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A3IR-COREe and Flightprofiler: An Academic-Industry Partnership for SMS Development

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FlightProfiler, a safety management system software for general aviation that has been under development since 2000, quantifies and illustrates how 79 different factors collectively affect planning for general aviation flights. The software uses advanced collaborative decision-making technology and NextGen analytics to prescreen an entire flight cycle, with objectives of improving flight safety and reducing costs. The Advanced Aviation Analytics Institute for Research (A^{3}IR-CORE) at Purdue University has entered a partnership with the software developer to improve the usability of the product in a collegiate aviation environment. This includes creating process flow diagrams of the software and of Purdue flight operations, gathering flight data, and improving the presentation of the output. Purdue will in turn be given access to the FlightProfiler tool for use in its flight program. The software development team consists of mathematicians, meteorologists, graphic technologists, and computer scientists who are in communication with A^{3}IR-CORE faculty and students to effectively collaborate and organize the task. Participating students will acquire business development skills working on a student-designed project plan in addition to the skills needed in industry to analyze, formulate and apply logical techniques for work task improvement.

The Purdue Masters of Science degree in Aviation and Aerospace Management is designed to prepare graduate students with the background necessary to become future leaders in the aviation industry. Some of the primary areas of concentration in this program include operational analysis, project management, human factors, safety and security, environmental sustainability, and resource analysis. AT 52000, a course taught by faculty associated with the Advanced Aviation Analytics Institute for Research (A^{3}IR-CORE), focuses on critical points in process workflow and their effects on customer service, employee relationships, cycle time, and profit. The course utilizes a combination of lecture and group projects and discussion to link subject material to practical applications thereof that are relevant to students' professional interests and career goals. The students in the course in the fall semester of 2014 were divided into multiple project teams; the research described herein resulted from the work of the FlightProfiler team.

The benefits to FlightProfiler included feedback regarding the utility of the software and recommendations for improvements thereto from users in an academic setting, as well as the potential for integration of the decision-making tool into the Purdue flight program. The benefits to the students included development of students' skills such as communication, project design and management, and professionalism, as well as growth of students' professional networks.

Literature Review

According to the U.S. Department of Transportation, there were 440 fatalities and 1,471 general aviation accidents in 2012. Although these numbers have generally decreased over time, they are still large compared to the zero fatalities and 27 commercial aviation accidents recorded in the same year (DOT, 2014). In an attempt to mitigate the relatively high proportion of general aviation accidents, the FAA identified a need for a risk assessment tool for general aviation pilots. There are several products on the market that are being tested and refined in addition to the FlightProfiler product that is the focus of the current research. These additional products are described below.

FltPlan.com, a web-based flight planning service, is one of the largest such services in North America, with a customer base of over 150,000 active pilots. FltPlan.com recently "enhanced its Safety Management System program by adding multiple Flight Risk Assessment Tools that are customizable for both a flight department's operation and the department's different aircraft" (General Aviation News). In addition to flight planning and safety management capabilities, the site also offers flight tracking, runway analysis, weight and balance calculators, an eLogbook program, and FBO and airport information. All of this information is helpful to pilots, but a new opportunity exists in effectively communicating potential flight risks to pilots. FltPlan's enhanced safety management system aims to capitalize on that opportunity.

Leveraging new technologies to produce new risk assessment tools can result in a major potential benefit to general aviation pilots. The new iPad Flight Risk Assessment Tool (iFRAT) offers pilots an easy way to examine risks associated with their flights (Sniderman, 2015). As the commercial airline industry moves further toward adoption of iPad technology, the general aviation industry would appear to be remiss in not adopting similar technology. The process of assessing a particular flight's risk can be accomplished in a few minutes either before or after a flight. iFRAT offers interactive risk displays that provide critical information in an easy-to-understand manner.

An additional product with enhanced risk assessment features is the Lockheed Martin Flight Services website. Lockheed-Martin provides flight planning services to over 80,000 general aviation flights per week, covering areas including pre-flight, in-flight, operational and special services, enroute communications, search and rescue services, and meteorological and aeronautical briefings (Lockheed Martin, 2015). When a general aviation user enters his or her flight information at the site, there are specific risks that are highlighted through the reports with which the user is presented. An easy-to-follow risk assessment is provided to the pilot through the appropriate smartphone, tablet, or computer application. Any concerns or warnings are highlighted in yellow or red, depending on the severity of the concern, and are also ranked as text in terms of importance to the pilot's flight and depicted on a map to help the pilot understand where the risks are positioned in relation to the flight. This information is presented in an easy-to-read and easy-to-remember format with a visually appealing layout and information flow.

Methods Used to Form Recommendations

A^3IR-CORE faculty and students met with FlightProfiler to establish business development objectives, which included testing the program in an academic setting, collecting feedback, drawing information from other current resources, and developing recommendations. To achieve these objectives, the team developed a project plan spanning the fall semester. The plan included the creation of process flow diagrams of the Flight Profiler website and Purdue flight operations using Microsoft Visio. Development of the flow diagrams included process map construction, critical sequence streamlining, and value-added analysis. As a result, the team could easily determine process overlaps, weaknesses, and other highlighted items.

The team first gathered information from Purdue flight operations to develop an understanding of all of the steps necessary to fly a visual flight rules (VFR) training flight. This included documenting all necessary steps, from arriving with the instructor to accepting the aircraft. Next, the team decomposed all of the steps necessary to complete a flight risk assessment on the FlightProfiler website. Once the processes were understood, the team facilitated focus groups of student pilots in which those pilots accessed Flight Profiler and tested it. 20 Purdue students enrolled in the professional flight program each created a personal flight risk assessment on the website, discussed observations with the researchers, and completed an online response form. Face-to-face communication was considered important for high-quality feedback, so a team member was present when the testing was conducted. The recommendations herein were derived from focus group response data, direct verbal feedback in focus groups, and the research team's own suggestions and findings.

FlightProfiler Recommendations

Purdue flight students currently use a flight risk assessment tool (FRAT) (see appendix) before every flight. The research team found that the FRAT tool covers many areas in a manner similar to that of the Flight Profiler questionnaire. The FRAT tool is grouped into preflight info, flight operations, weather, and training flight criteria, which each question weighted appropriately. At the end of the questionnaire, the pilot is given a score. If that score is above the minimum, then the pilot can fly the particular flight in question. If the score is in a “warning” range, the pilot must get approval from the chief pilot. If it is below a minimum, then the pilot cannot fly.

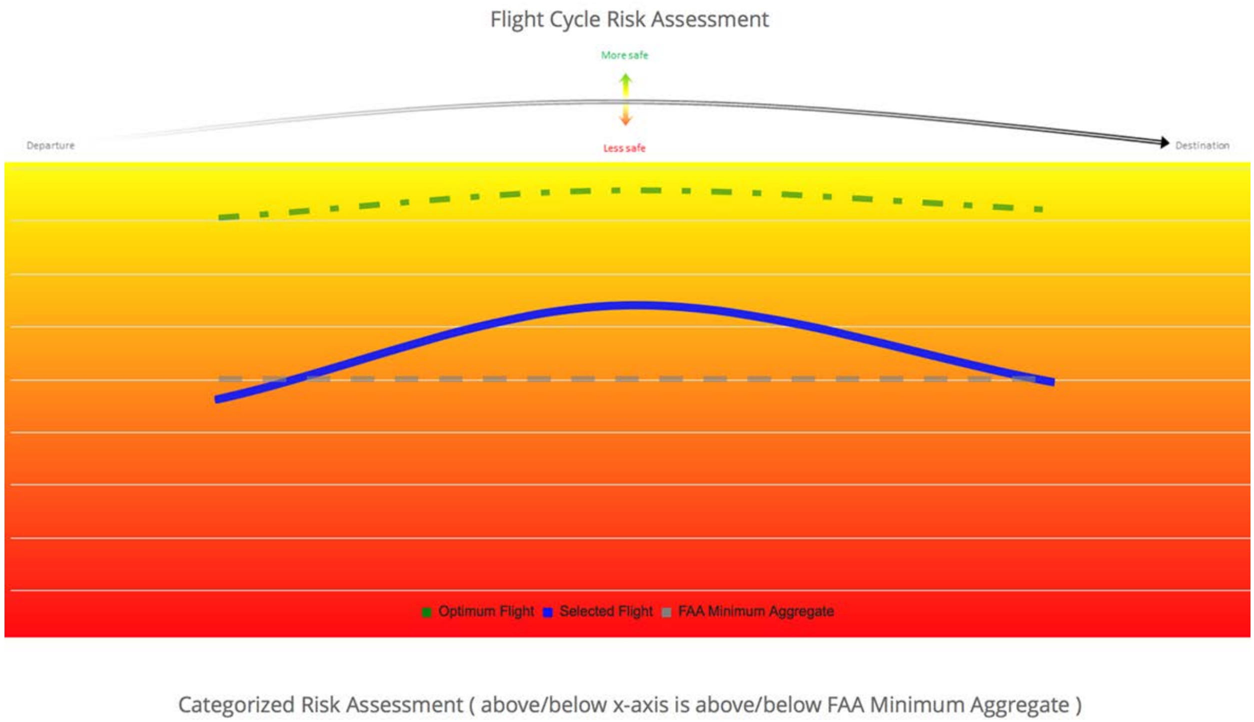

Figure 1. FlightProfiler output.

The team looked at a typical FlightProfiler output (Figure 1). The solid blue line shows the amount of risk a particular flight is expected to encounter during the course of the flight. The higher the line, the less risk the flight is predicted to have. The software will overlay other flights that have been assessed to show how a particular flight compares with those flights and to provide a general threshold of safety. The example in Figure 1 shows only a single flight between the listed departure and destination airports. The upper dashed line shows a realistically optimum flight and the lower dashed line depicts a minimum threshold, based on Federal Aviation Regulations. In this example, the flight begins below FAA minimums and terminates close to those minimums. Potential causes for this include a departure airport that may be below weather minimums and pilot fatigue as the flight arrives at the destination airport.

With regard to the entering of information on the website, the team suggested a better categorization of airports. Currently, the website has an alphabetical dropdown list of all commercial airports in the United States. Inclusion of a search bar or a means to sort airports by location allow more convenient entry of origin, destination, and alternate airports. In addition, the home airport for the Purdue flight program (Lafayette-Purdue University Airport [KLAF]) was not listed.

The team also suggested the addition of a mechanism to include personal preferences and safety minima. Because different kinds of training flights are flown by pilots possessing different levels of experience, it would be helpful for pilots to choose their own safety minimums, including safe minimum runway lengths, winds, ceilings, visibilities, and so forth.

Some of the specific questions that were asked during the data entry process were not applicable to Purdue’s training flights. For example, it would be helpful to have the software calculate proper fuel loads. The current software does not do this; rather, it asks for entry of the fuel load in units of thousands of pounds, which is not appropriate for most general aviation training aircraft. Questions relative to aircraft age were not relevant for

Purdue's new fleet and were asked twice. A question relative to arrival time may also be irrelevant, as most training flights may not have scheduled arrival times; such questions should be optional.

The software incorporates a color-coded radar image (Figure 2) with weather data that shows the area over which the pilot will fly during flight, and depicts the weather conditions relative to precipitation that may be anticipated at the origin and destination airports. This image also includes a color-coded line showing the change in risk over time. The line in the example below changes from red to green, indicating a general decrease in risk as the flight progresses.

Figure 2. Color-coded radar map.

Another output display the team suggested is a hazards display similar to that produced by Lockheed Martin's web-based software, which shows current NOTAMS, PIREPS, and other restrictions and warnings (Figure 3). All of these warnings are highlighted in yellow, orange, and red based on the level of risk. The information is summarized in boxes that are also color-coded in terms of risk level. For example, information presented in an orange box is high-risk, while information shown in a yellow box is intermediate-risk in nature. The blue line represents a sample training flight path and the user can see the risk of encountering the precipitation to the east of the path would be relatively low.

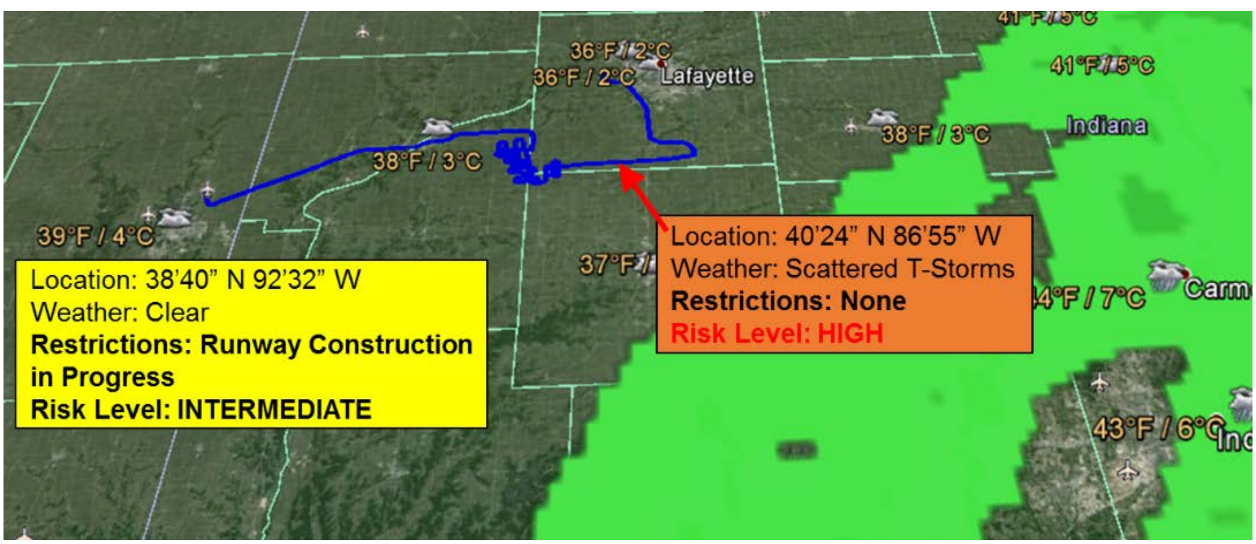

Figure 3. Hazards display.

The team recommended that an option be included to allow for determining alternate departure times associated with lower overall risk levels. This option could also suggest alternate airports that could result in reduced overall risk.

Relevance to the Next Generation of Pilots

Students are generally uninterested in large quantities of information. Younger general aviation pilots are accustomed to sending quick text messages and communicating in an abbreviated style. In order for information to be conveyed effectively, that information must be concise. The team agreed with the focus groups in their assessment that the FlightProfiler weather pages were not overly useful because of their lack of specificity and readability, and their failure to precisely depict which risks to a particular flight might exist. Other information presented was found to be excessive, which too much reliance on the pilot to sort through information to make an adequate determination of risk.

In order to provide relevant information to the next generation of pilots, the industry must emphasize the use of images, animation, and color-coding to help convey important information easily and quickly, an issue that was the primary basis for the team's recommendations. There is a need to create a risk display design that meshes satisfactorily with the decision-making process, to organize risks for quicker reference, to omit unneeded information, and to form better visuals of weather tailored to specific routes and time periods. Understanding and being able to evaluate risk is a very important skill for general aviation pilots. It takes continuous study and experience to develop these skills and to apply them to specific flights. Given information about levels of risk, there will likely always be pilots who choose to fly and others who do not. But the tools discussed here can assist the pilot in developing a better understanding of hazardous conditions that may impact that pilot's ability to safely complete a flight.

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Appendix

Purdue FRAT Tool

Pre Flight Info	YES	NO
solo flight (pre-private)	1	
Student less than 50 flight hours	2	
Student 50-150 flight hours	1	
Instructor's first semester teaching	1	
Instructor has CFII or MEL	-1	
Stress factor	2	
Flight Operations		
Runway less than 4000'	2	
Night landing	2	
No precision approaches available at destination (IFR only)	2	
Non-towered airport	2	
Unfamiliar airport	2	
Class C operations	2	
Student has not flown in the last 2 weeks		
Last Sleep Period (Less than 4hrs)		
Last Sleep Period (4 to 6 hrs)		
Last Sleep Period (6 to 8 hrs)		
Show time (between 7-8am)	2	
Show time (after 6pm)	3	
Maintenance test flight	3	
First flight after a phase or 50hr inspection	3	
Weather		
Departure- MVFR	2	
Departure- IFR	3	
Enroute- Turb. Forecasted along route	1	
Enroute- Thunderstorms forecasted	2	
Arrival - MVFR	2	
Arrival- IFR	3	
Arrival – winds > 15kts		
Training Flights		
Behind flight schedule	4	
Flying multiple approaches (253)	2	
Pattern work		
Instructor or student back to back training flights	1	
Class immediately before/after flight	1	