Accident Reports and Aeronautical Decision Making: Implementing Case-Based Reasoning to Improve General Aviation Safety

Ross Rozanski
University of Southern California

While the fatal accident rate for commercial aviation has been steadily decreasing over past years, that of general aviation has remained largely the same[1]. Although the implementation of concepts like crew resource management and aeronautical decision making have been linked to reducing many commercial accidents, a gap between teaching this knowledge and its successful implementation remains in general aviation. By successfully applying these concepts in general aviation, one of the largest attributed causes of general aviation accidents, pilot error, can be mitigated.

Aeronautical decision making is currently taught with the methodology of rule-based reasoning, which emphasizes learning objectives in a theoretical and academic framework. Research shows that mixing this methodology with case-based reasoning produces safer pilots more capable of reacting to emergency scenarios. Consequently, investigators are called to prepare more thorough accident reports that can be used with case-based reasoning in pilot

[1] NTSB

training, and that members of the aviation community to encourage use of case-based reasoning in pilot training in order to increase general aviation safety.

The fatal accident rate in general aviation (GA) has been constant in past decades, with about 300 fatal accidents each year since 2004[2]. This alarming statistic is indicative of a consistent problem in GA safety that has yet to be addressed, namely pilot error and loss of control of the aircraft, the largest causes of GA accidents. While these issues have been mostly resolved in commercial aviation with the implementation of crew resource management (CRM), the application of this concept in aeronautical decision making (ADM) and single-pilot resource management (SRM) has not yielded a similar decline in fatal accidents. One reason is experience, in which the decision-making processes of expert pilots is qualitatively better than those of novice or intermediate pilots[3]. Specifically, those with more experienced background demonstrated "a qualitative distinction . . in the process of information acquisition and not simply in terms of the quantity of information accessed"[4]. The ability to perform both of these tasks is evident in many fields, in which experts are best able to diagnose a problem by integrating the relevant factors. Although there is no substitute for pure flight hours, a way to increase the task assessment skills of expert pilots into less matured pilots is to encourage critical assessment of their own performance, providing access to simulated scenarios, and reflection of case studies[5],[6].

---

[2] NTSB
[3] Wiggins
[4] Wiggins
[5] Wiggins
[6] O'Hare

Case-based reasoning (CBR) is, in the most general sense, “the act of developing solutions to unsolved problems based on pre-existing solutions of a similar nature”[7]. Through the process of retrieval, analogy, adaption, and learning, one can systematically respond to a scenario with a degree of experience, even if they have never physically experienced the actual situation before. As a learning model, there are several advantages to CBR. Advantages of CBR include the ability to learn incrementally, the notion of adaption, a focus on failure as a learning experience, and taking advantage of the problem-solving information processing intrinsic to human cognition[8]. Although research has proved the advantages of learning with CBR in fields as diverse as medicine and law, only recently has this been studied in pilot training. Several studies using both pilots and non-pilots have demonstrated that reflection on others’ experiences, training that includes CBR with RBR, and recall of critical flight events have produced pilots with more expert decision making skills. Specific examples of this include, “case-based remindings play an important role in expert pilot decision making” and “Participants who reflected on a set of cases involving pilots flying into adverse weather conditions were more likely to follow the VFR rules for minimum visibility in a simulated flight than participants who simply completed a free recall task”[9]. In the context of GA pilot training, CBR and reflective practice enable students to achieves higher correlation between theory and practice and to better identify how they learn in order apply past problems/failures to future actions[10]. But despite the mounting evidence that the learning methodology of CBR and reflective reasoning creates safer

[7] McVea
[8] Batt
[9] O’Hare
[10] Henley

pilots, it contrasts with the methodology used in pilot training and the teaching of ADM currently in use.

The current approach to GA pilot training, specifically ADM and methods aimed to address pilot error, can be significantly improved by the utilization of CBR, with the aim of achieving its benefits. The traditional way to teach ADM differs greatly to how pilots make decisions in the real world[11]. ADM historically has been taught as a rulebook to follow, a concept that seeks to instruct principles broken into chapters that should be considered when pilot-in-command. Many of the situations pilots experience however do not have clear goals or well-defined alternatives, but rather possess an inherent "fuzziness." Situations with such vague and undefined options are best suited for determination of overall similarity, opposed to an exact search[12]. Multiple ways are suggested from literature of how to incorporate CBR and reflective reasoning into current training practices. Taking care never to curtail debriefings, use of a reflective journal, and self-description of maneuvers and tasks facilitate these practices[13].

But without giving students an unrealistically large amount of direct physical experience, the best way to implement CBR is with case studies. For student pilots, this includes scenarios regarding how low to fly, if and how to avoid adverse weather, and others in which a decisive choice must be made after analyzing many variables[14]. These case studies are intended to provide a framework for theoretical concepts with practical examples, in which there are many real-world instances that can be used in ADM.

---

[11] Henley
[12] Batt
[13] Henley
[14] Batt

A case that could be particularly effective if used for ADM purposes is the accident of a Cessna 441 on July 16th, 2008 (NTSB Number: SEA08FA161)[15]. As the private pilot was touching down at Sunriver Resort Airport, the aircraft bounced on and off the runway several times with increasing amplitude. Instead of choosing to go around at this point the pilot committed, and on the last bounce the propeller made contact with the runway. The pilot lost control and was killed. This case has several details that make it a superb example for CBR training. One is that the pilot experienced a challenge common with many pilots, having difficulty with touchdown. Another is that a definitive judgement call had to be made based off indefinite information, how many failed attempts are too many before deciding to go around. Third is the severe consequences of poor decision making, in this case the death of the pilot. The NTSB report cites probable cause as misjudged landing flare and improper recovery, but for ADM purposes this could be improved upon by also stating that any flare with bounces of increasing size should be aborted. Such cases can serve to demonstrate valuable lessons in very real contexts, and therefore focus on the investigations of such cases and the implementation of the reports should be encouraged in general aviation training.

For the purposes of ADM such case studies can be improved. Because humans tend to recall events better with affective details, it is recommended that the case studies used for ADM strongly engage the reader with specific and emotional details that may seem irrelevant in current reports[16]. These details are non-technical but add to the memorability of a given scenario, therefore becoming more effective for ADM purposes. There are three objectives investigators should set in order to improve CBR for GA pilot training: 1.) Provide GA accident reports that

[15] AOPA
[16] Batt

give a recommendation similar to commercial reports, 2.) Consider a pilot's CBR background while conducting investigations, and 3.) Give non-fatal accidents greater detail.

Commercial aviation accident reports often have recommendations to address errors with the goal of avoiding them in the future[17],[18]. But due to a multitude of factors, GA accidents rarely get the same focus, often providing a summary with many open questions for the common pilot. While the reports themselves can prove valuable in learning the consequences of poor ADM, a definitive recommendation at the end can significantly increase a report's learning value. Second, accidents' causes can be more readily identified by taking into account contextual details previously unconsidered, specifically one's case-based background. Although an accident can be attributed to individual incorrect pilot inputs, an evaluation of a pilot's history with the given scenario can shed light on why those errors occurred at all. For example, going off the end of a short runway can be directly attributed to many factors. But any of those factors could have occurred because of lack of experience landing at short runways. Therefore, specific factors could be encouraged to consider specifically for pilots new to that situation. Overall, particular caution can be recommended when entering these situations as a novice, therefore providing more insight into a crash than simply a pilot's fallibility. Third, non-fatal accidents should not receive less study and analysis because nobody died. Anybody in a high-risk field can describe "near-miss" situations in which a disastrous result was avoided by a small margin. Two events can have equally valuable lessons to learn even if their outcomes are wildly different[19]. Neglecting non-fatal accidents can mean neglecting relevant and beneficial insights. It would be unreasonable to declare that every aviation accident be met with the same rigor and resources as

[17] Omoh
[18] Karanikas
[19] Greenwell

some of the largest incidents, and thus it is encouraged priority is given based off occurrence rate of similar accidents and potential for fatal outcomes.

References

Aircraft Owners and Pilots Association (AOPA). ASF Accident Details, NTSB Number: SEA08FA161.

Batt, R. (2005). *Aeronautical decision making: Experience, training and behavior*. University of Otago, Dunedin, New Zealand.

Greenwell, W. (2003). *Learning Lessons from Accidents and Incidents Involving Safety-Critical Software Systems*. University of Virginia

Henley, I., Bye, J. (2003). Facilitating critical thinking and reflective practice. In I. Henley (Ed.), *Aviation Education and Training*. Aldershot, UK: Ashgate.

Henley, I. (2003). Using Problem-Based Learning to Develop Essential Skills in Aviation. In I. Henley (Ed.), *Aviation Education and Training*. Aldershot, UK: Ashgate.

Karankias, N. (2016). *Do experts agree when assessing risks? An empirical study*. Amsterdam University of Applied Sciences / Aviation Academy.

McVea, M. “CBR – Case Based Reasoning”. Purdue University.

National Transportation Safety Board. "Aviation Statistics." N.p., n.d. Web. 9 Apr. 2017

Omoh, A. (2017). “AIB publishes accident reports from four crashes, makes 17 safety recommendations”. *Nigerian Flight Deck*

O’Hare, R. (2010). *Enhancing Aeronautical Decision Making through Case-Based Reflection*. University of Otago, Dunedin, New Zealand.

Wiggins, M. (2002). *Expert, Intermediate and Novice Performance During Simulated Pre-flight Decision-making*. University of Western Sydney, Australia.