Life Cycle Cost Analysis Model," 1st AIAA Aircraft Engineering, Technology, and Operations Congress, Los Angeles, CA, September 19-21, 1995. AIAA-95-3861.