Modeling Forum

Results of the 2000 Mathematical Contest in Modeling and Interdisciplinary Contest in Modeling

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Introduction

COMAP is pleased to announce the results of the 16th annual Mathematical Contest in Modeling (MCM) and the 2nd annual Interdisciplinary Contest in Modeling (ICM). This year 495 teams representing 231 institutions from 9 countries spent the first weekend in February working on applied mathematics and interdisciplinary problems.

The 2000 MCM/ICM began at 12:01 A.M. on Friday, Feb. 4 and officially ended at 5:00 P.M. on Monday, Feb. 7, 2000 (local time). Teams of two or three undergraduates were to research and submit an optimal solution for one of

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three open-ended modeling problems. After a weekend of hard work, typed solution papers were mailed to COMAP. Twelve of the top papers appear in this issue of *The UMAP Journal*.

This year's Problem A was dedicated to the memory of Dr. Robert Machol, former chief scientist of the Federal Aviation Agency. Dr. Machol posed the problem when the FAA was considering adding software to the air traffic control system that would alert controllers to potential problems and thus improve safety and reduce workload. In addition to solving the problem, participants were asked to write a summary that could be presented to the FAA Administrator, Ms. Jane Garvey.

Problem B this year sought to model the assignment of radio channels to a symmetric network of transmitter locations so as to avoid interference. Many groups came to the conclusion that the pure mathematical solution needed some practical applications and included those as well.

This year's ICM Problem C offered information regarding the need to keep the elephant population in a national park in South Africa down to 11,000 while avoiding having to destroy any of the animals. A contraceptive dart has been developed that prevents conception for two years. Participants were to investigate a strategy for how to use the dart successfully. Six specific questions were posed and data were offered about emigration patterns, gender ratios, elephant conception patterns, and new calf survival rates.

Results and winning papers from the first fifteen contests were published in special issues of *Mathematical Modeling* (1985–1987) and *The UMAP Journal* (1985–1999). The 1994 volume of *Tools for Teaching*, commemorating the tenth anniversary of the contest, contains the 20 problems used in the first ten years of the contest and a winning paper for each. Limited quantities of that volume and of the special MCM issues of the *Journal* for the last few years are available from COMAP.

Problem A: Air Traffic Control

Dedicated to the memory of Dr. Robert Machol,
former chief scientist of the Federal Aviation Agency

To improve safety and reduce air traffic controller workload, the Federal Aviation Agency (FAA) is considering adding software to the air traffic control system that would automatically detect potential aircraft flight path conflicts and alert the controller. To that end, an analyst at the FAA has posed the following problems.

- Requirement A: Given two airplanes flying in space, when should the air traffic controller consider the objects to be too close and to require intervention?
- Requirement B: An airspace sector is the section of three-dimensional airspace that one air traffic controller controls. Given any airspace sector, how do we

measure how complex it is from an air traffic workload perspective? To what extent is complexity determined by the number of aircraft simultaneously passing through that sector

- at any one instant?
- during any given interval of time?
- during a particular time of day?

How does the number of potential conflicts arising during those periods affect complexity? Does the presence of additional software tools to automatically predict conflicts and alert the controller reduce or add to this complexity?

In addition to the guidelines for your report, write a summary (no more than two pages) that the FAA analyst can present to Jane Garvey, the FAA Administrator, to defend your conclusions.

Problem B: Radio Channel Assignments

We seek to model the assignment of radio channels to a symmetric network of transmitter locations over a large planar area, so as to avoid interference. One basic approach is to partition the region into regular hexagons in a grid (honeycomb-style), as shown in **Figure 1**, where a transmitter is located at the center of each hexagon.

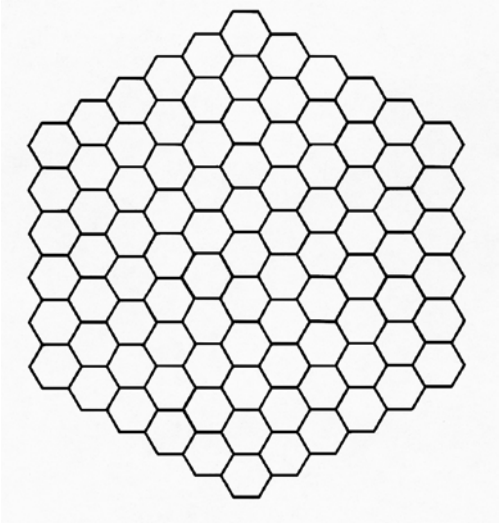

Figure 1. Honeycomb grid of hexagons.

An interval of the frequency spectrum is to be allotted for transmitter frequencies. The interval will be divided into regularly spaced channels, which we represent by integers 1, 2, 3,.... Each transmitter will be assigned one positive

integer channel. The same channel can be used at many locations, provided that interference from nearby transmitters is avoided.

Our goal is to minimize the width of the interval in the frequency spectrum that is needed to assign channels subject to some constraints. This is achieved with the concept of a span. The span is the minimum, over all assignments satisfying the constraints, of the largest channel used at any location. It is not required that every channel smaller than the span be used in an assignment that attains the span.

Let s be the length of a side of one of the hexagons. We concentrate on the case that there are two levels of interference.

- Requirement A: There are several constraints on frequency assignments:
  - No two transmitters within distance $4s$ of each other can be given the same channel.
  - Due to spectral spreading, transmitters within distance $2s$ of each other must not be given the same or adjacent channels: Their channels must differ by at least 2.

  Under these constraints, what can we say about the span in Figure 1?
- Requirement B: Repeat Requirement A, assuming the grid in the example spreads arbitrarily far in all directions.
- Requirement C: Repeat Requirements A and B, except assume now more generally that channels for transmitters within distance $2s$ differ by at least some given integer k, while those at distance at most $4s$ must still differ by at least one. What can we say about the span and about efficient strategies for designing assignments, as a function of k?
- Requirement D: Consider generalizations of the problem, such as several levels of interference or irregular transmitter placements. What other factors may be important to consider?
- Requirement E: Write an article (no more than 2 pages) for the local newspaper explaining your findings.

ICM Problem: Elephants: When is Enough, Enough?

> "Ultimately, if a habitat is undesirably changed by elephants, then their removal should be considered—even by culling."
>
> *National Geographic* (Earth Almanac) (December 1999)

A large national park in South Africa contains approximately 11,000 elephants. Management policy requires a healthy environment that can maintain a stable herd of 11,000 elephants. Each year, park rangers count the elephant population. During the past 20 years whole herds have been removed to keep the population as close to 11,000 as possible. This process involved shooting (for the most part) and occasionally relocating approximately 600 to 800 elephants per year.

Recently, there has been a public outcry against the shooting of these elephants. In addition, it is no longer feasible to relocate even a small population of elephants each year. A contraceptive dart, however, has been developed that can prevent a mature elephant cow from conceiving for a period of two years.

Here is some information about the elephants in the park:

- There is very little emigration or immigration of elephants.
- The gender ratio is very close to 1:1 and control measures have endeavored to maintain parity.
- The gender ratio of newborn calves is also about 1:1. Twins are born about 1.35% of the time.
- Cows first conceive between the ages of 10 and 12 and produce, on average, a calf every 3.5 years until they reach an age of about 60. Gestation is approximately 22 months.
- The contraceptive dart causes an elephant cow to come into oestrus every month (but not conceiving). Elephants usually have courtship only once in 3.5 years, so the monthly cycle can cause additional stress.
- A cow can be darted every year without additional detrimental effects. A mature elephant cow will not be able to conceive for 2 years after the last darting.
- Between 70% and 80% of newborn calves survive to age 1 year. Thereafter, the survival rate is uniform across all ages and is very high (over 95%), until about age 60; it is a good assumption that elephants die before reaching age 70.
- There is no hunting and negligible poaching in the park.

The park management has a rough data file of the approximate ages and gender of the elephants that they have transported out of the region during the past two years. These data are available on the Web: `www.comap.com/icm/icm2000data.xls`. Unfortunately, no data are available for the elephants that were shot or that remain in the park.

Your overall task is to develop and use models to investigate how the contraceptive dart might be used for population control. Specifically:

- Task 1: Develop and use a model to speculate about the likely survival rate for elephants aged 2 to 60. Also speculate about the current age structure of the elephant population.
- Task 2: Estimate how many cows would need to be darted each year to keep the population fixed at approximately 11,000 elephants. Show how the uncertainty in the data at your disposal affects your estimate. Comment on any changes in the age structure of the population and how this might affect tourists. (You may want to look ahead about 30–60 years.)
- Task 3: If it were feasible to relocate between 50 and 300 elephants per year, how would this reduce the number of elephants to be darted? Comment on the trade-off between darting and relocation.
- Task 4: Some opponents of darting argue that if there were a sudden loss of a large number of elephants (due to disease or uncontrolled poaching), even if darting stopped immediately, the ability of the population to grow again would be seriously impeded. Investigate and respond to this concern.
- Task 5: The management in the park is skeptical about modeling. In particular, they argue that a lack of complete data makes a mockery of any attempt to use models to guide their decisions. In addition to your technical report, include a carefully crafted report (3-page maximum) written explicitly for the park management that responds to their concerns and provides advice. Also, suggest ways to increase the park managers' confidence in your model and in your conclusions.
- Task 6: If your model works, other elephant parks in Africa would be interested in using it. Prepare a darting plan for parks of various sizes (300–25,000 elephants), with slightly different survival rates and transportation possibilities.

The Results

The solution papers were coded at COMAP headquarters so that names and affiliations of the authors would be unknown to the judges. Each paper was read preliminarily by two "triage" judges at Southern Connecticut State University (Problem A), Carroll College (Montana) (Problem B), or University of New Hampshire (Problem C). At the triage stage, the summary and overall organization were important. If the judges' scores diverged for a paper, the judges conferred; if they still did not agree, a third judge evaluated the paper.

Final judging took place at Harvey Mudd College, Claremont, California. The judges classified the papers as follows:

The twelve papers that the judges designated as Outstanding appear in this special issue of *The UMAP Journal*, together with commentaries. We list

	Outstanding	Meritorious	Honorable Mention	Successful Participation	Total
Air Traffic Control	4	21	45	84	154
Channel Assignment	5	43	72	151	271
Elephant Population	3	12	18	37	70
	12	76	135	272	495

those teams and the Meritorious teams (and advisors) below; the list of all participating schools, advisors, and results is in the **Appendix**.

Outstanding Teams

Institution and Advisor **Team Members**

Air Traffic Control Papers

"Air Traffic Control"
Duke University
Durham, NC
David P. Kraines

Samuel Westmoreland Malone
Jeffrey Abraham Mermin
Daniel Bertrand Neill

"The Safe Distance Between Airplanes and the Complexity of an Airspace"
Governor's School
Richmond, VA
Crista Hamilton

Finale Doshi
Rebecca Lessem
David Mooney

"The Iron Laws of Air Traffic Control"
U.S. Military Academy
West Point, NY
David Bailey

Kevin Arnett
Jonathan S. Gibbs
John J. Horton

"You Make the Call: Feasibility of Computerized Aircraft Control"
University of Colorado
Boulder, CO
Anne M. Dougherty

Richard D. Younger
Martin B. Linck
William P. Woesner

Channel Assignment Papers

"A Channel Assignment Model:
The Span Without a Face"
California Polytechnic State University
San Luis Obispo, CA
Thomas O'Neil
Jeffrey Mintz
Aaron Newcomer
James Price

"'We're Sorry, You're Outside the Coverage Area'"
Lewis and Clark College
Portland, OR
Robert W. Owens
Robert E. Broadhurst
William J. Shanahan
Michael D. Steffen

"Utilize the Limited Frequency Resources
Efficiently"
National University of Defence Technology
Changsha, Hunan, China
Wu Meng Da
Chu Rui
Xiu Baoxin
Zong Ruidi

"Groovin' with the Big Band(width)"
Wake Forest University
Winston–Salem, NC
Edward Allen
Daniel J. Durand
Jacob M. Kline
Kevin M. Woods

"Radio Channel Assignments"
Washington University
St. Louis, MO
Hiro Mukai
Justin Goodwin
Dan Johnston
Adam Marcus

Elephant Population Papers

"Elephant Population: A Linear Model"
Harvey Mudd College
Claremont, CA
Michael Moody
Nathan Cappallo
Daniel Osborn
Timothy Prescott

"A Computational Solution for Elephant
Overpopulation"
North Carolina School of Science and Mathematics
Durham, NC
Dot Doyle and Dan Teague
Jesse Crossen
Aaron Hertz
Danny Morano

"EigenElephants: When Is Enough, Enough?"
North Carolina School of Science and Mathematics
Durham, NC
Dot Doyle and Dan Teague
David Marks
Jim Sukha
Anand Thakker

Meritorious Teams

Air Traffic Control Papers (21 teams)
Chongqing University, Chongqing, China (Chen Yihua)
Drake University, Des Moines, IA (Alexander F. Kleiner)
East China Univ. of Science & Technology, Shanghai, China (Lu Yuanhong)
First Middle School of Jiading, Shanghai, China (Fang Yunping)
Harvey Mudd College, Claremont, CA (Zachary Dodds)
Lafayette College, Easton, PA (Thomas Hill)
Peking University, Beijing, China (Deng Minghua)
Rose-Hulman Institute of Technology, Terre Haute, IN (Frank Young)
Science School of Xi'an Jiaotong University, Xi'an, Shaanxi, China (He Xiaoliang)
Simpson College, Indianola, IA (M.E. Waggoner)
Stetson University, Deland, FL (Lisa O. Coulter)
Trinity University, San Antonio, TX (Tarynn Witten)
University College Cork, Cork, Ireland (Michael Quinlan)
University of Alaska Fairbanks, Fairbanks, AK (Chris Hartman)
University of Cincinnati, Cincinnati, OH (Charles Groetsch)
Univ. of Colorado at Colorado Springs, Colorado Springs, CO (Jon Epperson)
University of Saskatchewan, Saskatoon, SK, Canada (Raj Srinivasan)
University of Science & Technology of China, Hefei, Anhui, China (Sun Liang)
Worcester Polytechnic Institute, Worcester, MA (Bogdan Vernescu)
Youngstown State University, Youngstown, OH (Steve Hanzely)
Youngstown State University, Youngstown, OH (Thomas Smotter)
Zhejiang University, Hangzhou, Zhejiang, China (Yang Qifan)
Zhejiang University, Hangzhou, Zhejiang, China (He Yong)

Channel Assignment Papers (43 teams)
Anhui University, Hefei, Anhui, China (Chen Junsheng)
Asbury College, Wilmore, KY (Kenneth P. Rietz)
Beijing University of Post & Telecomm, Beijing, Beijing, China (He Zuguo)
Beijing University of Post & Telecomm, Beijing, Beijing, China (Sun Hongxiang)
Calvin College, Grand Rapids, MI (Dorothea Pronk)
China University of Mining & Technology, Xuzhou, Jiangsu, China (Wu Zongxiang)
East China Univ. of Science & Technology, Shanghai, China (Shi Jinsong)
East China Univ. of Science & Technology, Shanghai, China (Xiwen Lu)
Fudan University, Shanghai, China (Cai Zhijie)
Gettysburg College, Gettysburg, PA (James P. Fink)
Grinnell College, Grinnell, IA (Marc Chamberland)
Harbin Institute of Technology, Harbin, Heilongjiang, China (Wang Xuefeng)
Harvey Mudd College, Claremont, CA (Michael Moody)
Institution of Information Science & Engineering, Shenyang, Liaoning, China (Xiao Wendong)
Luther College, Decorah, IA (Reginald D. Laursen)
MIT, Cambridge, MA (Michael Brenner)
Mt. Mercy College, Cedar Rapids, IA (Kent R. Knopp)

National U. of Defence Technology, Chang Sha, Hunan, China (Cheng Lizhi)
Northwestern Polytechnical University, Xi'an, Shaanxi, China (Liu Xiaodong)
Northwestern Polytechnical University, Xi'an, Shaanxi, China (Peng Guohua)
Pacific Lutheran University, Tacoma, WA (Rachid Benkhalti)
Paivola College, Tarttila, Finland (Esa Lappi)
Peking University, Beijing, China (Lei Gongyan)
Rose-Hulman Institute of Technology, Terre Haute, IN (David Rader)
Shanghai Foreign Languages School, Shanghai, China (Wan Baihe)
Shanghai Jiao Tong University, Shanghai, China (Zhou Gang)
South China Univ. of Technology, Guangzhou, Guangdong, China (Fu Hongzhuo)
Southeast University, Nanjing, China (Huang Jun) (two teams)
Trinity University, San Antonio, TX (Allen Holder)
Tsinghua University, Beijing, China (Hu Zhiming)
U.S. Military Academy, West Point, NY (Greg Parnell)
University of Alaska Fairbanks, Fairbanks, AK (Chris Hartman)
Univ. of Michigan—Dearborn, Dearborn, MI (David James)
University of New South Wales, Sydney, Australia, (James Franklin)
University of Richmond, Richmond, VA (Kathy W. Hoke)
University of Toronto, Toronto, Ontario, Canada (Nicholas A. Derzko)
(two teams)
Wuhan Univ. of Hydraulic & Engineering, Wuban, Hubei, China (Peng Zuzeng)
Yale University, New Haven, CT (Steven Orszag)
Zhejiang University, Hangzhou, Zhejiang, China (Yang Qifan)
Zhejiang University, Hangzhou, Zhejiang, China (He Yong)

Elephant Population Papers (12 teams)
Bloomsburg University, Bloomsburg, PA (Kevin Ferland & Scott Inch)
California Academy of Math & Science, Carson, CA (Brian R. Lawler)
China University of Mining & Tech., Xuzhou, Jiangsu, China (Zhou Shengwu)
MIT, Cambridge, MA (Michael P. Brenner & Lakshmirarayanan Muhadevan)
Northwestern Polytechnical University, Xi'an, Shaanxi, China
(Xu Wei & Wang Mingyu)
Peking University, Beijing, Beijing, China (Shao Min & Zhang Tao)
Southeast University, Nanjing, China (Chen Enshui)
U.S. Military Academy, West Point, NY (Michael Jaye & Greg Fleming)
Univ. of Science & Tech. of China, Hefei, Anhui, China (Wan Qian)
Youngstown State University, Youngstown, OH (Scott Martin)
Zhejiang University, Hangzhou, Zhejiang, China
(Cong Zhang, Chu Jaiowu , & He Yong)
Zhejiang University, Hangzhou, Zhejiang, China
(Cong Zhang, Chu Jaiowu, & Yang Qifan)

Awards and Contributions

Each participating MCM advisor and team member received a certificate signed by the Contest Director and the appropriate Head Judge.

INFORMS, the Institute for Operations Research and the Management Sciences, gave a cash award and a three-year membership to each member of the teams from the University of Colorado (Air Traffic Control Problem), Washington University (Channel Assignment Problem), and North Carolina School of Science and Mathematics (the team of Jesse Crossen, Aaron Hertz, and Danny Morano) (Elephant Population Problem). Moreover, INFORMS gave free one-year memberships to all members of Meritorious and Honorable Mention teams.

The Society for Industrial and Applied Mathematics (SIAM) designated as SIAM Winners the teams from U.S. Military Academy, West Point, NY (Air Traffic Control Problem) and Wake Forest University (Channel Assignment Problem). Each of the team members was awarded a $300 cash prize. Their schools were given framed certificates hand-lettered in gold leaf. Both teams presented their results at a special Minisymposium of the SIAM Annual Meeting in Puerto Rico in July.

The Mathematical Association of America (MAA) designated as MAA Winners the teams from the Duke University (Air Traffic Control) and California Polytechnic State University (Channel Assignment Problem). The team from California Polytechnic State University presented their solution at a special session of the MAA Mathfest in Los Angeles in August. Each team member was presented a certificate by MAA President Thomas Banchoff.

Judging

MCM

Director
Frank R. Giordano, COMAP, Lexington, MA

Associate Directors
Robert L. Borrelli, Mathematics Dept., Harvey Mudd College, Claremont, CA
William Fox, Chair, Dept. of Mathematics, Francis Marion University, Florence, SC

Air Traffic Control Problem

Head Judge
Martin Keener, Executive Vice President, Oklahoma State University, Stillwater, OK

Associate Judges
Ron Barnes, University of Houston—Downtown, Houston, TX (MAA)
Patrick Driscoll, Dept. of Mathematical Sciences, U.S. Military Academy, West Point, NY (INFORMS)

David L. Elliott, Institute for Systems Research, University of Maryland, College Park, MD (SIAM)
Gordon Erlebacher, Dept. of Computer Science and Information Technology, Florida State University, Tallahassee, FL
Richard Haberman, Mathematics Dept., Southern Methodist University, Dallas, TX (SIAM)
Mark Levinson, Edmonds, WA (SIAM)
Theresa M. Sandifer, Southern Connecticut State University, New Haven, CT (Triage)

Triage Judges
Head Triage Judge
Theresa M. Sandifer, Southern Connecticut State University, New Haven, CT
Associate Triage Judges
Ross Gingrich, Southern Connecticut State University
Cynthia B. Gubitose, Western Connecticut State University, Danbury, CT
Ronald E. Kutz, Western Connecticut State University, Danbury, CT
C. Edward Sandifer, Western Connecticut State University, Danbury, CT
Jim Wohlever, Western Connecticut State University, Danbury, CT

Channel Assignment Problem

Head Judge
Maynard Thompson, Mathematics Dept., University of Indiana, Bloomington, IN

Associate Judges
Paul Boisen, Defense Dept., Ft. Meade, MD
James Case, Baltimore, Maryland
Lisette de Pillis, Mathematics Dept., Harvey Mudd College, Claremont, CA
Doug Faires, Dept. of Mathematics and Statistics, Youngstown State University, Youngstown, OH
Jerry Griggs, Dept. of Mathematics, University of South Carolina, Columbia, SC (SIAM)
Jeff Hartzler, Dept. of Mathematics, Penn State University, Middletown, PA (MAA)
Mario Juncosa, RAND Corporation, Santa Monica, CA
Deborah Levinson, Dept. of Mathematics, Colorado College, Colorado Springs, CO
Veena Mendiratta, Lucent Technologies, Naperville, IL
Don Miller, Dept. of Mathematics, St. Mary's College, Notre Dame, IN
Mark Parker, Dept. of Mathematical Sciences, U.S. Air Force Academy, CO (SIAM)
John L. Scharf, Carroll College, Helena, MT
Lee Seitelman, Glastonbury, CT
Kathleen M. Shannon, Salisbury State University, Salisbury, MD (MAA)

Jonathan Shapiro, Dept. of Mathematics,
California Polytechnic State University, San Luis Obispo, CA
Robert M. Tardiff, Dept. of Mathematical Sciences,
Salisbury State University, Salisbury, MD
Michael Tortorella, Lucent Technologies, Holmdel, NJ
Marie Vanisko, Carroll College, Helena, MT (Triage)
Martin Wildberger, Electric Power Research Institute, Palo Alto, CA (SIAM)

Triage Judges
(all from Mathematics Dept., Carroll College, Helena, MT)
Head Triage Judge
Marie Vanisko
Associate Triage Judges
Mark Keefe, Terence J. Mullen, Phil Rose, and Jack Oberweiser

ICM

Contest Director
David C. Arney, Dept. of Mathematical Sciences, U.S. Military Academy

Elephant Population Problem

Head Judge
Gary W. Krahn, U.S. Military Academy, West Point, NY

Associate Judges
Kelly Black, Mathematics Dept., University of New Hampshire,
Durham, NH (Triage)
John Boland, Center for Industrial and Applied Mathematics (CIAM),
University of South Australia, Australia
Karen Bolinger, Dept. of Mathematics, Clarion University of Pennsylvania,
Clarion, PA
Ben Fusaro, Mathematics Dept., Florida State University, Tallahassee, FL (MAA)

Triage Judges
(all from Mathematics Dept., University of New Hampshire, Durham, NH)
Head Triage Judge
Kelly Black
Associate Judges
John B. Geddes, Gertrud Kraut, Dave Mecker, Jason Owen, Phil Ramsey, and Kevin Short

Sources of the Problems

Contributors of the problems were as follows:

- **Air Traffic Control Problem:** Robert Rovinsky, Federal Aviation Agency, Washington, DC
- **Channel Assignment Problem:** Jerrold R. Griggs, Dept. of Mathematics, University of South Carolina, Columbia, SC
- **Elephant Population Problem:** Anthony M. Starfield, Dept. of Ecology, Evolution, and Behavior, University of Minnesota, Minneapolis, MN

Acknowledgments

The MCM was funded this year by the National Security Agency, whose support we deeply appreciate. The ICM received major funding from the National Science Foundation. We thank Dr. Gene Berg of NSA for his coordinating efforts. The MCM is also indebted to INFORMS, SIAM, and the MAA, which provided judges and prizes.

I thank the MCM judges and MCM Board members for their valuable and unflagging efforts. Harvey Mudd College, its Mathematics Dept. staff, and Prof. Borrelli were gracious hosts to the judges.

Cautions

To the reader of research journals:

Usually a published paper has been presented to an audience, shown to colleagues, rewritten, checked by referees, revised, and edited by a journal editor. Each of the student papers here is the result of undergraduates working on a problem over a weekend; allowing substantial revision by the authors could give a false impression of accomplishment. So these papers are essentially au naturel. Light editing has taken place: minor errors have been corrected, wording has been altered for clarity or economy, and style has been adjusted to that of *The UMAP Journal*. Please peruse these student efforts in that context.

To the potential MCM Advisor:

It might be overpowering to encounter such output from a weekend of work by a small team of undergraduates, but these solution papers are highly atypical. A team that prepares and participates will have an enriching learning experience, independent of what any other team does.

Appendix: Successful Participants

KEY:

P = Successful Participation
H = Honorable Mention
M = Meritorious
O = Outstanding (published in this special issue)
A = Air Traffic Control Problem
B = Channel Assignment Problem
I = Elephant Population Problem

INSTITUTION	CITY	ADVISOR	A	B	I
ALABAMA					
Huntingdon College	Montgomery	Bob Robertson		P	
ALASKA					
Univ. of Alaska Fairbanks	Fairbanks	Chris Hartman	M	M	
CALIFORNIA					
Calif. Acad. of Math & Sci.	Carson	Brian R. Lawler			M
Calif. Lutheran University	Thousand Oaks	Cindy Wyels		P	
Calif. Poly. State Univ.	San Luis Obispo	Thomas O'Neil		O,H	
Calif. State U.	Bakersfield	Joseph R. Fiedler	P	P	
Calif. State U.	Northridge	Gholam-Ali Zakeri		P	
Calif. State U. Fullerton	Fullerton	Mario Martelli	P		H,P
Calif. State U. Monterey Bay	Seaside	Dan Fernandez and Michael Dalton	C	P	
Harvey Mudd College	Claremont	Michael Moody	H	M	O,P
		Zachary Dodds	M	H	
Humboldt State Univ.	Arcata	Roland Lamberson	P		
Sonoma State University	Rohnert Park	Sunil K. Tiwari	P		
Univ. of Calif. - Berkeley	Berkeley	Rainer K. Sachs	H	P	
COLORADO					
Colorado College	Colorado Springs	Jane McDougall		H	
		Jennifer Courter		H	
Mesa State College	Grand Junction	Bill Tiernan		P,P	
		Edward Bonan-Hamada	H,H		
Regis University	Denver	Linda Duchrow	P	P	
U.S. Air Force Academy	USAF Academy	Dawn Stewart		P,P	
Univ. of Colorado	Colorado Springs	Jon Epperson	M	H	
	Boulder	Anne M. Dougherty	O		
		Anne Dougherty and Bengt Fornberg			H
Univ. of Southern Colorado	Pueblo	James Louisell		P	
CONNECTICUT					
Sacred Heart Univ.	Fairfield	Antonio A. Magliaro	P		
Southern Conn. State Univ.	New Haven	Ross B. Gingrich		P	
		Theresa Bennett		P	

INSTITUTION	CITY	ADVISOR	A	B	I
Univ. of Bridgeport	Bridgeport	Dr. Natalia Romalis	P		
U.S. Coast Guard Academy	New London	John Freda			P
Western Conn. State Univ.	Danbury	C Edward Sandifer	H,P		
Yale University	New Haven	Steven Orszag		M	
DISTRICT OF COLUMBIA					
Georgetown University	Washington	Andrew Vogt	P	P	
FLORIDA					
Florida A&M University	Tallahassee	Bruno Guerrieri		P	
Florida Inst. of Tech.	Melbourne	Gary W. Howell		P	
Jacksonville Univ.	Jacksonville	Robert A. Hollister	H	P	
Stetson University	Deland	Lisa O. Coulter	M,H		
Univ. of North Florida	Jacksonville	Peter A. Braza		P	
GEORGIA					
Agnes Scott College	Decatur	Robert A. Leslie		P	
Georgia Southern Univ.	Statesboro	Eric Funasaki		P	
		Dr. Goran Lesaja	P		
		Gary Huband	H		
State Univ. of West Georgia	Carrollton	Scott Gordon	H		
HAWAII					
Kapi'olani Community	Honolulu	Susan Moore	P		
IDAHO					
Boise State University	Boise	Stephen H. Brill			P
ILLINOIS					
Greenville College	Greenville	Galen R. Peters	P	P	
Northern Illinois University	Dekalb	Hamid Bellout		P	
Wheaton College	Wheaton	Paul Isihara		P,P	
INDIANA					
Goshen College	Goshen	David Housman	P	P	
		David Housman and Patricia Oakley			P
Indiana University	Bloomington	John Brothers		P,P	
Rose-Hulman Inst. of Tech.	Terre Haute	Dr. Frank Young	M		
		Frank Young		P	
		David Rader		M,P	
		Sharon A. Jones and Robert J. Houghtalen			H,P
Saint Mary's College	Notre Dame	Peter D. Smith		H,P	

INSTITUTION	CITY	ADVISOR	A	B	I
IOWA					
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		He Renbin and Zhang Dan			H
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		Tang Ping	P		
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		He Yong	M	M	
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