Active

Project #: E-25-597   Cost share #:   Rev #: 4
Center # : 10/11-6-P5208-0A0   Center shr #:   OCA file #:
                                                               Work type : INST
Contract#: NGT-51102   Mod #: SUPP. 4   Document : GRANT
Prime   #:   Contract entity: GTRC

Subprojects ? : N   CFDA: 43.002
Main project #:   PE #:

Project unit: MECH ENGR   Unit code: 02.010.126
Project director(s):
    MISTREE F   MECH ENGR   (404)894-8412

Sponsor/division names: NASA   / HEADQUARTERS/WASHINGTON, DC
Sponsor/division codes: 105   / 002

Award period: 930701   to   960930 (performance)   961231 (reports)

Sponsor amount   New this change   Total to date
    Contract value   0.00   66,000.00
    Funded   0.00   66,000.00
Cost sharing amount   0.00

Does subcontracting plan apply ?: N

Title: DETERMINING THE TOP-LEVEL SPECIFICATIONS OF AIRCRAFT

                        PROJECT ADMINISTRATION DATA

OCA contact: Anita D. Rowland   894-4820

 Sponsor technical contact   Sponsor issuing office

 JOHN LYNCH, CODE FEH   THERESA CURTIS, GRANT NEGOTIATOR
 (202)358-1531   (202)358-0510

 NASA HEADQUARTERS   SAME
 WASHINGTON, DC 20546

Security class (U,C,S,TS) : U   ONR resident rep. is ACO (Y/N): N
Defense priority rating   :   supplemental sheet
Equipment title vests with: Sponsor   GIT
  "USE OF GRANT FUNDS FOR PURCHASE OF EQUIPMENT IN STRICTLY PROHIBITED"
Administrative comments -
  SUPPLEMENT 4 AWARDS A NCE THROUGH *30 SEP 96.

                                              Closeout Notice Date   20-MAY-1997

Project Number E-25-597   Doch Id   36853

Center Number 10/11-6-P5208-0A0

Project Director MISTREE, FARROKH

Project Unit MECH ENGR

Sponsor NASA/HEADQUARTERS/WASHINGTON, DC

Division Id   3382

Contract Number NGT-51102   Contract Entity GTRC

Prime Contract Number

Title DETERMINING THE TOP-LEVEL SPECIFICATIONS OF AIRCRAFT

Effective Completion Date 30-SEP-1996 (Performance) 31-DEC-1996 (Reports)

Closeout Action:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	Y	
Government Property Inventory and Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

Comments

Distribution Required:

Project Director/Principal Investigator	Y
Research Administrative Network	Y
Accounting	Y
Research Security Department	N
Reports Coordinator	Y
Research Property Team	Y
Supply Services Department	Y
Georgia Tech Research Corporation	Y
Project File	Y

NOTE: Final Patent Questionnaire sent to PDPI

Georgia Tech

13. I am currently applying for faculty positions at some of the top engineering universities across the nation. I seek a position where I can work with teams and foster new ideas in a challenging environment to become a leading expert in the field of design theory and technology. I am interested in paradigm shifts both in education and research and therefore would like to be a catalyst for new ideas and an agent for change.

14. My research will benefit commercial technology and create dual use application in the following areas:

- The design of complex systems such as aircraft requires the coordination and cooperation of many different disciplines, each with their own analysis and synthesis routines. Many times complete cooperation in determining top-level system specifications is not practical, due to organizational barriers or information availability. By using game-theoretical principles to model the interactions among the disciplinary "players", more realistic design processes can be modeled and insights into both the product and the process structure can be made. These insights can be used to re-structure a design process or bridge gaps between disciplines.

- The Foraging-directed Adaptive Linear Programming (FALP) Algorithm has been shown to provide the same, and many times better solutions to mixed discrete/continuous design problems which have been solved by various methods previously. Being able to handle discrete and integer variables as well as continuous ones allows for more realistic modeling of a system, as many complex systems are composed of both discrete and continuous variables. The FALP Algorithm has become part of the commercial decision support software, DSIDES.

- These methods of system modeling, approximation, and solution will increase the efficiency and effectiveness of designers and design teams by reducing the computational time throughout a design process and providing more useful information concerning system behavior to support decision making to design better systems.

- Identifying fundamental linguistic statements in complex systems design which facilitate communication among designers concerning system configuration, the corresponding system model, and the solution process.

- In complex systems design, subsystem analysis and system synthesis is much more than a simple reversible process of decomposition and recomposition. My work will benefit dual use application by addressing the intelligent recomposition and coordination of systems such as aircraft, ships, and various other complex systems.

15. I am finishing my dissertation with a 4.0 GPA and plan on graduating this summer. This is right on track with my original research plan. Along the way, I have accomplished many exciting things. I was awarded a NSF graduate fellowship which I

declined in favor of the NASA Fellowship. I felt like my area of expertise and application would benefit commercial technology and fundamental research issues more effectively under the NASA Fellowship. This assumption was right on target. I completed by Masters in Winter 1994. For my work at the Masters level, along with maintaining a 4.0 GPA I was awarded the outstanding Masters student in Mechanical Engineering, Winter 1994. I was awarded a Woodruff Teaching Fellowship in Fall 95 where I lectured in half of the classes for a junior design course – "Creative Decisions and Design". This fellowship allowed me to learn how to teach. I was able to interact with the students in various forms including preparation and grading of design reports and exams.
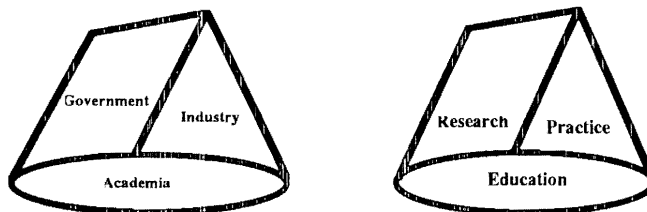
Apart from the research work, I have gained some invaluable knowledge into some of the present challengers in the education and research infrastructures of this nation. To help convey some of these thoughts, I introduce the following problem:

> *Construct a solid object that will fit snugly through a block with a circular hole, a square hole, and a triangular hole.*

This problem represents challenges typical of the following difficult issues:
- The integration of education, research, and practice in academia
- The integration and overlap of academia, industry, and government
- Difficult research issues in engineering design problems requiring this type of reasoning and processing.

Solving this problem involves information from different sources, seemingly conflicting requirements, and concurrent solution principles. I am interested in creating opportunities to learn about and solve these types of problems in the classroom, laboratory, and on the production floor. The solution to this problem illustrates the type of professional I strive to be: able to analyze *and* synthesize, decompose *and* recompose, teach *and* learn within one integrated philosophy for creating and fostering opportunities to learn.

16.

Awards:
NASA Graduate Fellowship 1993-6
NSF Graduate Fellowship 1993
Presidential Fellowship 1993-6
Woodruff Teaching Fellowship (1996)
Who's Who in American Graduate Students (93-95)
Outstanding Masters Student, Mechanical Engineering, Winter 1994

Publications:

Books

K. Lewis, F. Mistree, and J.R.J. Rao, "Optimization in Multidisciplinary Design," in CRC Handbook of Mechanical Engineering, under review/in press, 1996.

Refereed Journal Publications

K. Lewis and F. Mistree, "MDO: More than just Aircraft Design," Journal of Aircraft, under review, 1996.

Conference Proceedings (reviewed)

K. Lewis and F. Mistree, "Foraging-Directed Adaptive Linear Programming: An Algorithm for Solving Nonlinear Mixed Discrete/Continuous Design Problems", ASME Design Engineering Technical Conferences, under review, Irvine, CA, Sept. 1996.

Conference Proceedings (unreviewed)

K. Lewis, T. Lucas, and F. Mistree, "A Decision-Based Approach For Developing Ranged Top-Level Aircraft Specifications: A Conceptual Exposition," in *5th AIAA/USAF/NASA/ISSMO Symposium on Multidisciplinary Analysis and Optimization*, Panama City, Florida, September, 1994, pp. 465-481.

F. Mistree, K. Lewis, and L. Stonis, "Selection in the Design of Aircraft," in *5th AIAA/USAF/NASA/ISSMO Symposium on Multidisciplinary Analysis and Optimization*, Panama City, Florida, September, 1994, pp. 1153-1166.

K. Lewis and F. Mistree, "Designing Top-Level Aircraft Specifications: A Decision-Based Approach to a Multiobjective, Highly Constrained Problem," in 36th *Structures, Structural Dynamics and Materials Conference*, New Orleans, Louisiana, April 10-12, 1995, AIAA-95-1431.

K. Lewis and F. Mistree, " On Developing a Taxonomy for Multidisciplinary Design Optimization: A Decision-Based Perspective," in *First World Congress of Structural and Multidisciplinary Optimization*, Goslar, Germany, May 28-June 2, 1995, Paper No. 118.

Theses

K. Lewis, *The Adaptive Linear Programming Algorithm: Facilitating Robust Design*, Masters Thesis, George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, February, 1994.

17. Organization and Affiliations
Student Member, American Society of Mechanical Engineers
Student Member, American Institute of Aeronautics and Astronautics
Member, International Society for Structural and Multidisciplinary Optimization
Member, Pi Tau Sigma, Mechanical Engineering Honors Society

18. I think this program is invaluable to pushing the envelope of commercial technology advancement and pure fundamental research. I feel that it is nothing but a win-win situation between NASA and the institutions. I have been exposed to nothing but excellent people, ideas, and opportunities throughout the program. I will always be a proponent of this program and the kind of experiences and knowledge it facilitates and stimulates.

FELLOWS RESEARCH PROGRAM SUMMARY

For effective and efficient design of complex systems, an algorithm is being developed to handle the process-independent decomposition, analysis, solution, and synthesis of the system, including resolution of mixed discrete/continuous problems. The general uses of this algorithm along with some issues in each area are:
- provide decomposition and coordination procedures based on game theory protocols, depending on the amount of cooperation and information in a design process for a multidisciplinary, complex system
  issues:
  -cooperation and coordination
  -model allocation
  -information transfer according to couplings and level of uncertainty
- provide a robust solution algorithm for the resolution of mixed discrete/continuous problems at the system and subsystem levels
  issues:
  -convex transformations
  -calculus and heuristic solution techniques
- provide a foundation and lexicon for formulating and designing complex systems design problems using multidisciplinary design optimization and based on our decision-based design approach, namely the Decision Support Problem Technique.
  issues:
  -time and technology independent
  -domain independence
  -decision support, both of product and process

FELLOWS ACCOMPLISHMENTS JANUARY 1995 TO DECEMBER 1995

1   Finishing his PhD Dissertation, entitled *An Algorithm for Concurrent Subsystem Embodiment and System Synthesis*

2   Publications based on Ph.D. work.

Books

K. Lewis, F. Mistree, and J.R.J. Rao, "Optimization in Multidisciplinary Design," in CRC Handbook of Mechanical Engineering, under review/in press, 1996.

Refereed Journal Publications

K. Lewis and F. Mistree, "MDO: More than just Aircraft Design," Journal of Aircraft, 1996, under review.

Conference Proceedings (reviewed)

K. Lewis and F. Mistree, "Foraging-Directed Adaptive Linear Programming: An Algorithm for Solving Nonlinear Mixed Discrete/Continuous Design Problems", ASME Design Engineering Technical Conferences, Irvine, CA, Sept. 1996, under review.

<u>Conference Proceedings.</u>

K. Lewis and F. Mistree, "Designing Top-Level Aircraft Specifications: A Decision-Based Approach to a Multiobjective, Highly Constrained Problem," in 36th *Structures, Structural Dynamics and Materials Conference*, New Orleans, Louisiana, April 10-12, 1995, AIAA-95-1431.

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3 Recognition
    Awarded Woodruff Teaching Fellowship, Fall 1995.

FELLOWS RESEARCH PROGRAM
    Comment: The research program is on track and he is scheduled to gradute in Summer 1996.

COMMERCIALIZATION POTENTIAL
    1 The Fellow's work is being integrated with the work being undertaken under a separately funded MDO initiative (New Approaches to HSCT Multidisciplinary Design and Optimization, NASA NGT-51102).
    2 The potential for commercialization of the outcomes from NASA NGT-51102 is extremely high. Part of his work is already integrated into the software package DSIDES, Decision Support in the Design of Engineering Systems. The DSIDES package is owned by Farrokh Mistree. The augmentation to DSIDES by Kemper is available to NASA as part of this grant.
    3 Kemper's work can be used in *any* situation in which rigorous domain-dependent analysis tools already exist. If such tools exist Kemper's work will facilitate how that organization can do more with less. The key notion here is that Kemper has provided a rigorous basis for keeping the proverbial design freedom *open* in the early stages of system realization.

CLOSING COMMENT
    There is only one word that can be used to describe Kemper Lewis' performance in the past year: OUTSTANDING.