My Quest for a CAREER Award

Brian German
Assistant Professor
School of Aerospace Engineering
Georgia Institute of Technology

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The Short Story

I submitted my first CAREER proposal in 2009.

It was declined.

I submitted my second CAREER proposal in 2011.

It was awarded!
The Unsuccessful First Try: Proposal

CAREER: Topological and Geometric Characterization of High-Dimensional Multi-Objective Design Spaces

From the project summary:

“The PI’s long-term goal in research is to contribute approaches to improve concept exploration, optimization, stakeholder decision making, and training in the design of complex systems. In pursuit of these goals, the research objective of this CAREER project is to improve understanding of the structure of high-dimensional multi-objective design spaces by leveraging topological and geometric analysis. <Tedious description here on geometry of multi-objective optimization>”
The Unsuccessful First Try: Proposal

Continuing from the project summary:

“The PI’s career goal in education is to cultivate a diverse generation of engineers who understand that engineering design is a creative … process enabled not only by mathematics and applied science but also by deep skills in decision making amidst great uncertainties. In support of these goals, the educational objective … is to create a multi-faceted program to introduce high school, undergraduate, and graduate students to the “big picture” importance … of decision making in engineering. The focus on decision making is a central theme that integrates the research and educational programs in this proposal. “
"The educational approach is to develop case studies and a role-playing game to simulate the organizational design decision process. Some materials will be developed by vertical teaming of RET teachers, REU undergraduates, and graduate students. The cases and lectures … will be used to form an undergraduate elective course, and research results will be incorporated into an existing graduate course. Educational assessments will be conducted by surveys developed in collaboration with the Georgia Tech Center of Excellence in Teaching and Learning (CETL), and assessment results will be used to improve course materials."

Whew…Part of me is glad that this proposal was not awarded.
The Unsuccessful First Try: The Wait

I submitted the proposal on July 22, 2009.

I was informed of the results via email on ~December 28, 2009.

I had a Merry Christmas but not so happy a New Year.
The First Try: Review Highlights—Intellectual Merit

“Several pages of descriptions … are rudimentary, nor suitable for peer-review…. The PI could have made good use of this space to describe the intellectual developments…”

“The PI should describe the technical details of the proposal more clearly using the available space.”

“The PI is embarking on a rather ambitious project, and has developed key insights through ongoing industrial case studies. Prior work …has been packaged and presented in an abstract and exciting manner.”

“Proposal wastes crucial space explaining the basics of design optimization. Some of the ideas could be developed further to make a stronger proposal.”
The First Try: Review Highlights—Intellectual Merit

“The topic is relevant and the intellectual merit of the inherent challenges is excellent. However, the IM of the PI's proposed approach is difficult to assess. The PI uses a significant number of terms and ideas without clarifying their meaning or formal use. The research plan seems to jump around among topics without a clear, unifying strategy. The PI discusses a number of scientific investigations, but never articulates his primary research questions he wants to study and answer. The questions on page 8 are interesting, but they are not presented as guiding the entire research plan. I would suggest that the PI establish 2-3 key research questions that he wants to answer and then build a research plan around them.”
The First Try: Review Highlights—Intellectual Merit

“The intellectual merit of this proposal is not clear…. It is not clear what exactly the PI proposes to do, or why it would be useful. What would the information be used for during the design process? How will the information be processed or acted upon in the context of multiobjective optimization? What portion of complex systems will be addressed? Specifically, what is the problem? ‘Improving understanding’ of a broad and complex problem is not specific enough.”
The First Try: Review Highlights—Broader Impacts

“The broad impact is via a cohesive educational plan that is consistent with the research objectives. Good industrial collaboration. Significant focus on underrepresented students adds to the merit…”

“The broader impacts of the work are good. As evident from the [redacted] collaboration, there is a great need to be able to model and understand design tradeoffs in high dimensional space. The collaborations with CEISMIC, NSBE, and EWB are all excellent.”

“The case studies, interactive simulation and role playing educational modules sound interesting, but the connection and relevance to the research topic is not clear. A more focused educational component that is more … coupled with the original research would be better.”
The First Try: Reviews—Panel Summary

Intellectual Merit:
The research proposal is very ambitious. The practical aspects are difficult to be realized. It is essential that details of implementation are clearly elucidated and also supported by a step by step approach. The lack of clear objectives as well as key deliverables that would enable an evolution of the methodology into a practical product application is a clear indicator that this aspect has been neglected.

Broader Impact
The outreach efforts are viable and can enable a educational thrust in an area that would enable the attraction of new students into the field of engineering
CAREER SUGGESTIONS

Need to focus on specific proposal aspects with **concrete examples to validate and substantiate all aspects of the claims** and possible end prototype applications.

Need to **outline a specific step by step plan** to plan and execute the proposal.
In 2010, I decided not to submit a CAREER proposal.

I surmised that my previous idea did not have enough “legs” to build into a successful proposal. The general topic area was well-trodden.

And…I did not have a “good” new idea.

I decided to build up momentum in my “exploratory research” areas and to accelerate my publications.

During this time period, I went to technical workshops and conferences, met many new people, and started working in the area that would lead to my eventual successful proposal.
2011: Positive Transitions

In the fall 2010 submission window, I submitted a “collaborative research” proposal with a colleague at another university whom I had met at a workshop.

It was declined.

We updated the proposal based on the panel reviews and submitted it again in the spring 2011 window.

It was awarded! My first NSF grant!
2011: Positive Transitions

Based on this success, I decided that I would try for the CAREER again in 2011.

I had learned a lot from the previous two proposals, and I also felt that I had found an important and new topic area.

I submitted my new CAREER proposal in July 2011.
The Successful Second Try: Proposal

CAREER: Modeling the Dynamics of Design and Systems Engineering Processes

“The research objective … is to model the dynamics of … development processes for large-scale complex engineered systems. The research will leverage methods … from the fields of …. If successful, the primary innovation will be to relate the following factors to the dynamical behavior of systems engineering processes… The resulting model will be suitable to quantify characteristics including …. The framework will be used to study historical aerospace development projects to gain insights into causes for schedule and cost overruns and to calibrate and validate the dynamics model.”
The Successful Second Try: Proposal

“The educational objective … is to encourage students to pursue … engineering careers by illustrating the role of engineers in creating important … systems. The educational component will focus on the development of … case studies … based on historical engineering development projects. The program will build from the PI’s past work on product-centric design case studies to create process-centric cases that describe the activities in development projects. The effectiveness of the … approach will be assessed by …. The emphasis on the design process … is a unifying theme that integrates the research and educational objectives of this proposal. The PI intends to achieve synergies in effort by using the same historical programs for the calibration/validation of the dynamics model in the research and the development of cases and vignettes in the educational program.”
The Successful Second Try: Proposal

Intellectual Merit

F-18E/F and F-22 Airframe Weight Over Time. Adapted from (Younossi, 2005).
The Successful Second Try: Proposal

Broader Impacts

“Dynamical models may hold the potential to understand and mitigate the dramatic cost and schedule overruns that frequently occur in the development of complex systems. Progress in this area could ultimately assist in achieving multi-billion dollar savings to industry and government.”

“Broader impact in the educational program will be achieved by developing inspirational vignettes of engineering design projects for high school outreach. These vignettes will be used by the PI in outreach at his high school alma mater, a public school with high dropout rates in…. Both the vignettes and case studies will be disseminated ….”
I submitted the proposal on July 26, 2011.

I was informed of the results via email on January 9, 2012.

I was in a keynote address at a conference. It was the best keynote ever.
Review Highlights—Intellectual Merit

“Overall the concept for the PIs approach is very interesting and involves novel components. However, technical details are not sufficiently described, in particular approaches for handling the complexity of the various models...”

“PI has offered some very good ideas and insights into addressing this challenge. PI has also demonstrated an excellent understanding of the literature and has a good track record in this topic area. The proposal is overall well thought out.”

Some minor feedback was provided on specific technical issues, but most of the reviews reflected philosophically on the topic and/or posed additional interesting questions.
Review Highlights—Broader Impacts

“The impact of this research will be far reaching and beyond aerospace engineering. The design cases to be created in aerospace engineering applications will be beneficial for complex systems research.”

“The proposed … approach may lead to a better understanding of how dramatic cost and schedule overrun occur in large scale complex system development projects. In addition, the education program will impact on the proposer's former high school by developing inspirational vignettes of engineering design projects.”

“The education plan is reasonably well-integrated with research activities, which is excellent. The historical … case studies are a great application of the work. …Could students and practitioners test the system in some way…? Could this be placed online where others could access it?”
Review Highlights—Panel Summary

“This is a compelling proposal with an interesting idea at its core: combining physics-based and human behavior models to better understand development processes. The premise is that design attributes and design process can be linked and modeled as a dynamical system. The PI has a good understanding of the relevant literature and clearly articulates some nice insights.”

**Intellectual Merit**

There are some potential risks, which the PI seems well-positioned to mitigate. In particular, there is a concern that the resulting models will not have the predictive power necessary to modify design process. Additionally, there is a lot of complexity involved in both kinds of models. The PI acknowledges this, but doesn't specifically address how this will be managed.
Review Highlights—Panel Summary

Broader Impacts
...Processes for managing large, complex systems are not well-understood. The proposed effort would enable the exploration of these systems, using a quantitative approach... This would include an investigation of the interactions among elements of complex systems. This is a great opportunity.

CAREER-specific Criteria: Integration of Research and Education
The vignettes are an interesting outreach opportunity. The notion of historical vignettes particularly resonated with the panel. One consideration for the PI would be to consider how this work might be more broadly disseminated: how might communities beyond aerospace be made aware of--and take advantage of--the results of this potentially important effort...

Overall, this is a novel idea and the PI seems well-positioned to pursue this opportunity.
What I Learned or Now Believe

Writing a CAREER proposal, or any NSF proposal, is a learning process. It takes a lot of time and a lot of iteration. Be prepared to try more than once.

Pose research questions and be specific in your research plan.

Provide details about how you will mitigate risks in your research plan.

Some topic ideas are better than others. It may be better to move into an exciting new area rather than a well-trodden area. But, I think that both approaches can be successful.

You do not have to “do everything” in outreach to achieve broader impacts. One of the best broader impacts is if your topic could substantively affect industry or society at large.