Nicoletta Fala | Research Statement
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My central research focus in Systems Engineering and Human Factors is to characterize risk and improve safety in human-centric systems. In aviation, the system of interest consists of the human (flight crew) and machine (aircraft) working together to achieve a specific mission. Improved system performance and safety requires both parts to improve independently, as well as in their interactions with each other. Pilot-related accidents make up approximately 75% of all general aviation accidents every year, and compared to commercial aviation, the accident rates of general aviation are unacceptably high. With the demand for more pilots, mechanics, and engineers in the aviation industry increasing rapidly, evaluating risk in all parts of the infrastructure is imperative. The onset of technology in the flight deck and the availability of more reliable data creates opportunities for improving safety in aviation if used appropriately. My research develops data-driven methods to model and communicate risk and understand pilot perspectives by integrating systems engineering and human factors with my first-hand knowledge of general aviation.

My doctoral thesis focuses on automatically detecting unsafe behaviors in general aviation flight data and communicating these behaviors to the pilots so that they can fly more safely in the future. To detect unsafe behaviors, I mapped historical accident information, modeled by hazardous states and triggers, to events and parameters that I calculate from various sources of flight data. While we can assume that safety-driven post-flight feedback that alerts pilots to potentially hazardous situations can facilitate risk management in subsequent flights, it is not clear how the way we present feedback affects how pilots perceive risk, or what the best way to communicate risk to pilots is. Their perception of risk may be affected by cognitive biases such as the type of language messages are framed in. Training providers or electronic flight bag (EFB) application developers must consider these biases when designing feedback. To identify these cognitive biases, I designed and disseminated a survey that asked pilots to debrief sample flight debriefs and evaluate the flight risk. My doctoral research contributes to the wider body of knowledge by mapping accident information, in the form of hazardous states and triggers, to events and parameters that we can calculate and detect in various forms of flight data, designing different debrief representations to communicate information on these hazardous states and triggers to pilots in different ways, and then using a pilot survey to evaluate the effectiveness of different risk representations.

To continue my work in characterizing risk and improving safety in aviation and engineering, I propose three areas of future research that will help guide the development of my research program in aerospace systems engineering.

Personality assessment and communication

Surprisingly, most of the literature on risk communication has focused on the general public rather than specific populations. Research has also fixated on disaster and health risk, motivated by the need to disseminate information before disaster strikes and prepare the general public for recovery. Using the same methods to communicate risk with all groups can lead to frustration and a lack of understanding. In any human-centric system, it is essential to identify how the group of interest will behave, what affects their behavior, and how cognitive biases affect their understanding. My work currently evaluates cognitive biases that the pilot population is susceptible to when assessing risk. This work has created more questions that we have yet to answer, such as what survey methods are most appropriate for different groups, and what cognitive biases will make their way into our surveys depending on the group we are interacting with.

Another understudied subset of general population are engineers in the industry. In the world of high-risk engineering systems, we still do not know how to communicate risk well and we cannot predict how others will perceive it. Engineering and technology therefore present an opportunity to

apply my research methodology from the aviation industry to tools specifically designed to evaluate and communicate risk. I propose to apply similar methods to engineering students, or engineers in the industry, but also in populations in other areas where understanding and communicating risk is crucial, like medical students. By analyzing potential cognitive biases and evaluating whether there are personality characteristics that trigger them, we can develop guidelines on how to communicate risk better.

Applying the same methods to the aviation student population can help increase student retention and the probability of success in a flight training program. Assessing personality and behaviors among collegiate student pilots will help increase understanding of how pilots perceive their performance and what motivates them to improve or continue.

My work on risk communication among general aviation pilots has been presented at the *2019 AIAA Aviation Technology, Integration, and Operations Conference* and the *2019 International Symposium on Aviation Psychology*.

Data-driven flight analysis

The introduction of new technology in the flight deck as well as the ADS-B 2020 mandate have increased the availability and accessibility of flight data of various types. In my doctoral research, I used different forms of data to detect unsafe behaviors in post-flight debrief. Similar flight data can help guide training operations and decision making. For example, using flight data to calculate the safety or performance of a training flight provides students with a better understanding of specific aspects of their flying that they need to improve. I propose to use different forms of data to develop algorithms that alert pilots to potentially hazardous events or opportunities for improvements in performance in-flight.

When designing solutions for the general aviation community, one of the most important factors is cost. The aging fleet is not always updated with the newest avionics systems or flight deck technologies, due to incompatibility issues, the prohibitive cost, or as a matter of operator or pilot preference. Low cost sensors and technologies, like smartphones, tablets, and DIY units, make it possible to provide the recreational pilot with safety and performance information without requiring them to install permanent solutions on their airplane. My proposed research on combining different sources of flight data will develop tools that all pilots can benefit from.

My work on using data to improve the efficiency, safety, and environmental impact of aviation has been published in *Air Traffic Control Quarterly* and presented at the *AIAA Aviation Technology, Integration, and Operations Conference*.

Risk modeling

Despite our best efforts, accidents in aviation are still occurring at an unacceptably high rate. Some of these accidents are repeatable—pilots inducing a spin on the base-to-final turn while on an approach to a runway, or pilots losing control after continuing flight into instrument meteorological conditions without the required equipment or training. We do not only need to evaluate *how* to best communicate risk in situations where not mitigating risk has adverse consequences, but also *what* to communicate. Engineering students in design and safety classes discuss tools like the risk matrix or FMECA, but these tools have yet to stop projects from failing or accidents from occurring. Aviation relies on chain of events or Swiss cheese models to describe how accidents happen. However, accidents that are (in hindsight) predictable still occur, making us wonder why those chains were never broken. Risk communication can benefit from more objective methods of calculating and presenting risk, but all the methods available to both the aviation and engineering industries today are very reliant on human perception.

My research on risk modeling in the aviation industry has been presented at the *AIAA Aviation Technology, Integration, and Operations Conference*.