Anchoring and Black Swans:
Reconsidering Risk Aversion and the Future of Commercial Space – Project Overview, Findings, and Recommendations

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Overview

This cover note describes a package of material Resources for the Future (RFF) is submitting to NASA for the project with the above title. Along with this note, the package contains the following items:

- The program and participant list for an experts' workshop organized by Molly Macauley and James Bennett, held at RFF in Washington, DC on March 22, 2016 to gather information for the project (Document #1).
- Slides for presentations by Molly Macauley, James Bennett, and Katrina McLaughlin to participants presenting an overview of the project, explicating the concept of the "value of statistical life" (VSL), and discussing surveys of the public regarding tolerance for risk in the U.S. space program (Document #2).
- Narratives by McLaughlin on VSL and public polling, accompanying her presentation (Document #3).
- Notes of comments made by participants during the workshop, edited by McLaughlin, then a research assistant at RFF (Document #4).
- A paper by James Bennett, co-principal investigator, "Historical Analogues as Anchoring References in Popular Perceptions of Spaceflight Risk" (Document #5).
- A summary paper by Tim Brennan of RFF, "Usefulness of "Value of Statistical Life" in the Commercial Space Context: Limited, But Still Relevant," looking at the relevance of VSL, public attitudes, and risk aversion by participants themselves in the commercial space context (Document #6).

Each of these contributions addresses different aspects of the problem of how NASA, entrepreneurs, and the public may and should react to accidents, particularly those involving loss of life, which may and perhaps probably will occur in the development of commercial space enterprises.[1]

[1] We also thank Juile Alleyne, Isabel Echarte, and Karen Palmer for their valuable help in completing this project.

The title of this project provides some of the context. In the philosophy of science, a "black swan" refers to the inherent impossibility of proving generalizations. Specifically, finding the billionth "white swan" does not prove that "all swans are white," as a "black swan" could exist that would, if found, refute the generalization. However, in contexts involving financial and other risks, a "black swan" has come to refer to events thought highly unlikely to occur but, in fact, did occur, and with larger costs than typical or expected events. The term entered public discourse as fitting the confluence of widely unexpected events that led to the 2007-08 financial crisis. In this context, the "black swans" would be accidents in the development and execution of commercial space enterprise that result in the loss of life.

The term "anchoring" arose in behavioral economics to refer to reference levels of resources or well-being where people place relatively little value on gains above that point but a great deal of value on avoiding losses below that point. This notion of a reference point or "anchor" in attitudes in the context of this study refers not to individual consumption or welfare levels as such, but to what past or current experiences people might use to compare their willingness to accept their risk. This can lead to questions, such as why might people regard space-related risk as less tolerable than, say, risks taken by pioneers in the early days of aviation or, for a present example, the development of self-driving cars. The term "space exceptionalism" refers to the idea that space risk is inherently different, due in part to its historical role as a program closely tied to national prestige and power.

Consequently, the title of this project, "Black Swans and Anchoring", expresses our interest in understanding how participants in commercial space development, those charged with setting rules and regulations for it, and the public at large, do and should regard rare accidents that result in a loss of life. We examine how risks are evaluated in (1) the development of public policies such as safety regulations or pollution controls, (2) historical precedents and current attitudes regarding public attitudes toward participation in risky situations, and (3) the extent to which those evaluation methods do or do not apply in the commercial space industry context.

To inform our understanding of this issue, Resources for the Future, the home institution of Dr. Molly Macauley, the principal investigator on this project, hosted on March 22, 2016, a gathering of experts in space exploration and commercialization. Participants included experienced persons working in the space sector, both government and private, and researchers in risk analysis from academia and RFF. The workshop description and participant list is Document #1 in the package.

The description of that workshop states that key aspects were three presentations. The first was an overview of the project itself; the second was a review of historical analogues such as early aviation; and the third was on the meaning and use of the value of a statistical life (VSL) and on public attitudes toward space risk as revealed by survey data. Document #2 is the printout of the combination of those three presentations, as prepared by Katrina McLaughlin incorporating direction from Dr. Macauley. Document #3 includes short notes Ms. McLaughlin prepared to

accompany the slides as she presented them during the workshop and to provide further detail to some of the issues covered in her presentation.

As that workshop description states, the discussion was conducted under Chatham House rules: "Participants are free to use the information received, but neither the identity nor the affiliation of speakers nor that of any other participant may be revealed." Accordingly, Ms. McLaughlin prepared notes of the discussion but without attribution of comments to any specific participant. Those notes, which include extensive lists of references, constitute Document #4 in this package.

Based on his research and the workshop discussion, co-principal investigator James Bennett prepared a paper, "Historical Analogues as Anchoring References in Popular Perceptions of Spaceflight Risk," Document #5 in this package. The purpose of this paper is to investigate the historical sources of public attitudes toward spaceflight risk. He examines attitudes formed during the era of early private and commercial aviation, leading to the evolution of "an implicit 'zero loss' standard, in which every accident required an explanation and visible measures to prevent its recurrence." He then discusses the role of safety regulation as the commercial space sector unfolds.

To support these views, he examines attitudes in other "high-risk scientific research environments". These include exploration in terrestrial remote areas and polar regions, undersea, and volcanoes. He then turns to "assumed risk" recreation and adventure activities including aviation, mountain climbing and skydiving. He finds that VSL and other methods for evaluating the benefits and costs of mortality risk "are of only limited value in sport/recreational regulation." He concludes that one cannot infer a consensus regarding the definition and criteria for when a risk is acceptable.

The last part of the package, Document #6, is a short paper by me on the relevance of VSL in the commercial space contexts. After describing VSL, I suggest, following Mr. Bennett's observation in Document #5, that VSL is most clearly relevant in contexts where a policy choice produces a small change in the mortality risk faced by members of the public. As such, two factors call into question its relevance in the commercial space context. The first is those bearing risks from commercial space exploration generally choose to accept that risk, in contrast to the public which lacks the ability to choose whether to accept the risk of a policy choice. A second is that the public's attitudes toward commercial or non-commercial space ventures in this context concern risks born by others, that is, if and when a member of the general public accepts risk of death to astronauts and others who go out into the space. Despite these differences, VSL may retain some relevance in thinking more carefully about consent to accept risk by participants in commercial space ventures. It is likely to be less useful in informing judgments about public attitudes toward risks borne by others.

Findings and Recommendations

The history of the formation of public attitudes toward fatalities, what we refer to in this project by "anchoring," provides numerous insights that will be useful as the commercial space sector continues to develop. A useful example is air transport. The public was willing to leave risk to the participants when it was in the testing stage, and took a strong attitude, reflected in the need to investigate causes of every accident, once air travel became relatively commonplace. Comparing polar explorations to present-day tourist cruises to the Arctic and Antarctic reveals a similar pattern. While "space exceptionalism" may warrant extra public scrutiny, having regulators adopt a common framework for justifying safety regulations may limit the extent to which commercial space enterprise would face unduly stringent risk mitigation policies.

Transparency and better communication can help as well. People sometimes assume activities are more risky than they are because of news coverage of extreme events. They may often have difficulty distinguishing relatively conventional endeavors from those at the edge of experimentation. Better communication of risk standards and the role of informed consent—if limited, as noted below—can help the public form a more realistic view of the risks and how they are balanced against the benefits.

The standard measure for the benefits of mortality risk, the "value of a statistical life", is like other measures of benefit based on how much people are willing to pay for it, e.g., by forgoing higher wages to take a safer job. It may be relevant in settings where participants in commercial space enterprise are the only ones at risk, because those participants may not be able to become adequately informed regarding the risks they take. "Informed consent", while an attractive standard, may be impossible to meet.

In such cases, safety regulation may be necessary, as it is regarding workplace, travel, and food safety today. However, when using VSL to balance benefits against cost in setting safety standards, future regulators of space enterprise should also factor into their decisions the willingness of those participants to take on more risk in exchange for the value to them of the experience of space travel and the sense of contributing to humanity's knowledge. A potential topic for future research is coming up with useful methods for ascertaining and placing a reliable monetary estimate on that value, to be included along with VSL in setting regulatory standards.

A conceptually more difficult problem is "space exceptionalism" as revealed by the aggregate willingness of the general public to pay not to mitigate the risk they bear, but to limit the risk that participants bear. One problem is that this willingness to pay is open-ended. One can add up a small willingness to pay over a very large population to get a number large enough to materially delay commercial space ventures. This could prevent participants from taking on risks acceptable to them and

commercial space venture regulators. Better transparency and education may help assure the public that regulators would be appropriately balancing the cost of risk reductions against the benefits of commercial space enterprise. Moreover, the history of "anchoring" provides some reason to think that excessive pressure to mitigate risk may not be forthcoming, at least before the general public itself participates in commercial space ventures. The public may be less reluctant to accept space risk when projects are public—an instance of something Molly Macauley referred to as "government risk conservatism"—than when the private sector undertakes commercial space ventures.

A special note

Most people who review the documents in this package will likely know that Molly Macauley was unable to complete her work on the project because of her sudden and tragic death. All of us who worked on the project, and her colleagues at RFF, are painfully coping professionally and personally from that loss. I was fortunate to have dozens of conversations with Molly over the years on space policy issues, including co-authoring articles and pieces on remote sensing and privacy. I lack the temerity to claim that Molly would agree with my part of this package. None of us will benefit from the special insights that she would have brought to this project. But there would be no project at all without her intellectual leadership and energy, and her deep affection for space ventures in all their forms. We complete this project in her memory.