**The 2016 International Mathematical Modeling Challenge**
**IM$^2$C - An Announcement and an Invitation**
**March 16, 2016 – May 9, 2016**

## Rationale:

The purpose of the IM$^2$C is to promote the teaching of mathematical modeling and applications at all educational levels for all students. It is based on the firm belief that students and teachers need to experience the power of mathematics to help better understand, analyze and solve real world problems outside of mathematics itself – and to do so in realistic contexts. The Challenge has been established in the spirit of promoting educational change.

For many years there has been an increased recognition of the importance of mathematical modeling from universities, government, and industry. Modeling courses have proliferated in undergraduate and graduate departments of mathematical sciences worldwide. Several university modeling competitions are growing and flourishing. Yet at the school level there are only a few such competitions with many fewer students, even amid signs of the growing recognition of modeling's centrality.

One important way to influence secondary school culture, and teaching and learning practices, is to institute a high-level, prestigious new secondary school contest – one that will have both national and international recognition. We have therefore founded the International Mathematical Modeling Challenge (IM$^2$C).

This is a true team competition, held over a number of days with students able to use any inanimate resources. Real problems require a mix of different kinds of mathematics for their analysis and solution. And real problems take time and teamwork. The IM$^2$C provides students with a deeper experience both of how mathematics can explain our world and what working with mathematics looks like.

In the coming years the Challenge, inspired by other major international contests, will consist of two rounds of competition. In the first round national teams will work on a common problem and submit their solutions to an expert panel. Then there will be a second round hosted each year by a different country, in which the national teams present their solutions in person and engage in additional modeling experiences together.

## Plans for 2016:

In 2016 our plans call for a contest of only the first phase. We are inviting countries to choose up to two teams of up to four students with one teacher/faculty advisor. The contest will begin in mid-March and end on early-May. During that time teams choose five (5) consecutive days to work together on the problem. All solutions must be sent in by the faculty advisor, who must certify that the students followed the rules of the contest.

Papers will be judged in early June by the international expert panel and winners announced by late-June. Papers will be designated as Outstanding, Meritorious, Honorable Mention, and Successful Participant with appropriate plaques and certificates given in the name of students their advisor and their schools.

The IM$^2$C is overseen by an international Organizing Committee of the following people:

Solomon Garfunkel, COMAP, USA - Chair
Keng Cheng Ang, National Institute of Education, Singapore
Fengshan Bai, Tsinghua University, China
Alfred Cheung, NeoUnion ESC Organization, Hong Kong SAR
Frederick Leung, University of Hong Kong, Hong Kong SAR
Vladimir Dubrovsky, Moscow State University, Russia
Henk van der Kooij, Freudenthal Institute, the Netherlands
Zbigniew Marciniak, Warsaw University, Poland
Mogens Allan Niss, Roskilde University, Denmark
Ross Turner, Australian Council for Educational Research, Australia
Jie "Jed" Wang, University of Massachusetts, Lowell, USA

The problem selection and final grading is the responsibility of the Expert Panel:

Frank Giordano, Naval Post Graduate School, USA – Chair
Konstantin K. Avllov, Institute for Numerical Mathematics, Russia
Ruud Stolwijk, Cito, The Netherlands
Yongji Tan, Fudan University, China

Initial funding for planning and organizational activities was provided by IM$^2$C co-founders and co-sponsors - The Consortium for Mathematics and its Applications (COMAP), a not-for-profit company dedicated to the improvement of mathematics education and by NeoUnion ESC Organization in Hong Kong. Additional support was graciously provided by CSIAM and Tsinghua University.

For more information about the IM$^2$C visit www.immchallenge.org

**2015 Problem**

## Movie Scheduling

A great deal of preparation must take place before a movie can be filmed. Important sets and scenes need to be identified, resource needs must be calculated, and schedules must be arranged. The issue of the schedule is the focus of the modeling activities. A large studio has contacted your firm, and they wish to have a model to allow for scheduling a movie. You are asked to answer the questions below. You should provide examples and test cases to convince the movie executives that your model is effective and robust.

### Question 1:

Develop a model that will produce a filming schedule given the following constraints:

* The availability dates of the stars of the film.
* The time required to film at a list of specific sites.
* The time required to construct and film on a list of sets.
* The availability dates for specific resources. For example a war movie might require helicopters which are available only at specific times.
* Some scenes cannot be shot until after certain computer generated content is defined and other physical items are constructed.

Your schedule must include extra time to allow for redoing some shots if they turn out to be inadequate after editing and review.

### Question 2:

Develop a model that will take the information and schedule generated from the first question and can adjust them in the event that some delay in one aspect or the availability of some asset changes. For example, if one of the stars has an accident and cannot film for a certain period of time, you should be able to adjust the schedule.

### Question 3:

Use the model developed in the first question to develop a way to determine the most important constraints. That is, identify the constraints that will cause the longest delays if a problem occurs.

# NEWS RELEASE
# First Annual International Mathematical Modeling Challenge ($IM^2C$)
# 2015

We are pleased to announce the results of the first annual International Mathematical Modeling Challenge ($IM^2C$). There were 10 countries invited to participate in the 2015 $IM^2C$ and after the national selection round, 17 teams competed in the international round of judging. All teams worked at their own schools during a 5 day period between April 15th and May 15th, 2015. Each team was given a modeling problem and then constructed their solutions. This year's problem **Movie Scheduling** asked the teams to design a model for the effective filming and production of a motion picture.

## Outstanding Teams

- **Palo Alto High School, Palo Alto, CA, USA**
- **Advisor, Radu Toma**
  - **Eric Foster**
  - **Kathryn Li**
  - **Allison Zhang**
  - **Andrew Lee**
- **The Affiliated High School of Peking University, Beijing, China**
- **Advisor, Yaoyang Wang**
  - **Donghan Wang**
  - **Haimei Zhang**
  - **Wanchun Shen**
  - **Dingding Dong**
- **Raffles Girls' School (Secondary), Singapore**
- **Advisor, Samuel Lee**
  - **Siah Kelly**
  - **Wang Huaijin**
  - **Li Anqi**
  - **Lee Estelle**
- **Shanghai Nanyang Model School, Shanghai, China**
- **Advisor, Gao Junxiang**
  - **Cai Yiyi**
  - **Chen Zhihao**
  - **Xiao Zhijun**
  - **Yan Yijia**

All schools are to be commended for their efforts. The judges were impressed with all the teams' creativity and ingenuity in mathematical modeling and in their ability to explain their strategies and problem-solving techniques in clear terms. Each participant is a true winner. A complete Results Report, listing all teams by designation, as well as the full problem statement can be found at www.immchallenge.org. For additional contest information, contact $IM^2C$ at: info@immchallenge.org.

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**2015**

# The International Mathematical Modeling Challenge ($IM^2C$)
# Judges' Commentary

The Judges would like to congratulate the students who participated in the first annual $IM^2C$. We considered the **Movie Scheduling Problem** to be very open-ended and difficult to model. We were quite satisfied with the very creative model building that we saw. Devising a practical schedule from the models that typically were developed proved to be an interesting and challenging mathematical problem. Finding an optimal solution to most models that were developed required finding good solutions to computationally complex algorithms, or revising the model to allow an optimal solution to be found.

What characteristics distinguished the better papers? First, the better teams developed and presented their models in a very logical manner. They moved from the very vague scenario they were provided to identifying a problem they could model mathematically. They explained their assumptions very clearly and discussed how well the assumptions were met by the situation they had identified. After analyzing their model for solutions, they tested the model's conclusions against test cases they constructed or found in their research. They performed a sensitivity test to determine how the conclusions changed based upon changes in their data thereby identifying the most important variables.

Team 2015010 succeeded in profoundly developing the building of their model. Step-by-step, they introduce the various elements of their model in a very clear manner that is understandable to a wide audience. Due to time restrictions, they did not succeed in extending this approach through the remainder of the paper, but clearly demonstrated the ability to present their ideas in a clear logical manner. For these reasons paper 2015010 was awarded the meritorious award.

A good example of testing your model can be found in Paper 2015007. This team extracted data by hand from an actual movie, taking the data from the screen. This down-to-earth approach links the model with real-world data and gives a basis for testing and improving the model, a vital step in the modeling process. For these reasons paper 2015007 was awarded the meritorious award.

A good example of sensitivity analysis can be found in Paper 2015005 where a great amount of random data was used to identify the variables to which their conclusions were most sensitive. Team 2015004 provided a methodology for reacting to changes by choosing the objective of "changing the current schedule as little as possible." Both papers 2015004 and 2015005 stood out above the rest and were recognized as Outstanding by the judges.

Second, the better papers typically developed an optimization problem that generalized to larger data sets: more scenes, more filming sites, more actors with greater restrictions on their availability, and so forth. Typically, the algorithms for solving their optimization models were computationally complex. The better papers used heuristics for finding good solutions in reasonable amounts of time, or adding constraints to their models to reduce the number of possible solutions. Team 2015015 was awarded the meritorious award and used both a

heuristics-based algorithm and Kuhn's algorithm (also known as the Hungarian method) that guarantees a globally optimal solution and compared the results of the two methodologies. The better papers generalized to larger problems and tested their models using a case study or a practical example, and carefully presented their conclusions.

Third, the better papers excelled at scientific writing. The papers had a structure that was easy to follow. A very distinguishing discriminator among all papers was the quality of the summary. A good summary provides a very clear overview of what is accomplished in the paper. The summary not only clearly outlines the method of attack, but also serves as an invitation to the reader to study the paper itself.

An excellent example of a well-constructed summary can be found in the work of Team 2015016. The summary gives an excellent overview of the work in a well-structured manner that invites the reader to read the complete work. Because of this paper 2015016 was awarded the meritorious award.

Our advice to future contest participants is to allow plenty of time to construct a report. Build a structure which allows you to present the development of your model in a logical fashion. Similarly, present the analysis and conclusions of your model in a manner that can be easily understood by a wide audience. Use graphs, charts, networks and other appropriate visualizations where possible to aid understanding. Test your model in as realistic a fashion as possible, and clearly state your conclusions. Finally, write a summary that gives an overview of your work that excites the reader to study your paper.

A good example of using visualizations is provided by the Outstanding Team 2015017. The pictures of graphs included in their work clarify the complexity of the making of a film, thereby helping the reader understand the process that will be modeled in the following paragraphs.

To view the complete results and the outstanding papers visit www.immchallenge.org