Judges' Commentary: The Frank Giordano Award for 2015

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Introduction

The Frank Giordano Award goes to a paper that demonstrates an excellent example of the modeling process.

For the fourth year in a row, the award goes to a paper for "Problem B"—the MCM Problem oriented toward methods of discrete mathematics. This year, that problem was the Lost Plane Problem.

Having worked on the contest since its inception, Frank Giordano served as Contest Director for 20 years. As Frank says:

> It was my pleasure to work with talented and dedicated professionals to provide opportunities for students to realize their mathematical creativity and whet their appetites to learn additional mathematics. The enormous amount of positive feedback I have received from participants and faculty over the years indicates that the contest has made a huge impact on the lives of students and faculty, and also has had an impact on the mathematics curriculum and supporting laboratories worldwide. Thanks to all who have made this a rewarding and pleasant experience!

The Frank Giordano Award for 2015 goes to a team Bethel University in Arden Hills, MN, for their solution to the Lost Plane Problem. This solution paper was in the top group, receiving the designation of Outstanding, and is characterized by a high-quality application of the complete modeling process, including

- assumptions with clear justifications, a well-defined, logical series of models, model testing, and sensitivity analysis of six parameters;

The UMAP Journal 36 (3) (2015) 277–280.

- originality and creativity in the modeling effort to solve the problem as given; and
- clear and concise writing, making it a pleasure to read.

The Problem

Recall the lost Malaysian flight MH370. Build a generic mathematical model that could assist "searchers" in planning a useful search for a lost plane feared to have crashed in open water such as the Atlantic, Pacific, Indian, Southern, or Arctic Ocean while flying from Point A to Point B. Assume that there are no signals from the downed plane. Your model should recognize that there are many different types of planes for which we might be searching and that there are many different types of search planes, often using different electronics or sensors. Additionally, prepare a 1–2 page nontechnical paper for the airlines to use in their press conferences concerning their plan for future searches.

The Bethel University Paper

Executive Summary Sheet and Position Nontechnical Paper for the Airlines

The summary is well-written and gave the reader a good idea of what to expect. It contains the appropriate specifics with regard to issues and is both concise and thorough. The team's nontechnical paper, written in an appropriate nontechnical manner, summarizes the unique approach of this team for future searches in large bodies of water.

Assumptions and Parameters

After a brief introduction of their modeling process, the team states clearly and justifies specific assumptions and the parameters used. For the most part, the assumptions are reasonable and useful in addressing the model. Further, these assumptions are cross-referenced throughout the paper. The parameters are described clearly in words and individually analyzed for sensitivity later in the paper.

The Model

Considering the generic nature of a lost plane in an ocean, the team deftly approaches the problem by combining the same three aspects that most of the Finalist papers used:

- identify the crash area,
- adjust the search area for current and drift of debris, and
- allocate resources to conduct the search for debris, the plane, and the crash site.

Finally, using the parameters identified and the current and drift data from the Malaysian flight MH370 search, they developed a simulation and ran over 900 scenarios.

The approach to modeling the crash site was unique in describing in detail how, after losing power, the plane's turning would impact the worst case of a search area. The team's assumptions make it clear that they would be looking for only floating debris. But they demonstrate that they could backtrack the drift and current of the debris to find the original crash site, where they might find sunken items from the plane such as the "black boxes."

Of note regarding modeling the ocean current and drift in the search area is that the team had access only to specific data from Malaysian flight MH370. The team later declares this particularity as a weakness, with a recommendation of future work for research or development for all large bodies of water.

Finally, the allocation of planes for searching utilizes three specific patterns for a rectangular search area. Searching for debris is only visual from a plane flying one of these three patterns. The pattern of search is determined by the number of aircraft available. The simulations determine the efficiency of one pattern over another. Again, the team notes that this part is a weakness of their model, with a need for future work in investigating other patterns.

Model Testing

Model testing for the search area is done on the 2009 lost Air France Flight 447. In comparing the radii for the areas, the Bethel University team shows how their "worst case" approach produces a much larger area for search. But of more significance for this judge are the many different simulations run with "three different search methods with varying numbers of search planes, weather conditions, visibility distances, and sizes of search areas." This versatility allows the team to make recommendations on allocations of planes and search patterns in many diverse circumstances.

Sensitivity Analysis

One particular item that makes this team's presentation stand out is the sensitivity analysis. They establish a realistic baseline with the six parameters identified initially and then vary each parameter to see its impact on the overall outcomes of the model. In each case, the results are analyzed to conclude the effect on stability of the model and recommendations for changes or future work.

Evaluation of the Model and Recommendations for Future Work

In their analysis of strengths and weaknesses and recommendations for future work, the team identifies the need for access to locally specific current data. This would be important to the airlines and/or agencies directing the search. Further, the team identifies the need for identifying take-off and landing bases for the search planes. These locations would also be specific to the search area. Finally, realizing that the size and shape of the search area will change from day to day, they recommend incorporating a parameter in the model for time elapsed.

References and Bibliography

The list of references is fairly thorough, and it is very good to see specific documentation of where those references were used in the paper.

Conclusion

The careful exposition in the development of the mathematical model, significant model testing, and extensive sensitivity analysis make this paper one that the judges felt was worthy of the Outstanding designation. The team is to be congratulated on their analysis, their clarity, and the use of the mathematics that they knew to create and justify their own model for searching for a lost plane in a large ocean.

About the Author

Rich West is a Mathematics Professor Emeritus from Francis Marion University in Florence, SC, where he taught for 12 years. Prior to his time at Francis Marion, he served in the U.S. Army for 30 years, 14 of which were spent teaching at the U.S. Military Academy. He is currently working on a National Science Foundation Grant on freshmen placement tests. He has judged for both the MCM and HiMCM for more than 12 years.