Judge's Commentary: The Outstanding Asteroid Impact Papers

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Introduction

The A problem has, over time, assumed near mythological association, upon first reading by contestants, with challenging mathematical analysis. Upon further discussion and examination by team members, however, the problem typically succumbs to rather straightforward mathematics combined with innovative thinking. The Asteroid Impact problem continued this trend, providing contestants with an opportunity to wrestle with a sophisticated and challenging real-world problem. Despite the wealth of reference material accessible to contestants in reference libraries and on the Internet, the task of clearly identifying the short- and long-term effects of an asteroid impact in Antarctica left plenty of ideas for contestants to explore.

In past years, the diverse backgrounds of the undergraduate contestants provided teams with an ability to bring more than one discipline's perspective to bear on the problem. This typically resulted in an interesting array of hybrid modeling approaches. This year, however, there seemed to be a convergence to only a handful of approaches despite team demographics. Our speculation is that this effect is in direct response to the astronomical (no pun intended) increase in network connectivity via the Internet.

As many teams discovered during their weekend effort, using the Internet as a source of information in support of their analyses proved to be a two-edged sword. Sites such as those at Sandia Laboratories or the Jet Propulsion Laboratory provided interesting and in some cases accurate and relevant information dealing with asteroid impacts with Earth. Unfortunately, as evidenced

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in many papers, teams extracting information from these sites without first thinking about and discussing the problem soon found themselves under the spell of the siren, lulled into a mathematical approach that they were not able to bring to successful closure in the time allotted for the competition. Moreover, to judge from their lack of direct supporting documentation and reasoning, in the end they apparently found themselves unprepared to explain clearly and sufficiently the underlying assumptions and reasoning of the mathematics presented in the sites. As in most modeling efforts, this provided an all-too-fatal flaw to their paper.

A second general note also worth mentioning concerns team strategies for coping with the impending competition deadline. The vast majority of good papers represented a team strategy that, when faced with a decision either to present complicated mathematical analysis on only a portion of the problem or else to attempt a complete modeling effort, chose the latter. The exceptional papers contained a judicious amount of both elements woven together to answer the questions posed by the problem. Exactly how the balance was struck between the degree of inclusion of the two elements varied from paper to paper. However, it was clear that each team had chosen one or two appropriate mathematical techniques (e.g., partial differential equations, kinetic energy modeling, etc.) to develop within the context of a complete modeling effort.

By and large, the exceptional papers provided conclusive evidence that their teams had dedicated a substantial amount of time thinking about the problem prior to starting their quest for supporting information. This choice seemingly enabled them to weigh the cost and benefit of identifying exact modeling parameters versus making reasonable assumptions and working with approximate, in-range values. The many facts directly associated with the problem—such as the geological composition of both the asteroid and Antarctica, the typical source of Earth-bound asteroids, the angle of incidence upon impact, the human population distribution, and atmospheric currents and circulation—mandated adopting such a strategy. Those papers failing to provide evidence of having considered important problem characteristics, whether implicit or explicit, were eliminated from further consideration. As a minimum, it would have been better to identify and explain the impact of a particular feature (e.g., upper atmospheric wind currents) and then to choose explicitly not to include this factor for reasons of mathematical tractability.

Modeling assumptions fall into two broad categories: physical assumptions requiring justification with discussion, and numerical parameter assumptions that may result from citations noted. The plausibility and applicability of either type directly depended on how well teams linked a particular assumption to the problem as stated in the MCM, rather than to some problem stated in the reference source document. Regardless of a paper's calculations, a 10-meter instantaneous rise in all of the Earth's oceans is a bit too far-fetched of a result for the problem presented, even for the most devout of science fiction followers to accept.

As in past competitions, the need for precise supporting documentation in the body of the report cannot be stressed enough. The exceptional papers all conveyed a clear link to verifiably credible information sources within the body of their paper. Lesser-quality papers showed a reliance on Internet sites for supporting information that failed to include necessary explanations of why certain parameter values were valid and what assumptions their methods were based on. Although the temptation to "cut-and-paste" directly from Internet sources is recognizably strong, doing so most often resulted in a paper that was predominantly statements of unsupported "facts" rather than one showing that the team had a clear understanding of the model. Additionally, dedicating an inordinate amount of time to display the derivation of known relationships (e.g., Kepler's law of gravitational attraction) added little value to a paper.

Lastly, the finer papers presented complete summaries, contained few or no grammatical errors, and presented well-designed tables and graphics that illuminated their team's underlying analytical reasoning.

About the Author

Pat Driscoll is an Academy Professor in the Department of Mathematical Sciences at USMA. He received his M.S. in both Operations Research and Engineering Economic Systems from Stanford University, and a Ph.D. in Industrial and Systems Engineering from Virginia Tech. He is currently the program director for math electives at USMA. His research focuses on reformulation–linearization techniques in the context of linear and nonlinear optimization. Pat was the Head Judge for the Asteroid Impact Problem.