



# **ANNUAL REPORT**

## **Graduate Program in Operations Research**

**July 1, 2008—June 30, 2009**

# **ANNUAL REPORT**

## **Graduate Program in Operations Research**

**July 1, 2008—June 30, 2009**

# Table of Contents

<b>I. Students</b>	
A. Enrollment .....	1
B. Degrees Conferred .....	1
C. Recruiting .....	1
D. Awards and Honors .....	1
E. Ph.D. Qualifying Exam .....	2
F. Student Support .....	2
G. Ph.D. Candidates .....	2
H. Other Activities .....	2
<b>II. Faculty</b>	
A. Co-Directors .....	2
B. Membership .....	2
C. Research and Publications .....	3
D. Faculty Meeting .....	3
<b>III. Administration and Staff</b>	
A. Personnel .....	3
B. Facilities and Equipment .....	3
C. Seminar Series .....	3
D. OR Program Review .....	3
<b>IV. Recommendations and Concerns for the Future</b> .....	3
<b>APPENDIX A</b>	OR Student Enrollment Summary
<b>APPENDIX B</b>	Student Classification
<b>APPENDIX C</b>	Graduate Degrees Awarded
<b>APPENDIX D</b>	Recruiting – Fall 2007
<b>APPENDIX E</b>	Student Honors and Awards
<b>APPENDIX F</b>	2006 Qualifying Exam
<b>APPENDIX G</b>	OR Student Assistantships 2006-2007
<b>APPENDIX H</b>	OR Faculty
<b>APPENDIX I</b>	OR Faculty Meeting Minutes
<b>APPENDIX J</b>	Equipment Acquired
<b>APPENDIX K</b>	OR Seminar Series
<b>APPENDIX L</b>	Program Review Report
<b>APPENDIX M</b>	Preliminary Action Plan

## **I. Students**

### **A. Enrollment**

During Fall 2008 semester fifty-five (55) students were enrolled in the Operations Research Program consisting of thirty-eight (38) Ph.D. students, nine (9) MS and eight (8) MOR students. Of these, seventeen (31%) were new, twenty-two (40%) were female, three (5%) were African American, and eighteen (33%) were US students.

In Spring 2009 five (5) new students were admitted and six (6) students graduated, decreasing the enrollment to fifty-four (54). In Spring 2009 there were forty (40) Ph.D. students, seven (7) MS and seven (7) MOR students.

The enrollment summary is provided in APPENDIX A, and a breakdown of OR students classified by department codes is show in APPENDIX B.

### **B. Degrees Conferred**

The program was very productive during the academic year. It graduated a total of twenty-one (21) students [two (2) Ph.D., twelve (12) MOR, seven (7) MS] in Operations Research (including those who graduate in Summer 2009). The names of the graduating students, the degrees awarded and student advisors are listed in APPENDIX C.

### **C. Recruiting**

The Operations Research Admission Committee consisted of Drs. Denton (ISE), Devetsikiotis (ECE), Li (Math), Fathi (ISE) and Medhin (Math). The program received one hundred nine (109) applications for admission for Fall 2009 (14% increase compared with 2008). From these applicants, seventy-seven (77) students were accepted for admission, and from these, we expect fourteen (14) students will start their program at the beginning of the Fall Semester. A complete breakdown of the list of applicants in various categories is included in APPENDIX D.

### **D. Awards and Honors**

The qualifications and performances of the OR students were well recognized. Six (11%) of the students received scholarships or fellowships during the academic year. The list includes NASA – Harriet G. Jenkins Pre-doctoral Fellowship, University Provost Fellowships, and United States Army and Air Force scholarships.

Zhe Liu won the Elmaghraby Award and ten (10) students were inducted into the Omega Rho International Honor Society. The complete list of honors and awards received by OR students is included in APPENDIX E.

In October 2008 the national organization of INFORMS chose the North Carolina State University Student Chapter of INFORMS to receive the INFORMS Student Chapter Annual Award *Magna Cum Laude*. This is the second highest distinction given to a student chapter and recognizes the outstanding achievements of the OR chapter in 2007. A plaque was presented at the INFORMS conference during Fall 2008 and was received by Ayca Erdogan (president of the

NCSU student chapter). This was the second year in a row that NCSU student chapter received this award from INFORMS.

### **E. Ph.D. Qualifying Exam**

The Ph.D. Qualifying Exam was administered during the week of August 11-15, 2008. A total of eleven (11) students registered for the exam. Six students passed unconditionally, two with conditions and three failed. The names of the students who took the exam and the examining committee are provided in APPENDIX F.

### **F. Student Support**

During the 2008-2009 academic year, thirty-four (34) students were supported (21 on teaching assistantships and 13 on research assistantships). The details of the TA/RA assignment are given in APPENDIX G. The OR program would like to recognize the following departments for their support: Civil Engineering, Computer Science, Electrical & Computer Engineering, Industrial and Systems Engineering, Mathematics, Statistics, and Zoology.

### **G. Ph.D. Candidates**

During this academic year the following students passed their preliminary Ph.D. exams: Ning Liu (January 2009), Zhe Zhang (January 2009) and Zhi Wen (April 2009). Yu-Min Lin and Zhe Liu completed their Ph.D. degrees during the 2008-2009 academic year.

### **H. Other Activities**

The following students served as officers of the Student Chapter of INFORMS: Ayca Erdogan (President), Sharolyn Wynter (Vice-President), Brian Piper (Treasurer) and Emine Yaylali (Secretary).

## **II. Faculty**

### **A. Co-Directors**

Under the organizational structure reflecting the interdisciplinary nature of the Operations Research programs at NC State, Dr. Negash Medhin (Mathematics) and Dr. Yahya Fathi (Industrial and Systems Engineering) continued to serve as co-directors of the Operations Research Program.

### **B. Membership**

The OR faculty consisted of fifty-five (55) faculty members who have their academic appointments in 10 participating departments: Industrial and Systems Engineering (12), Mathematics (13), Computer Science (10), Statistics (4), Civil Engineering (4), Electrical and Computer Engineering (4), Mechanical and Aerospace Engineering (1), Management (3), Forestry (1), and Textiles (3). A listing of OR faculty members and academic departments is included in APPENDIX H.

### **C. Research and Publications**

Not all faculty members participate to the same extent in the OR program; indeed some are only tangentially involved. This makes it difficult to provide accurate statistics on the activities of the OR faculty body. For a complete listing of research and publications of each faculty member please see the corresponding departmental annual report. Also the OR website includes links to all OR faculty personal web pages.

### **D. Faculty Meetings**

One faculty meeting was held in Spring 2009 semester. The minutes of this meeting is appended to this report as APPENDIX I.

## **III. Administration and Staff**

### **A. Personnel**

Ms. Barbara Walls continued as OR Program Assistant.

### **B. Facilities and Equipment**

Eleven computers were purchased to update student computer labs in Daniels and in Burlington. Two computers were purchased for the OR offices (one unit for the co-director's office and the second unit for the program assistant's office). Detailed items are listed in APPENDIX J.

### **C. Seminar Series**

Seven speakers were invited to give talks to OR students in Fall 2008 and eight speakers were invited in Spring 2009. All seminars were well attended. A detailed listing of seminars is given in APPENDIX K.

### **D. OR Program Review**

Following the external review of the program conducted during the previous academic year, the review committee submitted its report in June 2008. The program faculty and administration formulated its response to the report during the academic year 2008-2009 and a preliminary action plan was prepared. This plan was presented to the Provost during a meeting held on April 27, 2009 and it was approved. Appendix L contains a copy of the Review Report and Appendix M contains a copy of the action plan.

**APPENDIX A**  
**OR Student Enrollment Summary**

<b>Enrollment</b>	<b>Fall 2008</b>	<b>Spring 2009</b>
-------------------	------------------	--------------------

Total	55	54
Continued	38	49
New	17	5

Male	33	32
Female	22	22

PhD	38	40
MS	9	7
MOR	8	7

NC/Resident	11	9
USA	7	8
International	37	37

## APPENDIX B Students

<u>Name</u>	<u>Degree</u>	<u>Code</u>
Abdelijawad, Karmel F.	MOR	OR
Aghdashi, Behzad	DR	ORI
Allen, Shanae	MS	ORM
Asgharzadeh Talebi, Zohreh	DR	ORC
Atkinson, Jeannette	MS	ORM
Azizzadeh, Shahrzad	DR	ORI
Bhaid, Pallavi	MOR	ORM
Bjerkaas, James	MS	OR
Carter, Matthew	MOR	ORM
Deshpande, Amogh	DR	ORI
Ding, Chian-Fen	DR	ORM
Erdogan, Saadet Ayca	DR	ORI
Finley, Edward	DR	OR
Frank, Dennis	DR	OR
Hong, Tao	MS	ORI
Horne, Jason	DR	OR
Huang, Rong	DR	OR
Kim, So Yeon	DR	ORM
Koehler, Erin	MS	ORM
Kramer, Jeremy	MS	ORM
Li, Yue	DR	ORM
Lin, Frank (Yu-Min)	DR	ORI
Liu, Ning	DR	ORC
Liu, Ran	DR	ORM
Liu, Zhe	DR	ORI
Mason, Jennifer	MS	ORM
Mears, Curtis	MS	OR
Morgan, Clay	DR	OR
Nanavati, Krunal	MOR	OR
Norouzi, Amirhosein	DR	ORI
Osborne, Susan	DR	OR
Pandit, Omkar	MOR	ORI
Parker, Erica	MOR	OR
Peng, Yuanyuan	DR	ORM
Piper, Brian	MS	ORM

<b><u>Name</u></b>	<b><u>Degree</u></b>	<b><u>Code</u></b>
Rajneesh	DR	ORM
Ramakrishnan, Suja	MOR	ORI
Rubtsov, Alexey	DR	ORM
Sabouri, Alireza	MOR	OR
Sayyady, Fatemeh	DR	ORD
Shih, Cheng-Hau	DR	ORM
Song, Peng	DR	ORS
Tharaldson, Derek	DR	ORI
Underwood, Daniel	MOR	ORM
Viktorovna, Natalia	DR	ORI
Wang, Hui	DR	ORS
Wen, Zhi	DR	OR
Wynter, Sharolyn	DR	OR
Yang, Song	DR	ORS
Yarmand, Hamed	DR	ORI
Yaylali, Emine	DR	ORI
Yin, Shijun	DR	ORM
Yu, Lu	DR	ORI
Zhang, Jingyu	DR	ORM
Zhang, Yuan	DR	OR
Zhang, Zhe	DR	ORC

**APPENDIX C**  
**Graduate Degrees Awarded**

<b>December 2008</b>		
<b>Graduate</b>	<b>Degree</b>	<b>Advisor</b>
Hong, Tao	MS	Dr. S. Hsiang
Lin, Yu-Min	PhD	Dr. Shu-Cherng Fang
Ramakrishnan, Suja	MOR	Dr. Yahya Fathi
Zhang, Jingyu	MOR	Dr. Brian Denton
Pandit, Omkar	MOR	Dr. Yahya Fathi
Frank, Dennis	MOR	Dr. Negash Medhin

<b>May 2009</b>		
<b>Graduate</b>	<b>Degree</b>	<b>Advisor</b>
Allen, Shanae	MS	Dr. Yahya Fathi
Carter, Matthew	MOR	Dr. Negash Medhin
Koehler, Erin	MOR	Dr. Negash Medhin
Mears, Curtis	MS	Dr. Thom Hodgson
Nanavati, Krunal	MOR	Dr. Yahya Fathi
Norouzi, Amir	MOR	Dr. Reha Uzsoy
Parker, Erica	MOR	Dr. Negash Medhin
Sabouri, Alireza	MOR	Dr. Yahya Fathi
Wang, Hui	MOR	Dr. Yahya Fathi
Zhang, Yuan	MOR	Dr. Michael Devetsikiotis

**August 2009**

<b>Graduate</b>	<b>Degree</b>	<b>Advisor</b>
Kramer, Jeremy	MS	Dr. Shu-Cherng Fang
Mason, Jennifer	MS	Dr. Brian Denton
Piper, Brian	MS	Dr. Ranji Ranjithan
Wynter, Sharolyn	MS	Dr. Julie Ivy
Liu, Zhe	PhD	Dr. Yahya Fathi

**APPENDIX D**  
**Recruiting – Fall 2009**

	<b>Applicants</b>	<b>Admitted</b>	<b>Expected to Enroll</b>
Number of Applicants	109	77	14
PhD Students	63	49	6
MS Students	39	23	7
MOR Students	7	5	1
Male	74	47	6
Female	35	30	8
International	80	52	3
US	29	25	11

<b>Admission Committee</b>	
Dr. Brian Denton	Member
Dr. Michael Devetsikiotis	Member
Dr. Zhilin Li	Member
Dr. Yahya Fathi	Co-Chair
Dr. Negash Medhin	Co-Chair

**APPENDIX E**  
**Student Honors and Awards**

<b>Student</b>	<b>Scholarships</b>
Aghdashi, Behzad	University Provost Fellowship
Yin, Shijun	University Provost Fellowship
Wynter, Sharolyn	NASA – Harriet G. Jenkins Pre-doctoral Fellowship
Bjerkaas, James	United States Army
Tharaldson, Derek	United States Air Force
Mears, Curtis	United States Army

<b>Student</b>	<b>Honor Societies &amp; Awards</b>
Erdogan, Saadet Ayca	Omega Rho International Honor Society
Hong, Tao	Omega Rho International Honor Society
Huang, Rong	Omega Rho International Honor Society
Koehler, Erin	Omega Rho International Honor Society
Kramer, Jeremy	Omega Rho International Honor Society
Mason, Jennifer	Omega Rho International Honor Society
Wang, Hui	Omega Rho International Honor Society
Yang, Song	Omega Rho International Honor Society
Yaylali, Emine	Omega Rho International Honor Society
Yu, Lu	Omega Rho International Honor Society
Liu, Zhe	Dr. Elmaghraby Distinguished Student

**APPENDIX F**  
**August 2008 Qualifying Exam**

**Exam Committee:**

Linear Programming, Dr. Shu-Cherng Fang  
Nonlinear Programming, Dr. Kartik Sivaramakrishnan  
Stochastic Processes, Dr. Julie Ivy  
Dynamical Systems, Dr. Ralph Smith  
Dynamic Programming, Dr. Richard Bernhard

**The following students took the 2008 Qualifying Exams:**

Amogh Deshpande  
Jeffrey Everette  
Dennis Frank  
Rong Huang  
Alireza Sabouri  
Fatemeh Sayyady  
Robert Shih  
Natalie Viktorovna  
Hui Wang  
Song Yang  
Emine Yaylali

**APPENDIX G**  
**OR Student Assistantships 2008-2009**

Source	Fall 2008			Spring 2009		
	TA	RA	Total	TA	RA	Total
Civil Engineering	0	1	1	0	1	1
Computer Science	2	2	4	2	2	4
Electrical & Computer Engineering	0	0	0	0	1	1
Industrial & Systems Engineering	3	8	11	3	9	12
Mathematics	10	0	10	9	0	9
Operations Research	5	1	6	5	1	6
Statistics	1	0	1	1	0	1
Zoology	0	1	1	0	1	1
Totals	21	13	34	20	15	35

Type of Support	Fall 2008	Spring 2009
TA and Fellowship	1	2
TA	20	18
RA	13	15
Fellowship only	1	1
Self Supported	16	16
Other	4	2
Totals	55	54

## APPENDIX H

### OR Faculty

<u>Name</u>	<u>Department</u>
John Baugh	Civil Engineering
Richard H. Bernhard	College of Management
E. Downey Brill	Civil Engineering
Robert Buche	Mathematics
Stephen L. Campbell	Mathematics
Rada Chirkova	Computer Science
Brian Denton	Industrial & Systems Engineering
Mike Devetsikiotis	Electrical and Computer Engineering
Salah E. Elmaghraby	Industrial & Systems Engineering
Shu-Cherng Fang	Industrial & Systems Engineering
Yahya Fathi	Industrial & Systems Engineering
Subhashis Ghosal	Statistics
Robert Handfield	College of Management
Robert E. Hartwig	Mathematics
Thom J. Hodgson	Industrial & Systems Engineering
Duncan M. Holthausen	College of Management
Thomas L. Honeycutt	Computer Science
Ilse Ipsen	Mathematics
Kazufumi Ito	Mathematics
Julie Ivy	Industrial & Systems Engineering
Jeffrey Joines	Textiles
Michael G. Kay	Industrial & Systems Engineering
C. T. Kelley	Mathematics
Russell E. King	Industrial & Systems Engineering
Zhilin Li	Mathematics
George List	Civil Engineering
Negash Medhin	Mathematics
Carl D. Meyer	Mathematics
Arne A. Nilsson	Electrical and Computer Engineering
Tao Pang	Mathematics
Harry Perros	Computer Science
S. Ranji Ranjithan	Civil Engineering
Michael Rappa	College of Management
Thomas W. Reiland	Statistics
Stephen Roberts	Industrial & Systems Engineering

<b><u>Name</u></b>	<b><u>Department</u></b>
Joseph P. Roise	Forestry
George N. Rouskas	Computer Science
Carla D. Savage	Computer Science
Munindar P. Singh	Computer Science
Ralph C. Smith	Mathematics
Charles E. Smith	Statistics
Matthias F. Stallman	Computer Science
William J. Stewart	Computer Science
Moon W. Suh	Textiles
Kristin Thoney-Barletta	Textiles
Hien T. Tran	Mathematics
Reha Uzsoy	Industrial & Systems Engineering
Ioannis Viniotis	Electrical and Computer Engineering
Mladen A. Vouk	Computer Science
Wenye Wang	Electrical and Computer Engineering
Don Warsing	College of Management
James R. Wilson	Industrial & Systems Engineering
Fen Wu	Mechanical & Aerospace
Ting Yu	Computer Science
Zhao-Bang Zeng	Statistics
Dmitry Zenkov	Mathematics

### **OR Faculty Emeritus**

Bibhuti Bhattacharyya	Statistics
John W. Bishir	Mathematics
Joseph C. Dunn	Mathematics
Robert E. Funderlic	Computer Science
Clarence J. Maday	Mechanical & Aerospace Engineering
David F. McAllister	Computer Science
Henry L. Nuttle	Industrial & Systems Engineering
Elmor L. Peterson	Mathematics

# APPENDIX I

## OR Faculty Meeting Minutes

**April 21, 2009**

**Attendees:** Dr. Yahya Fathi , Dr. S.C. Fang, Dr. Negash Medhin, Dr. Duncan Holthausen, Dr. Brian Denton, Dr. Julie Ivy, Dr. Moon W. Suh, Dr. Salah Elmaghraby, Dr. Tim Kelley, Ayca Erdogan (Student Representative) and Barbara Walls (OR Program Assistant).

Dr. Fathi opened the meeting.

Faculty meeting minutes from Spring 2008 were reviewed by those in attendance and were accepted.

Dr. Fathi reported on the number of current students and the number of applicants for the next academic year. He reported that in academic year 2008-2009 there are 54 students, 22 of them entering in Fall 2008. Of these 54 there are 31 male and 23 female; 37 PhD and 17 Masters; and 17 US and 37 International. In the Fall semester 2008 the OR Program awarded four MOR, one MS, and one PhD degrees. In Spring 2009 we awarded eight MOR and two MS degrees, and in the upcoming Summer we expect to award three MS and two PhD degrees.

Dr. Fathi also noted that the number of applications for the next academic year is up with 106 applications already processed (compared with 94 total last year), and that 77 students are admitted. The breakdown on the 106 applications is as follows: 63 PhD applicants; 41 MS applicants and 2 MOR. There were 72 male and 34 female applicants; 79 International and 27 US applicants. The admission committee was comprised of Dr. Brian Denton (ISE), Dr. Zhilin Li (Math), Dr. Michael Devetsikiotis (ECE), Dr. Negash Medhin (OR Co-Director) and Dr. Yahya Fathi (OR Co-Director). Dr. Fathi reported that five applicants have accepted our offer of TA positions for next academic year (4 US citizens and 1 international applicant). Dr. Fang asked how the number of TA positions available for next academic year compares with the current academic year. Dr. Fathi responded that due to the recent budget reductions the number of TA positions available to OR (for students in their first 2 years) is reduced from 18 to 13. More specifically, the number of TA positions supported by each participating unit for the next academic year is as follows: COE Dean's Office 3 (reduced from 4 now), PAMS Dean's Office 1 (same as now), Department of Mathematics 4 (reduced from 8 now), Department of ISE 3 (same as now), Department of Statistics 1 (same as now), and Department of CSC 1 (same as now).

It was announced that the PhD qualifying exam will be given during the week of August 10<sup>th</sup> through 15<sup>th</sup> in 2009. The committee will be as follows: Linear Programming – Dr. Fathi; Non-Linear Programming - Dr. Fang; Dynamical Systems – Dr. Ralph Smith; Dynamic Programming – Dr. Elmaghraby; and Stochastic Processes – Dr. Ivy.

Dr. Fathi announced that the process of 10-year Program Review by the Graduate School is in its final stages. The Program was reviewed on April 24 and 25, 2008. The review committee submitted its report in June 2008. After consulting with the OR Faculty, the co-directors prepared the Program Response and submitted it to the Graduate School on December 18, 2009. The Graduate School has now prepared the Preliminary Action Plan, and the Post-Review meeting with the Provost is scheduled for Monday April 27, 2009. After this meeting a Final Action Plan will be prepared by the Graduate School. This report would be available to the OR faculty and it will be posted on the Graduate School website.

Discussion followed regarding the faculty positions in various departments in support of the OR Program. Drs. Elmaghraby, Medhin, and Fang made various remarks regarding this subject and stated

that we need more faculty members in support of the OR Program both for teaching courses and to supervise student research. Dr. Kelley expressed hope that the department of Mathematics would hire a new faculty member in the area of optimization who would support the OR Program. Dr. Fathi mentioned that in view of the recent departure of some faculty members the programs needs urgent support for teaching courses in the area of Linear Programming and Non-Linear Programming.

Ayca Erdogan (INFORMS Student Representative) announced that the INFORMS Student Chapter at NCSU received a Magna Cum Laude award in recognition of outstanding participation and performance during the year of 2007. This is a national award given each year by the professional society INFORMS during their annual fall meeting. Ayca Erdogon represented the NCSU chapter at the national meeting of INFORMS in Washington, DC, in October 2008, and received this award. This was the second consecutive year that the NCSU chapter of INFORMS received this award. Ayca also talked about student chapter activities during the current academic year. The student chapter will have a Spring picnic on April 24<sup>th</sup> at Pullen Park. They also held a welcome back party in the Fall and a bowling party at the end of the Fall semester. Officers for next year will be President – Hui Wang, Vice President - Fatemeh Sayyady, Treasurer – Daniel Underwood, and Secretary – Behzad Aghdashi.

Ayca also reported that the INFORMS chapter is working on a new website to be linked to the OR website and also plans to publish a newsletter this semester. The newsletter will include information on the new OR faculty members and it will feature an interview with Dr. Elmaghraby.

There are ten Omega Rho inductees this year. They will receive certificates at the picnic on April 24<sup>th</sup>.

There will be a graduation lunch to honor OR graduates on April 28<sup>th</sup> at 11:45. Students and faculty will be invited.

There was no new business from the floor and the meeting was adjourned at 4:50 pm.

**APPENDIX J**  
**Equipment Acquired**

**Equipment**

Dell Optiplex 755

Dell Optiplex 755

**Location**

Co-Director's office

Program Assistant Office

## APPENDIX K OR Seminar Series

### Fall 2008

- Aug 26, 2008 Welcome Back/Orientation
- Sep 2, 2008 Navigating the Academic Programs
- Sep 12, 2008 Dr. Denis Cormier and Dr. Michael Kay, ISE, NCSU  
“Getting the Most Out of MS-Word for Manuscript Preparation and Citation Searches”
- Sep 19, 2008 Dr. Min Liu, Dept of Civil, Construction and Environmental Engineering, NCSU  
“Work Flow Variation and Its Relation to Labor Productivity”
- Sep 30, 2008 Dr. Javier Pena, Tapper School of Business, Carnegie Mellon University  
“Algorithms for Computing Nash Equilibria of Large Sequential Games”
- Oct 21, 2008 Dr. Oguzhan Alagoz, University of Wisconsin-Madison  
"Cancer Screening"
- Oct 24, 2008 Ali Tafazzoli, PhD Candidate, NCSU ISE  
"Skart: A Skewness - and Autoregression-Adjusted Batch-Means Procedure for Simulation Analysis”
- Nov 11, 2008 Dr. Nilay Argon, Department of Statistics and Operations Research, University of North Carolina  
“Priority Scheduling of Patients in Mass Casualty Incidents”
- Nov 18, 2008 Dr. Rodney Waschka, Art Studies, NCSU  
"Composing the Gene Pool: Music Made with Genetic Algorithms"

## APPENDIX K OR Seminar Series

### Spring 2009

- Jan 27, 2009 Dr. Amy Cohn, University of Michigan  
"Test-and-Prune: Solving Applied Resource Allocation and Utilization Problems"
- Feb 3, 2009 Dr. Mani Agrawal, Dastur Business & Technology Consulting  
"Operations Research Journey - Post NCSU"
- Feb 24, 2009 Dr. Benjamin Armbruster, Northwestern University  
"Contact Tracing for Chronic Viral Diseases"
- Mar 10, 2009 Zohreh Asgharzadeh Talebi, NCSU OR PhD Candidate  
"Exact and Inexact Methods for Selecting Views and Indexes for OLAP Performance Improvement"
- Mar 17, 2009 Dr. Yu-Min Lin, NCSU OR Alumnus, SAS  
"Tabu Search and Genetic Algorithms for Phylogeny Inference"
- Mar 24, 2009 Dr. Robert White, Department of Mathematics, NCSU  
"Hazards with Impulsive Sources: Identification and Control"
- Mar 31, 2009 Zhe Liu, NCSU OR PhD Candidate  
"The Nearest Point Problem in a Polyhedral Cone and Its Extensions"
- Apr 7, 2009 Dr. Negash Medhin, Department of Mathematics and OR Co-Director, NCSU  
"First and Second Order Conditions for Stochastic Programming Problems"

## **APPENDIX L**

### **Operations Research Review Report**

**Review Report**  
**Graduate Program in Operations Research**  
**North Carolina State University**

**April 24-25, 2008**

**Review Committee Members**

**Dr. J. George Shanthikumar**

Professor of Industrial Engineering and Operations Research  
University of California at Berkeley

**Dr. Duncan Holthausen**

Professor of Economics  
North Carolina State University

**Dr. Michael Carter**

Associate Dean, the Graduate School  
North Carolina State University

On April 24-25, a review of the department was conducted by 1 external and 2 internal reviewers. The reviewers met with administrators from COE and PAMS, the co-directors of the program, faculty, and students. In this report, the reviewers identify strengths of the department, concerns that emerged in the review, and recommendations for improvement.

## Executive Summary

The graduate program in operations research was begun in 1970. It offers two master's degrees (a master of and an MS) and a PhD. Operations Research is a multidisciplinary program that incorporates faculty from most of the colleges at NC State but mainly the College of Engineering (COE) and Physical and Mathematical Sciences (PAMS). Within those two colleges, the primary contributors are the Department of Industrial and Systems Engineering and the Department of Mathematics. Currently, the enrollment is 56, up from about 40 10 years ago and close to the program's peak. About 60% of the students are international, nearly 40% female. Among domestic students, close to 10% are African American.

NC State's OR program is unique in its multidisciplinary, interdepartmental structure. Many other programs in OR have failed or been absorbed into departments. There is also a growing trend for departments that have housed OR programs to eliminate OR from their titles because so many excellent OR faculty reside in other departments. The program at NC State remains healthy largely because it has a structure that allows OR faculty from a wide variety of departments to participate fully in it. But that structure is also its primary challenge. It may be healthy, but it's not living up to its potential. Like nearly all other interdisciplinary programs at NC State, it suffers from problems of funding, unclear administrative status, and lack of control over the faculty it depends on for teaching and research. Its continued health depends on solving these problems.

### **Strengths**

- Excellent students who come with very good training in mathematics and cite the multidisciplinary nature of the program as a primary reason they applied
- A solid core of OR courses that provides students an excellent foundation in the field before they move to the various disciplinary specializations of their research
- A strong and widely diverse faculty across many departments and colleges
- An excellent reputation of faculty nationally

### **Critical Challenges**

- An administrative structure, specifically the co-directorship, with no clear lines of authority and responsibility
- A lack of cohesion among the associated faculty, which is evidenced by a drop-off in active participation among many of the faculty
- A difficulty in attracting domestic students to the doctoral program; in addition to the implications of producing very few domestic PhDs, this situation has the potential of jeopardizing funding for TAs from mathematics, which strongly prefers domestic students as TAs

- The loss of faculty who were hired with an OR emphasis; the early agreements to hire faculty with an OR emphasis seem no longer to have administrative force and thus there is a possibility that OR may lose faculty to teach OR courses

## **Concerns and Recommendations**

### **Administration**

1. Because the OR program is not a department, it has no faculty and little funding of its own. The two colleges most closely associated with OR, COE and PAMS, have both been supportive of the program, providing its operating budget, space, computers, and teaching assistantships. To grow and thrive, however, the program needs to establish an independent administrative identity and source of funding.

**Recommendation:** There are three options or combinations of these options. One is to move to the new structure that has been proposed by the university's Interdisciplinary Task Force. In brief, the program would be able to participate in the compact planning process with the provost as an individual unit. Second is to create a research center for OR and use it to establish an individual identity for the program. Such a center could provide a much-needed focal point for OR, a locus for promoting research collaborations, consulting with industry, and research assistantships for students. Third is for the program to remain as it is, but that option does not offer the opportunity for much growth.

2. The Governing Council, which includes the dean of the Graduate School, the deans of COE and PAMS, and department heads from ISE, mathematics, statistics, and computer science, provides the opportunity for valuable guidance for the program. However, it appears that the Council is underutilized.

**Recommendation:** The program should consider reviving the Council and making it an active part of its administrative structure. The Council should meet regularly, at least once a year. The directors could give a report on the program and seek input on issues that involve all the major players and give them the opportunity to bring up concerns of their own. Having regular meetings could also have the effect of making sure that OR remains a focus of attention by the people on whom the program most depends.

3. The co-directorship appears to make lines of authority and responsibility unclear. There seems to be some confusion as to whom each director answers—to his own department head, to his own dean? How are decisions made?

**Recommendation:** Consider returning to the previous arrangement of having a single director of OR. Perhaps the best solution is for the director to answer ultimately to the Governing Council. An organizational chart should make it quite clear that the director does not answer to department heads. The directorship could rotate between COE and PAMS at defined intervals, such as 4 or 5 years (there could be a 1-year overlapping semester or year for the new director to learn the job). In addition, the director could have an advisory committee made up of core faculty. Even if the present co-directorship is continued, it is essential to clarify the organizational chart and job descriptions spelling out the responsibilities of each director.

4. There are over 60 faculty from nearly every college associated with the OR program. Only 24 of those faculty members have served on master's or doctoral committees in the past 10 years. Clearly, not all the associated faculty are active. This was very apparent when only five faculty attended the two review sessions set aside for meetings with the program's graduate faculty. There is a lack of cohesiveness among the faculty due not only to the size and divergent levels of participation but also due to the wide variation in the dedication of faculty to teaching and research in OR. It is important that the faculty become smaller and more cohesive and thus encourage greater participation.

**Recommendation:** The review team suggests that OR take 2 steps. One is to encourage faculty who are no longer participating in OR to be delisted or to go on inactive status (for those who may want to participate in the future). The program by-laws could be revised so that at a defined interval, such as every 5 years, the director should send an email to all OR associated faculty giving them the opportunity to have themselves moved to inactive status or removed from the list altogether. All those who would like to remain on active status must make that request. It would be assumed that those who do not respond after 2 notifications would be removed from the list, at the discretion of the director. Inactive faculty who would like to return to active status may simply inform the director. The second step is to return to something like the earlier core faculty. The health of the program depends on having a set of faculty whose research and teaching interests define them as more central to the mission of the program than other affiliated faculty. These would include faculty whose SMEs would include research and teaching goals in OR. Thus, they would be evaluated in part according to their participation in the OR program. For decisions of promotion and tenure, the director of the program would be asked to write a letter to be included in the candidate's file.

## Students

1. Enrollment in the OR program has grown steadily over the last ten years from about 40 to 56 students. It is now at the limit of what it can manage with current resources. The goal of the university to grow its graduate enrollment, especially at the doctoral level, is shared by the program. But it will need more resources and new degree offerings in order to meet that goal.

**Recommendation:** The two factors limiting growth at the doctoral level are the number and levels of stipends and the number of research opportunities available to students working on dissertations. Both need to be increased for the program to grow. The key sources of stipends are the Department of Mathematics, Department of Industrial and Systems Engineering, and COE. To increase research positions, the directors of the program should market the program to likely faculty sponsors, educating them about the quality of students and the kinds of research skills they offer.

To grow at the master's level, the program should continue its pursuit of an Accelerated Bachelor's-Master's (ABM) degree. There are 2 approaches. One is to identify the undergraduate departments whose students would be most likely to take an OR degree and negotiate a standing agreement with those departments. The second is to encourage students from other departments to create individual plans of work. Both approaches would require marketing to attract students (see below). In addition to the ABM degree, the OR program should consider creating a professional master's degree. The Graduate

School is supporting such programs. Students in the professional master's degree would combine OR and business courses and do an internship. An attraction for faculty in the program is the opportunity to create relationships with local industries and corporations, which could also become donors to endowment funds. Another important element of the professional master's is an industry advisory board, which could be useful to the broader OR program and to each of the colleges.

The reviewers also encourage OR faculty to continue their work on building dual degree programs, such as the dual Ph.D. with Monterrey Institute of Technology that is currently under discussion.

2. Despite its unique status among OR programs in North America, this OR program is not competitive for the best doctoral students. Those students are offered much better incentives by other universities, primarily fellowships for the first several years and significantly higher stipends.

**Recommendation:** The directors of the program should consider working with the development offices of each of the colleges to seek endowments for fellowships. Offering fellowships to the best doctoral candidates would allow them not to teach in their first two years. The program could exploit industry connections by offering the opportunity for named fellowships. COE and PAMS should find a way to increase the stipends for the best doctoral students. A competitive stipend would be \$22,000 for 11 months.

3. Several students reported that some of the courses listed in the OR curriculum had not been offered in the years that they had been at NC State. This suggests a lack of continuity of topics covered in the program, which itself may be a result of the lack of control of faculty who teach courses. Some students also said that OR seems to be a second priority for many faculty and departments.

**Recommendation:** At a minimum, the program directors should review the course listings to determine which of them have not been taught regularly enough to warrant a place on the list. After discussions with faculty associated with the courses, the directors should consider eliminating those that are deemed unlikely to be taught by existing faculty. Beyond that, the directors should consider restructuring their course listings to ensure regular offerings of all courses. The directors should use the Governing Council to encourage departments to hire faculty to teach key OR courses that cannot be covered with current faculty and to encourage greater support of the OR program in general.

4. Some students said they were confused about the logistical details of the program, such as how to find research advisors and how to find the most appropriate courses among all the offerings. With such a widely dispersed faculty and so many options for courses and research opportunities, students could use more help in negotiating the program.

**Recommendation:** One way of helping students is to provide a serious orientation to the program at the beginning of the fall term, offering students an overview of the program and its procedures. Advanced students could also be there to answer questions. In addition, the students would benefit from a Web handbook with more detail. The faculty section of the Web site should be better organized. Presently, when students are

searching for faculty to serve on research advisory committees, they are faced with a listing of 64 faculty in alphabetical order and must look at each individually to identify faculty in their areas with ongoing appropriate research projects. The list would be much more usable if it were ordered primarily according to areas of specialization and perhaps with identifiers for core faculty.

5. Many of the students questioned the value of the qualifying examination. They complained that because the exams tended to be specific to the interests of the faculty member creating the exam it did not provide the occasion for synthesizing the material they learned in classes. Also, preparing for the exam took time away from other, more productive work, such as their research. In addition, such exams may disadvantage otherwise capable students who do not perform well in exam situations.

**Recommendation:** Faculty in the program should take this review as an opportunity to revisit the qualifying exam. The question is what sort of experience best prepares the student for a profession in operations research? If the answer to that question is a research experience, then it may be better for students who have demonstrated mastery over the course material (such as by getting no grade lower than a B+) to engage in a summer research project after their first year, write a paper on the project, and take an oral examination on it. Another approach is for students to write a full grant proposal and defend it.

## Communication

1. The OR seminar plays a crucial role in the OR program. It is the one academic event that should bring the diverse faculty and students together. Ideally, it would provide the venue for developing interdisciplinary relationships among faculty and the opportunity for students to develop potential research relationships with faculty. It also provides the opportunity for top scholars invited to speak to form productive relationships with faculty and students. From what the reviewers can tell, the seminar is not living up to this ideal. Attendance among faculty is low and many students find that seminars outside their on area of interest are of little use.

**Recommendation:** There are several ways the seminar could be improved. One is to provide more resources to bring in top scholars, which would more likely spark faculty interest. Also, the seminars could have a pre-seminar lecture for students (and faculty) that would provide the scholarly background for the research being presented. Perhaps an article could be distributed beforehand. This would help students to understand the presentation and perhaps to discover relevance to their own work. The directors should find ways of better publicizing each seminar and the seminar series.

2. OR provides extraordinarily powerful methodologies that can be useful in virtually all fields. However, OR is not well understood outside its own domain. There are good opportunities for marketing OR at NC State. Such marketing would be beneficial to OR as it seeks to attract students to its ABM program and perhaps a professional master's degree.

**Recommendation:** The program should consider sponsoring an undergraduate service course, a non-technical introduction to the use of OR methodologies to a diverse field of applications, such as economics, business, health care, education, as well as manufacturing and services. It is important that such a course fit into students'

curriculum, such as in general education, perhaps in the new interdisciplinary category or science, technology, and society.

### **Space and Facilities**

Presently, students occupy offices in Burlington and Daniels. The computer labs are in Burlington along with a rudimentary break room. It is a challenge to maintain a strong sense of belonging to the OR program when students are separated.

**Recommendation:** One way of maintaining cohesion among OR students is to locate them in the same building and to improve their space. Perhaps as space becomes available in Burlington when other engineering programs are moved to Centennial Campus, that space could be provided to OR for more offices, a conference room, and a student and faculty lounge. The lounge should be spacious enough for a get-together once a month or so between faculty and students.

# APPENDIX M

## Preliminary Action Plan Graduate Program in Operations Research Colleges of Engineering and Physical and Mathematical Sciences April 27, 2009

The graduate program in Operations Research was reviewed on April 24-25, 2008. The review committee consisted of Dr. J. George Shanthikumar (University of California at Berkeley), Dr. Duncan Holthausen (internal reviewer), and Dr. Mike Carter (representing the Graduate School). The committee submitted a report that focused primarily on recommendations to guide the improvement of the graduate program. The program faculty responded to those recommendations. The purpose of this preliminary action plan is to present the actions that program faculty have taken or plan to take to implement the recommendations. It consists of two sections, the Resources Needed to Implement Recommendations in prioritized order and Reviewers' Recommendations and Program Actions.

Operations Research is an interdisciplinary program that crosses the Colleges of Engineering and Physical and Mathematical Sciences. It is administered by a Governing Council (GC) consisting of the deans (or designees) of those two colleges, the dean of the Graduate School, and heads of the Departments of Computer Science, Industrial and Systems Engineering, Mathematics, and Statistics. The co-directors of the program submitted their response to the reviewers' recommendations to the members of the GC, which met on October 24, 2008, to consider the response. The members asked for a revision of the response, which was submitted and then addressed by the GC on December 18, 2008. This version of the response was accepted.

The external review and the program response provided the GC the opportunity to consider various issues related to the program. The results of those deliberations are included **in bold font** as actions to be taken by the program. Because these items were approved by the GC and thus carry its administrative weight, they are presented together in Appendix B of this document, "Policies and Actions by OR Governing Council."

### Resources Needed to Implement Recommendations

1. Hiring two faculty members in support of the OR Program.  
**PAMS has committed to hiring a faculty member in mathematics with a half-time appointment in OR (one of the four positions dedicated to OR). No other commitments have been made at this time.**
2. Increase stipend for TAs.  
**PAMS has committed to permanent new stipend funding of \$20,000 with the stipulation that it be given only to doctoral students who provide teaching assistance in PAMS departments and who intend to work with PAMS faculty. PAMS further expects that the OR program will "top-up" the stipend with a provost fellowship when available. The GC suggested other means for increasing stipends:**
  - **Reduce the number of stipends and increase the amount of remaining stipends accordingly**
  - **Use summer school funds**
  - **Place students as RAs after the first year instead of the present practice of placing them after the second year**

**Members of the GC decided that they no longer intend to provide OR with stipends for incoming master's students.**

3. Additional space for student offices, conference room, and a student lounge area. **The space currently occupied in Burlington by biomedical engineering will be vacated soon, probably in a year. The COE will work with the directors of OR to determine how best to use that space.**

### **Reviewers' Recommendations and Program Actions**

#### **Administration**

1. Because the OR program is not a department, it has no faculty and little funding of its own. The two colleges most closely associated with OR, COE and PAMS, have both been supportive of the program, providing its operating budget, space, computers, and teaching assistantships. To grow and thrive, however, the program needs to establish an independent administrative identity and source of funding.

**Recommendation:** There are three options or combinations of these options. One is to move to the new structure that has been proposed by the university's Interdisciplinary Task Force. In brief, the program would be able to participate in the compact planning process with the provost as an individual unit. Second is to create a research center for OR and use it to establish an individual identity for the program. Such a center could provide a much-needed focal point for OR, a locus for promoting research collaborations, consulting with industry, and research assistantships for students. Third is for the program to remain as it is, but that option does not offer the opportunity for much growth.

***Response:** We believe that the current administrative structure fits well with the interdisciplinary nature of the program and its principle sources of support (i.e., College of Engineering and College of Physical and Mathematical Sciences). We also believe that growth is possible within the current structure and that it ultimately depends on allocating additional resources to the program (such as hiring additional faculty, offering additional support for the students, etc.).*

2. The Governing Council, which includes the dean of the Graduate School, the deans of COE and PAMS, and department heads from ISE, mathematics, statistics, and computer science, provides the opportunity for valuable guidance for the program. However, it appears that the Council is underutilized.

**Recommendation:** The program should consider reviving the Council and making it an active part of its administrative structure. The Council should meet regularly, at least once a year. The directors could give a report on the program and seek input on issues that involve all the major players and give them the opportunity to bring up concerns of their own. Having regular meetings could also have the effect of making sure that OR remains a focus of attention by the people on whom the program most depends.

**Action:** After a long hiatus, the members of the GC decided to reinstate its role in the administration of the OR program (see appendix A for OR organizational chart). The members agreed that:

- **The GC will be chaired by the deans of COE and PAMS (or designees) alternating annually.**
- **When considering new resources for the program, no vote will be taken that would obligate any unit to provide these resources. Rather, the members will discuss the need for new resources and come to a consensus as to their origins**

- **Proposals for new OR courses or changes in existing courses initiated by OR must be approved first by the OR Graduate Committee and then sent to the graduate committee(s) of cross-listed departments for approval. If passed by all affected departments, the proposal will be sent to the graduate committees of COE and PAMS. If there are irreconcilable differences at the departmental or college levels, the proposal will be submitted to the GC for resolution. The proposal must be signed by appropriate associate deans of both colleges to be sent to the Administrative Board of the Graduate School.**
  - **Proposals initiated by departments for cross-listing new or existing courses with OR or for changing existing cross-listed courses with OR will follow the same procedure as described above, with the difference that it moves from the departmental graduate committee to that of the OR program.**
  - **When new resources are needed for a new course, the department head who signs the proposal is responsible for funding the course. If there is an issue related to this funding, then it is taken to the dean of that college. If still not resolved, it will be sent to the GC.**
  - **If there are new financial needs for an existing OR course, those needs will be taken directly to the GC.**
  - **The GC will meet once a semester or whenever a critically important issue must be addressed.**
  - **The directors of the program will submit an annual report to the GC including, but not limited to, program statistics, policy changes, new courses approved, progress toward implementing the final action plan, and program budget.**
3. The co-directorship appears to make lines of authority and responsibility unclear. There seems to be some confusion as to whom each director answers—to his own department head, to his own dean? How are decisions made?

**Recommendation:** Consider returning to the previous arrangement of having a single director of OR. Perhaps the best solution is for the director to answer ultimately to the Governing Council. An organizational chart should make it quite clear that the director does not answer to department heads. The directorship could rotate between COE and PAMS at defined intervals, such as 4 or 5 years (there could be a 1-year overlapping semester or year for the new director to learn the job). In addition, the director could have an advisory committee made up of core faculty. Even if the present co-directorship is continued, it is essential to clarify the organizational chart and job descriptions spelling out the responsibilities of each director.

***Response:** We believe the current co-directorship arrangement provides a measure of control to the two colleges COE and PAMS with regard to their respective support and involvement that is essential for the day-to-day operation of the program. Furthermore, this arrangement is supported by the Heads of the four participating departments that form the backbone of the program in terms of its faculty and student support. Therefore we recommend that the current co-directorship arrangement be continued. An organizational chart is attached and discussed in item 2 above. Program assistant(s) provide support to the co-directors with respect to the activities and administration of the program.*

4. There are over 60 faculty from nearly every college associated with the OR program. Only 24 of those faculty members have served on master's or doctoral committees in the past 10 years. Clearly, not all the associated faculty are active. This was very apparent when only five faculty attended the two review sessions set aside for meetings with the program's graduate faculty. There is a lack of cohesiveness among the faculty due not only to the size and divergent levels of participation but also

due to the wide variation in the dedication of faculty to teaching and research in OR. It is important that the faculty become smaller and more cohesive and thus encourage greater participation.

**Recommendation:** The review team suggests that OR take 2 steps. One is to encourage faculty who are no longer participating in OR to be delisted or to go on inactive status (for those who may want to participate in the future). The program by-laws could be revised so that at a defined interval, such as every 5 years, the director should send an email to all OR associated faculty giving them the opportunity to have themselves moved to inactive status or removed from the list altogether. All those who would like to remain on active status must make that request. It would be assumed that those who do not respond after 2 notifications would be removed from the list, at the discretion of the director. Inactive faculty who would like to return to active status may simply inform the director. The second step is to return to something like the earlier core faculty. The health of the program depends on having a set of faculty whose research and teaching interests define them as more central to the mission of the program than other affiliated faculty. These would include faculty whose SMEs would include research and teaching goals in OR. Thus, they would be evaluated in part according to their participation in the OR program. For decisions of promotion and tenure, the director of the program would be asked to write a letter to be included in the candidate's file.

**Response:** *We agree with the reviewer's comments to encourage faculty who are no longer participating in OR to go on inactive status or be delisted. With regard to the second recommendation, it is our understanding that there are certain faculty positions in PAMS and COE which are earmarked in support of the OR Program since its inception. The status of these positions should be clarified.*

**Actions:**

1. *Consistent with the recommendation of the review committee, every five years the co-directors should send an email to all OR faculty giving them the opportunity to have themselves moved to inactive status or removed from the list altogether. All those who would like to remain on active status must make that request. It would be assumed that those who do not respond after 2 notifications would be removed from the list, at the discretion of the director. Inactive faculty who would like to return to active status may simply inform the co-directors. In addition to associated faculty from various departments, the members of the GC confirmed that there are four designated faculty positions with partial appointments in OR, two in PAMS and two in COE. These positions currently reside, one each, in computer science, industrial systems and engineering, mathematics, and statistics. The GC agreed that:*
  - Each of these positions should have a half-time teaching load in OR, with flexibility from semester to semester.
  - These positions would be continuing OR positions within the colleges, that is, when a faculty member vacates the position, the replacement will also be half time in OR.
  - Departments hiring in these positions should be encouraged to include another designated OR faculty member on the search committee.
2. **Instead of a core faculty, the GC instated an OR Graduate Committee (see appendix A for OR organizational chart). Like departmental graduate committees, this one will provide guidance to the co-directors in program policy, admissions, and curriculum. It will also assist in recruiting and vetting new associated faculty.**

**Students**

1. Enrollment in the OR program has grown steadily over the last ten years from about 40 to 56 students. It is now at the limit of what it can manage with current resources. The goal of the

university to grow its graduate enrollment, especially at the doctoral level, is shared by the program. But it will need more resources and new degree offerings in order to meet that goal.

**Recommendation:** The two factors limiting growth at the doctoral level are the number and levels of stipends and the number of research opportunities available to students working on dissertations. Both need to be increased for the program to grow. The key sources of stipends are the Department of Mathematics, Department of Industrial and Systems Engineering, and COE. To increase research positions, the directors of the program should market the program to likely faculty sponsors, educating them about the quality of students and the kinds of research skills they offer.

To grow at the master's level, the program should continue its pursuit of an Accelerated Bachelor's-Master's (ABM) degree. There are 2 approaches. One is to identify the undergraduate departments whose students would be most likely to take an OR degree and negotiate a standing agreement with those departments. The second is to encourage students from other departments to create individual plans of work. Both approaches would require marketing to attract students (see below). In addition to the ABM degree, the OR program should consider creating a professional master's degree. The Graduate School is supporting such programs. Students in the professional master's degree would combine OR and business courses and do an internship. An attraction for faculty in the program is the opportunity to create relationships with local industries and corporations, which could also become donors to endowment funds. Another important element of the professional master's is an industry advisory board, which could be useful to the broader OR program and to each of the colleges.

The reviewers also encourage OR faculty to continue their work on building dual degree programs, such as the dual Ph.D. with Monterrey Institute of Technology that is currently under discussion.

**Response:** *We agree that in order for the program to grow beyond its current number of students (or even to maintain the current level) more resources are needed. In particular, more faculty members need be hired in support of the OR Program. Recently the program lost one of its most active faculty members as he retired (Dr. Elmor L. Peterson). Another active faculty member is currently in the second year of his phased retirement (Dr. Salah E. Elmaghraby) and he will go into full retirement by the end of the next academic year. We recommend that these positions be filled by faculty members with similar and overlapping expertise as soon as possible. We also agree that the level of stipends for doctoral students should be increased in order to make us more competitive with our peer institutions.*

**Actions:**

1. Hire two new faculty members in support of the OR Program.
2. Increase graduate student stipends by the participating departments and by COE in order to be competitive with peer institutions. **PAMS has committed to permanent new stipend funding of \$20,000 with the stipulation that it be given only to doctoral students who provide teaching assistance in PAMS departments and who intend to work with PAMS faculty. PAMS further expects that the OR program will "top-up" the stipend with a provost fellowship when available. The GC suggested other means for increasing stipends:**
  - **Reduce the number of stipends and increase the amount of remaining stipends accordingly**
  - **Use summer school funds**
  - **Place students as RAs after the first year instead of the present practice of placing them after the second year**

3. **Members of the GC decided that they no longer intend to provide OR with stipends for incoming master's students. (See alternatives for attracting self-funded master's students through ABM, professional master's, and DE master's degrees below.)**
  4. *Create new Accelerated Bachelor's-Master's (ABM) degrees with the participating departments as well as for individual students from other departments.*
  5. *Pursue building dual degree programs, such as the dual Ph.D. with Monterrey Institute of Technology that is currently under consideration.*
  6. *Pursue building a co-major program with financial mathematics.*
  7. **The members of the GC advise the program directors to pursue a professional master's degree in OR. They suggest that it be designed with a curriculum of one year or so, perhaps a summer "boot camp," two semesters, and a summer practicum/internship. (The directors should consult with Lis Borbye of the Graduate School.)**
2. Despite its unique status among OR programs in North America, this OR program is not competitive for the best doctoral students. Those students are offered much better incentives by other universities, primarily fellowships for the first several years and significantly higher stipends.
- Recommendation:** The directors of the program should consider working with the development offices of each of the colleges to seek endowments for fellowships. Offering fellowships to the best doctoral candidates would allow them not to teach in their first two years. The program could exploit industry connections by offering the opportunity for named fellowships. COE and PAMS should find a way to increase the stipends for the best doctoral students. A competitive stipend would be \$22,000 for 11 months.

***Response:** we agree that creating endowments for fellowships would be a strong tool for attracting best doctoral students.*

***Action:** Co-directors and the OR faculty should work with their respective colleges, the participating departments within each college, and with their industry connections in order to create fellowship endowments for OR students. The recent 20K stipend from the office of the dean (PAMS), if made permanent, together with Provost fellowship (5K), is a competitive offer.*

3. Several students reported that some of the courses listed in the OR curriculum had not been offered in the years that they had been at NC State. This suggests a lack of continuity of topics covered in the program, which itself may be a result of the lack of control of faculty who teach courses. Some students also said that OR seems to be a second priority for many faculty and departments.
- Recommendation:** At a minimum, the program directors should review the course listings to determine which of them have not been taught regularly enough to warrant a place on the list. After discussions with faculty associated with the courses, the directors should consider eliminating those that are deemed unlikely to be taught by existing faculty. Beyond that, the directors should consider restructuring their course listings to ensure regular offerings of all courses. The directors should use the Governing Council to encourage departments to hire faculty to teach key OR courses that cannot be covered with current faculty and to encourage greater support of the OR program in general.

***Response:** We reviewed the current list of OR courses and we identified three courses that have not been offered at least once over the past three years (OR502, OR527, and OR722). OR502 has not been offered since 1986 (no records are kept for years prior to 1986). The last offering of OR527 and OR722 are in 1995 and 1999, respectively.*

**Action:** *These three courses will be discussed at the next meeting of the OR faculty and proper action will be taken with respect to each course, i.e., either remove the course from the list of OR courses or develop a plan to offer the course in the near future.*

4. Some students said they were confused about the logistical details of the program, such as how to find research advisors and how to find the most appropriate courses among all the offerings. With such a widely dispersed faculty and so many options for courses and research opportunities, students could use more help in negotiating the program.

**Recommendation:** One way of helping students is to provide a serious orientation to the program at the beginning of the fall term, offering students an overview of the program and its procedures. Advanced students could also be there to answer questions. In addition, the students would benefit from a Web handbook with more detail. The faculty section of the Web site should be better organized. Presently, when students are searching for faculty to serve on research advisory committees, they are faced with a listing of 64 faculty in alphabetical order and must look at each individually to identify faculty in their areas with ongoing appropriate research projects. The list would be much more usable if it were ordered primarily according to areas of specialization and perhaps with identifiers for core faculty.

**Response:** *We agree that the program should provide as much assistance as possible to the students with regard to the logistical details of the program.*

**Action:** *It has been a long standing tradition in OR that at the beginning of each semester the co-directors conduct an orientation session for all incoming students. For the fall semester 2008 this session was held on August 26, 2008, and it was well attended by OR students and several faculty members. Pursuant to this recommendation of the review committee, starting with the fall semester 2008 we also offer an additional orientation session with the title of "Navigating the Academic Programs". This session was held on September 2, 2008, and it was well attended. Furthermore, the personal website of every OR faculty member is now linked to his or her name within the OR directory (with the exception of a few faculty members who do not maintain a personal website). With the help of ITECS personnel we are also changing the website for the program in an attempt to make it more user friendly for the students.*

5. Many of the students questioned the value of the qualifying examination. They complained that because the exams tended to be specific to the interests of the faculty member creating the exam it did not provide the occasion for synthesizing the material they learned in classes. Also, preparing for the exam took time away from other, more productive work, such as their research. In addition, such exams may disadvantage otherwise capable students who do not perform well in exam situations.

**Recommendation:** Faculty in the program should take this review as an opportunity to revisit the qualifying exam. The question is what sort of experience best prepares the student for a profession in operations research? If the answer to that question is a research experience, then it may be better for students who have demonstrated mastery over the course material (such as by getting no grade lower than a B+) to engage in a summer research project after their first year, write a paper on the project, and take an oral examination on it. Another approach is for students to write a full grant proposal and defend it.

**Response:** *In view of the fact that the OR Program has a large body of faculty in four colleges, with diverse backgrounds and with varying degrees of involvement in the program, we believe that the OR Qualifying exam plays a vital role in maintaining a standard of quality and focus in our Ph.D. program. We consistently hear from OR faculty in various departments who work with OR Ph.D. students that they feel these students are better prepared for research due to the*

*presence of the qualifying exam. We strongly recommend that we keep this exam in its present form, with minor adjustments as needed.*

***Action:** The subject of qualifying exam and its structure was discussed at the meeting of a subcommittee of OR faculty in August 2008. Members of the subcommittee were unanimously in favor of keeping the exam in its present form, and they suggested a few minor updates to make it compatible with the corresponding recent changes in one of the participating departments.*

## **Communication**

1. The OR seminar plays a crucial role in the OR program. It is the one academic event that should bring the diverse faculty and students together. Ideally, it would provide the venue for developing interdisciplinary relationships among faculty and the opportunity for students to develop potential research relationships with faculty. It also provides the opportunity for top scholars invited to speak to form productive relationships with faculty and students. From what the reviewers can tell, the seminar is not living up to this ideal. Attendance among faculty is low and many students find that seminars outside their own area of interest are of little use.

**Recommendation:** There are several ways the seminar could be improved. One is to provide more resources to bring in top scholars, which would more likely spark faculty interest. Also, the seminars could have a pre-seminar lecture for students (and faculty) that would provide the scholarly background for the research being presented. Perhaps an article could be distributed beforehand. This would help students to understand the presentation and perhaps to discover relevance to their own work. The directors should find ways of better publicizing each seminar and the seminar series.

**Response:** *We agree that attendance in the seminar among the faculty is low. This, in turn, results in a relatively low attendance by the students, in spite of the continuous efforts of the co-directors to reverse the situation. We also agree that we need to make every attempt to increase this attendance. Of course providing more resources to bring top scholars from other universities and research institutions could help, but presently the attendance is relatively low even when we do invite such speakers. Nevertheless, we believe the OR seminar plays a vital role in creating a collegial atmosphere among the students and faculty. It also provides an opportunity for the students to learn about research topics outside of their own field of specialization, and it could result in promoting cross-disciplinary activities. Co-directors should make every attempt to increase faculty and student involvement and attendance.*

2. OR provides extraordinarily powerful methodologies that can be useful in virtually all fields. However, OR is not well understood outside its own domain. There are good opportunities for marketing OR at NC State. Such marketing would be beneficial to OR as it seeks to attract students to its ABM program and perhaps a professional master's degree.

**Recommendation:** The program should consider sponsoring an undergraduate service course, a non-technical introduction to the use of OR methodologies to a diverse field of applications, such as economics, business, health care, education, as well as manufacturing and services. It is important that such a course fit into students' curriculum, such as in general education, perhaps in the new interdisciplinary category or science, technology, and society.

**Response:** *We agree. In fact we believe we can target a larger audience by offering such a course via Distance Education as well. We presently have an introductory course in Operations Research (OR501) that can serve this purpose. An additional course can be created if proper resources are available.*

**Action:** In the fall semester 2008 the course OR501 was offered via Distance Education and it presently has 7 students registered. Co-directors should contact various departments to develop ABM programs as well as to make appropriate arrangements so that OR501 becomes available to undergraduate students in those departments and count towards their respective degree requirements. Co-directors should also start a conversation with the participating departments to assess the feasibility of introducing an additional OR course at undergraduate level. **The GC has asked the directors to investigate the possibility of creating a master's of operations research degree by distance education. They should work with departments to find a way to schedule the core OR courses with sufficient frequency to be able to offer the DE degree.**

### **Space and Facilities**

Presently, students occupy offices in Burlington and Daniels. The computer labs are in Burlington along with a rudimentary break room. It is a challenge to maintain a strong sense of belonging to the OR program when students are separated.

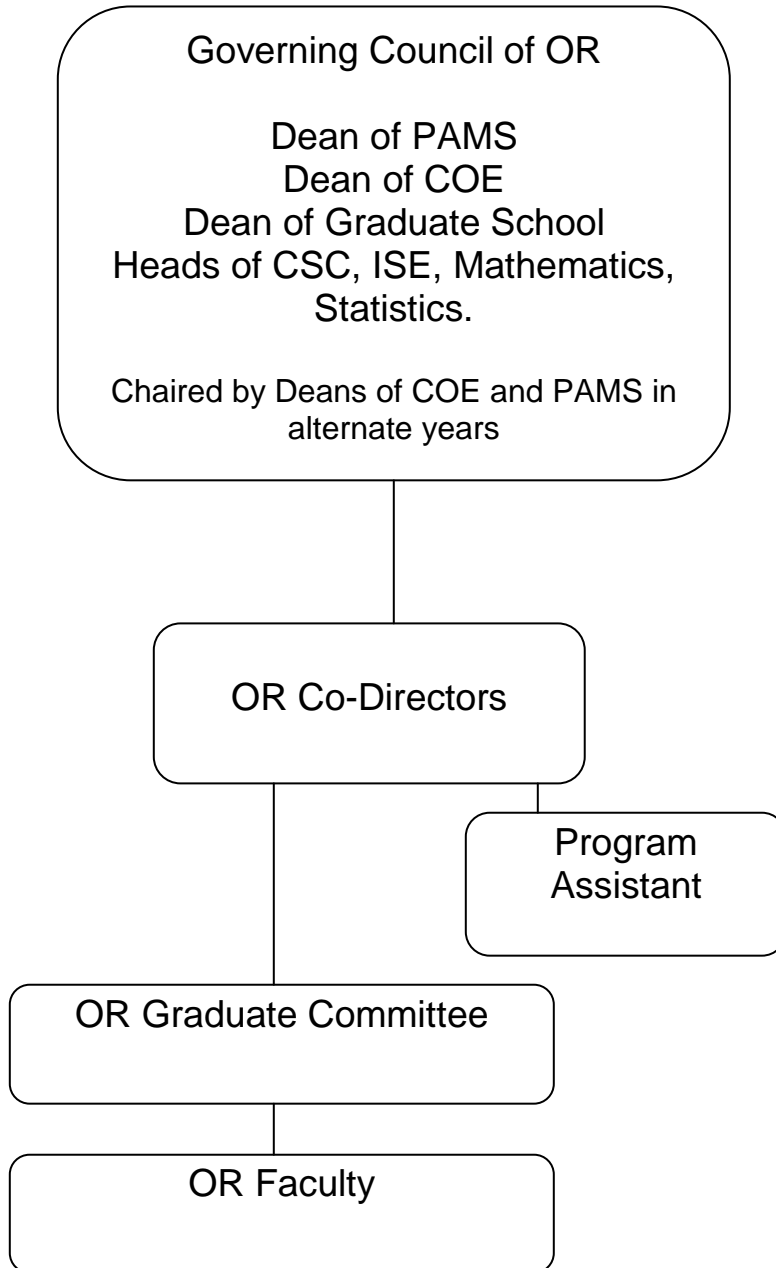
**Recommendation:** One way of maintaining cohesion among OR students is to locate them in the same building and to improve their space. Perhaps as space becomes available in Burlington when other engineering programs are moved to Centennial Campus, that space could be provided to OR for more offices, a conference room, and a student and faculty lounge. The lounge should be spacious enough for a get-together once a month or so between faculty and students.

**Response:** We agree. Locating all students and other OR offices in the same building would be a great help in maintaining cohesion and a sense of belonging among OR students and faculty. Additional space to provide more student offices, a conference room, and a student lounge area would also be greatly beneficial.

**Action:** Plans be drawn to co-locate all OR offices and provide additional space for a conference room and a student lounge. **The space currently occupied in Burlington by biomedical engineering will be vacated soon, probably in a year. The COE will work with the directors of OR to determine how best to use that space.**

**Resources:** Additional space as needed.

**Appendix A**  
**Organizational Chart of Operations Research**



## **Appendix B**

### **Policies and Actions by OR Governing Council**

At its meetings on October 24 and December 18, 2008, the Governing Council (GC) considered policy and actions related to the administration of the Operations Research program. The members approved the following items:

#### **Policies**

##### 1. Role and operation of GC

The members agreed that:

- The GC will be chaired by the deans of COE and PAMS (or designees) alternating the chair annually.
- When considering new resources for the program, no vote will be taken that would obligate any unit to provide these resources. Rather, the members will discuss the need for new resources and come to a consensus as to their origins
- Proposals for new OR courses or changes in existing courses initiated by OR must be approved first by the OR Graduate Committee and then sent to the graduate committee(s) of cross-listed departments for approval. If passed by all affected departments, the proposal will be sent to the graduate committees of COE and PAMS. If there are irreconcilable differences at the departmental or college levels, the proposal will be submitted to the GC for resolution. The proposal must be signed by appropriate associate deans of both colleges to be sent to the Administrative Board of the Graduate School.
- Proposals initiated by departments for cross-listing new or existing courses with OR or for changing existing cross-listed courses with OR will follow the same procedure as described above, with the difference that it moves from the departmental graduate committee to that of the OR program.
- When new resources are needed for a new course, the department head who signs the proposal is responsible for funding the course. If there is an issue related to this funding, then it is taken to the dean of that college. If still not resolved, it will be sent to the GC.
- If there are new financial needs for an existing OR course, those needs will be taken directly to the GC.
- The GC will meet once a semester or whenever a critically important issue must be addressed.
- The directors of the program will submit an annual report to the GC including, but not limited to, program statistics, policy changes, new courses approved, progress toward implementing the final action plan, and program budget.

##### 2. Graduate Committee

GC instated an OR Graduate Committee (see appendix A for OR organizational chart). Like departmental graduate committees, this one will provide guidance to the co-directors in program policy, admissions, and curriculum. It will also assist in recruiting and vetting new associated faculty.

##### 3. Faculty Positions in OR

The members of the GC confirmed that there are four designated faculty positions with partial appointments in OR, two in PAMS and two in Engineering. These positions currently reside, one each, in computer science, industrial systems and engineering, mathematics, and statistics. The GC agreed that:

- Each of these positions should have a half-time teaching load in OR, with flexibility from semester to semester.
- These positions would be continuing OR positions within the colleges, that is, when a faculty member vacates the position, the replacement will also be half time in OR.

- Departments hiring in these positions should be encouraged to include another designated OR faculty member on the search committee.

4. Assignment of Stipends

Members of the GC decided that they no longer intend to provide OR with stipends for incoming master's students.

**Actions**

5. Increasing Stipends

PAMS has committed to permanent new stipend funding of \$20,000 with the stipulation that it be given only to doctoral students who provide teaching assistance in PAMS departments and who intend to work with PAMS faculty. PAMS further expects that the OR program will "top-up" the stipend with a provost fellowship when available. The GC suggested other means for increasing stipends:

- Reduce the number of stipends and increase the amount of remaining stipends accordingly
- Use summer school funds
- Place students as RAs after the first year instead of the present practice of placing them after the second year

6. Investigating Professional Master's Degree

The members of the GC advise the program directors to pursue a professional master's degree in OR. They suggest that it be designed with a curriculum of one year or so, perhaps a summer "boot camp," two semesters, and a summer practicum/internship.

7. Creating Distance Education Program

The GC has asked the directors to investigate the possibility of creating a master's of operations research degree by distance education. They should work with departments to find a way to schedule the core OR courses with sufficient frequency to be able to offer the DE degree.

7. Hiring Faculty Members

PAMS has committed to hiring a faculty member in mathematics with a half-time appointment in OR (one of the four positions dedicated to OR).

8. Expanding Space for Student Offices, Conference Room, and a Student Lounge

The space currently occupied in Burlington by biomedical engineering will be vacated soon, probably in a year. The COE will work with the directors of OR to determine how best to use that space.