Knowns and Unknowns in Air Traffic Controller Safety Reports: Developing a New Method

Paul Krois

Julia Pounds

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Paul Krois, Ph.D., PMP[1]
Crown Consulting Inc.
Aurora, CO

Julia Pounds, Ph.D.[1]
TempoLogics
Mustang, OK

Air traffic controllers in the Federal Aviation Administration can submit voluntary safety reports when significant safety concerns and potential safety events are encountered during their everyday operations. We tested two questions: Can safety reports be classified according to whether the risk was known or unknown to the controller or the system; and would classifying reports in this manner yield useful safety information? A sample of 36 reports was assessed using this known-unknown method. 55% of the reports were classified as risks known to the controller but unknown to the system. 17% of the reports were scored as known to both the controller and the system. 14% were classified as unknown to the controller but known to the system, and 14% as unknown to both the controller and the system. Trends, limitations, and next steps are discussed.

The Federal Aviation Administration (FAA) continues in its mission of providing the safest National Airspace System (NAS) in the world. The Air Traffic Organization (ATO) uses policy, process, programs, and data to monitor safety in operations consistent with its Safety Management System (SMS) and includes safety-related performance targets in its annual business plan. The ATO seeks to mitigate known risks and to uncover unknown risk through its safety assurance and risk mitigation efforts. One of the avenues the ATO identifies and assesses risk, and improves safety culture, is through the Air Traffic Safety Action Program (ATSAP). The National Aeronautics and Space Administration (NASA) has a separate aviation voluntary safety reporting system called the Aviation Safety Reporting System (ASRS) used by pilots, controllers, and others to report safety concerns and issues (Billings et.al., 1976). A commercial airline may have its own Aviation Safety Action Program (ASAP) for a pilot to file a report.

Controller Safety Reporting System

Air traffic controllers in the ATO can submit voluntary safety reports when significant safety concerns and potential safety events are encountered during their everyday operations (FAA, 2017). These reports of hazards and risks are processed and, if appropriate, mitigations are developed and collected as part of safety data. The employee is responsible to ensure that all occurrences of which they are aware, through either direct involvement or observation, are reported. All personnel with knowledge of an occurrence are encouraged to report, even if this

[1] Retired from the Federal Aviation Administration. The opinions expressed in this paper are those of the authors and do not reflect any entity.

results in multiple submissions of the same occurrence. The Operations Supervisor, Operations Manager, and controller-in-charge (CIC) must also report occurrences. Reported occurrences are first reviewed at the facility level as a Mandatory Occurrence Report (MOR), e.g., airborne loss of separation. Facility points of contact review the MOR for possible inclusion of additional data before submission to Quality Assurance.

An ATSAP Event Review Committee (ERC) includes a member of FAA's Air Traffic Organization Management, a National Air Traffic Controllers Association (NATCA) representative, and a member of FAA's Air Traffic Safety Oversight Service. The ERC evaluates each report submitted and determines if it meets the requirements established through the FAA-NATCA Memorandum of Understanding. If the report meets the standards prescribed, the ERC accepts the report and logs it into the ATSAP. During the review process, the ERC also reviews each report to identify actual or potential safety issues and causal factors.

Between 2008, when ATSAP was established between the FAA and NATCA and 2018 over 160,000 reports were generated (NATCA, 2018). Certain ATSAP reports are shared with airlines through the Confidential Information Sharing Program (CISP) involving over 28 participants and over 98,000 reports.

By 2018 NATCA indicated there were over 185 formal Corrective Action Requests (CARs) issued to address serious system safety concerns, of which 112 had been closed/resolved. At least 805 systemic positive changes had been developed from voluntary reporting and informal changes taking place at FAA facilities as reported by NATCA (2018). Reports were used to develop recurrent training curricula and contributed to the development of the ATO's Top 5 safety issues. ATSAP Positive reports were use in this study (NATCA, 2015, 2016). Key to ATSAP and its relationship with safety culture are that reports are de-identified so the reporting employees are kept anonymous.

A Paradigm for Knowns and Unknowns

We tested two questions. First, can safety reports be classified according to whether the hazard or risk was known or unknown to the controller or the system? The system is broadly defined and encompasses the work environment including local facility management and operations, air traffic control procedures and airspace, and airlines. Second, would classifying reports yield useful safety information according to whether the reports represent safety issues either known or unknown to either the controller or the system?

For the purpose of this paper, in a safety management system (SMS), what can be considered as knowns and unknowns corresponds to what the front-line air traffic controller understands juxtaposed to what the system understands. The controller's understanding is based upon expertise built on cumulative years of experience, knowledge of automated systems, airspace, and operational procedures, controller training programs (initial and recurrent), reading safety-related and other ATC informational materials, and discussing operational situations with others. Controllers are professionals who continually take in and apply information to provide the safest ATC service.

Understanding of knowns and unknowns by the system is based on integration of complex types of information from many sources. Systems have been defined to "be people, hardware, software, information, procedures, facilities, services, and other support facets which are directly related to the organization's aviation safety activities" (FAA, 2015). What is known by one part of the system does not mean it is known throughout the system. People are part of the system and include the supervisor and operations manager, controller-in-charge, other controllers, airspace and training specialists, Technical Operations personnel (e.g., software specialists), and pilots.

How the system is expected to operate is prescribed through procedures and inter-facility letters of agreement with prescriptive instructions such as on airspace, communications, and flight restrictions. Automated radar and flight data systems perform functions the controllers use to ensure safe traffic flow and manage workload. Aircraft and avionics are designed, built, and integrated according to standards and certification requirements, and flown by pilots certified through training requirements.

Although the front-line controller is the person who first recognizes or deals with a safety issue, the situation may be emergent and heretofore not previously encountered. Its nature, origin, causal and contributing factors, and possible outcomes may not be understood especially if it has not been directly encountered it before, i.e., it does not fit any known pattern.

The ATO and NATCA categorized safety issues as knowns and unknowns for the controller and management based on over 130,000 ATSAP reports from 2010 through 2016 (2017). 100% of the reports were problems known to rank and file personnel. Of those, 75% were problems known to supervisors. Of those, only 9% were problems known to middle management, and of those, 4% were problems known to top management. Using our taxonomy decision rules, these results can be interpreted to mean that 25% of the problems were unknown to the system and 0% were unknown to controllers, as shown in Table 1.

Table 1. *NATCA Reports Classifications.*

		System		
		Known	Unknown	**Total**
Controller	Known	75%	25%	100%
	Unknown	0%	0%	0%
	Total	75%	25%	

Unknowns represent safety risks. What kinds of unknowns occur? Risk can result from the system performing a function in a manner unknown to the controller. For example, Fort Hill examined ATSAP reports associated with the en route automated handoff function (2012). Review of system design specifications showed there were 17 ways that the automated handoff feature could be manually discontinued for a flight being handed off from the transferring sector and many controllers were not aware of those conditions. The controller was also not informed that the aircraft would be handed off to the incorrect sector if the controller initiated the hand-off just after entering the altitude. This poses that what is known to one part of the system (e.g., software designers) may not be known to other parts (e.g., front-line supervisors and trainers).

Method

Our criteria for classification decisions are shown by our 2 x 2 table of knowns and unknowns as shown in Table 2.

Table 2. *Classification of Knowns and Unknowns Between Controllers and the System*.

		System	
		Known	Unknown
Air Traffic Controller	Known	• Known to the controller such as based on 7110.65, local agreements, or training. • Controller might say "I've seen that before," or "I've not seen that before but other controllers have told me about it." • Known to the system as part of design and operations (procedures, automation design documentation, automation expert knows of interaction in software design, airspace layout, airline flight operations information, etc.).	• Known to the controller such as based on 7110.65, local agreements, or training. • Unknown to the system (e.g., pilot not aware of NOTAM change, local operational workaround, unexpected behavior of system or equipment; unexpected outage, information not included in design or training documentation, etc.) • System unknowingly changes or removes information without understanding impacts or reverberations on the controller. • System creates a threat or hazard that the controller has to contend with. • Report states the condition was unknown to management or other system elements. • Error of omission or commission.
	Unknown	• Report states the condition was unknown to the controller. • Unknown to the controller (e.g., unexpected system action or response). • Unexpected surprise to the controller. • Known to the system as part of design (procedures, automation documentation, automation expert knows of interaction in software design, airspace layout, airline flight operations information, etc.). • Not everything known by the system is known by the controller, or known throughout the system.	• Unknown to the controller (e.g., unexpected system action or response). • Unknown to the system (e.g., pilot not aware of NOTAM change, local operational workaround, unexpected behavior of system or equipment; unexpected outage, information not included in design documentation, etc.)

Classification of an ATSAP Positive report as unknown to the controller was based on a lack of information in the report that the controller knew of the issue before encountering it or the report stated the controller did not know about it. Classification of an ATSAP Positive report as unknown to the system was based in part on a lack of information contained in the report that the facility knew of the issue until it was reported by the controller, the facility did not demonstrate awareness until prompted by the report, and avoiding assuming awareness by supervisor and other managers. The classification was based solely on the information contained in the report. Assumptions were avoided about what might have been implied in the reports or how the reports might have been prepared relative to policy, procedure, or process.

A sample of 36 ATSAP Positives reports were used in this study. There was no identifying information about the controller(s) involved with the reports. A pilot test of the method was applied to ten of the reports to assess the viability of the classification table and to develop agreed upon stopping rules for the actual classification by the authors. The reports were separately assessed and classified by the authors working independently. The classifications were then compared and coding differences were resolved by discussion. Final classification agreement was reached for all reports.

Results

Results of the classification are shown in Table 3 with 72% of the ATSAP Positives reports involved safety issues known to the controller. The system was aware of 31% of the issues.

Table 3. *Results of ASTAP Reports Classifications.*

		System		
		Known	Unknown	**Total**
Controller	Known	17%	55%	72%
	Unknown	14%	14%	28%
	Total	31%	69%	

Safety issues known to the controller but unknown to the system included different issues with terminal procedures (e.g., instrument flight procedures used by the terminal controller were refused by pilots because those procedures were not in their flight database, and a new missed approach procedure took aircraft directly into the flow of traffic at another airport) and areas of missing radio coverage.

Safety issues known to the system but unknown to the controller included controllers not being informed of equipment outages and en route controllers not informed about special approach procedures developed for one airline by Jeppesen and not being trained to read and interpret those procedures. An example of an unknown to both the controller and the system involved not fully understanding sector combine/de-combine en route automation so aircraft and data tags would not be seen in the proper sector.

Discussion

The purpose of this study was to develop and test a classification method for assessing safety data based on a pattern of knowns and unknowns between the controller (human operator) and the system (broadly defined). The data set used in this study was a set of safety reports called ATSAP Positives. The method used stopping rules for making classification decisions using information from the reports. Results showed that 17% of the safety issues shown in the ATSAP Positive reports were known to both the controller and the system. Controllers may need to be better informed about how automation works for different operational conditions as reflected by both 28% of the safety issues being unknown to them and findings from the Fort Hill study. The large percentages of safety issues unknown to the system reflect in part the complexity of interdependencies between different parts of the system.

Limitations of this study include that the ATSAP Positives reports used are not current and the procedures, automation, and training are different now so the identified issues and trends have most likely been mitigated, with perhaps new issues and trends emerging. The amount and quality of information found in the ATSAP Positives reports were considered in classification decisions relative to the stopping rules as well as coding reconciliation between the authors.

Further work is needed to assess the approach using a larger sample of reports such as from ASRS having more details. This method is not intended to replace current techniques for detailed safety analysis but rather to understand trends in safety data from a different perspective. Moreover, revealing patterns of unknowns can reveal potential system risks for mitigation.

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