WHAT IS SAFETY DATA?

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This paper reports on our efforts to determine if the ubiquitous term *safety data* can be more specifically defined. That is, whether data can be categorized as safety data based on some unique characteristics such that other data not having these would be categorized as *not safety data*. FAA analysts rely on multiple sources of objective data for virtually all analyses supporting FAA's decision making. While profuse amounts of data are continuously collected twenty-four hours a day, only subsets are deemed useful for any particular purpose, such as assessing how well an organization conducts its safety or efficiency or security missions on a day-to-day or long-term basis. Therefore, safety data appears to be defined by whether it is used for safety activities, i.e., surveillance, compliance and verification. Conversely, data used exclusively for security and efficiency assessments could be defined as *not* safety data. We concluded that safety data are generally defined a posteriori by how the data are used rather than due to any intrinsic characteristics.

The Air Traffic Safety Oversight Service (AOV) monitors the Air Traffic Organization (ATO) using, in part, reports of ATO safety occurrences/data and, in turn, AOV shares safety data with ATO (FAA, 2006). The AOV order lists examples but does not specify what safety data are and are not.

S*afety data* has become such a ubiquitous term across safety studies that we questioned whether using this expression is essentially just a general convenience or whether it is actually being used as a specific construct in aviation as well as in other industries. Having well-defined data for analysis is the sine qua non - the gold standard - for safety professionals in the Federal Aviation Administration (FAA) and other industries around the world.

Researchers of all stripes learn early the need to define their work so that it is not open to nultiple interpretations; that is, to clearly define their constructs, methods, and data in terms of measurable and observable properties with operational definitions. Unambiguous and measurable data are essential for accurately identifying performance indicators, risk indicators, thresholds, tolerances, and so forth. Unambiguous results better support decision makers' interpretations. If the definition is determined by the industry using it, definitions of *safety data* would be expected to vary across different industries.

As practitioners striving to solve applied problems, we depend on clear and specific constructs and methods to reduce variability in our analyses. Otherwise, how would a researcher determine unambiguously what data were safety-related and useful for safety analyses versus "not safety data" that could be disregarded. Perhaps all data used for safety analyses are defined as "*safety data*." In that case, the term is merely a convenience.

According to the Miriam-Webster Dictionary online, *safety* is defined as *the condition of being safe from undergoing or causing hurt, injury, or loss,* which implies that it pertains to people, places, and things that can be hurt, injured, or lost. Perhaps data are labeled *safety data* if results of analyses are intended for protection of these entities. We collected some high-reliability industry examples to explore these hypotheses.

Nuclear Power Industry

The nuclear power industry uses safety data in its analyses and reports focusing on authorized activities and fundamental problems or hazards related to them, such as unintended conditions or events and radiological releases. The Nuclear Regulatory Commission (NRC) is responsible for regulation and its policies governing nuclear reactor safety relative to commercial use of nuclear materials. As an ultra-high reliability industry, safety data are developed by safety inspectors, reactor operators, equipment vendors, research laboratories, and other sources. Data and methods can include incident and investigation reports, probabilistic fast-time simulation models, equipment inspections, human-in-the-loop simulations, reactor operator training data, surveys, and evaluation checklists (NRC, 2018).

The NRC previously maintained a human factors information system reports database. The database provided annual summaries for each commercial reactor of human performance issues identified in Licensee Event Reports, inspection reports, and licensed operator examination reports. The information was a general overview of the types and approximate numbers of human performance issues documented in reports by either the NRC or licensees.

Other industry analyses focus on the industry's security and safeguards, which are linked but are also defined uniquely. Security analyses focus on intentional misuse to cause harm from external threats to materials or facilities. Safeguards analyses focus on unauthorized activities related to acquisition of materials and equipment or development of nuclear weapons.

The nuclear industry measures for safety, security, and power production tend to be independent of one another. Conceivably, undesirable occurrences in any of these categories might adversely influence persons, places, or things. If so, the idea of safety might be applicable to security and safeguards of people, places, or things. Testing this logic leads to the idea that safety data could pertain to all of these: authorized activities, materials/facilities, and unauthorized activities. However, the soundness of this idea is a bit strained and no instances of this industry using safety data for analyzing facility security, for example, was discovered during this activity.

Chemical Industry

Chemical safety involves a broad number of industries. These industries involve toxic chemical handling (e.g., chlorine and ammonia), hazards of combustible dust, reactive chemicals, oil and gas production, and hot work activities (e.g., welding). The Chemical Safety Board (CSB) has reponsibility to investigate significant chemical incidents and hazards and advocate for the implementation of recommendations to protect workers, the public, and the environment (CSB, 2017). The CSB mission has a cross-cutting relationship with federal and state regulations, industry standards, and other local policies and procedures. The CSB's focus is primarily on specific accidents and incidents especially those involving loss of life and injury.

As part of its work, the CSB may collect data to identify and analyze existing industry hazards and conduct broad safety studies of such hazards to examine commonalities among significant incidents and draw attention to key lessons learned. Their analysis can identify direct and proximate causes of equipment failures, underlying systemic and organizational causes such as inadequacies in corporate or facility-level safety management systems and organizational culture, and opportunities to improve operational practices, regulatory standards, and enforcement. The CSB issues safety recommendations to a variety of recipients, including Federal and state regulatory agencies, companies, industry and labor organizations, standard-setting bodies, and emergency responders.

An example of a CSB investigation was the West Fertilizer Company Fire and Explosion (CSB, 2013). The accident involved 15 fatalities and more than 260 individuals injured from the fire and detonation of fertilizer grade ammonium nitrate. The CSB report used data from multiple sources to assess contributing and causal factors. The report organized key safety findings as technical, regulatory, insurance, emergency response, emergency planning, and land use planning. Underlying many of these findings were the people involved in various roles, making decisions based on information available at that time, at varying points in time prior to the accident for which there could not have been any line of sight leading up to the accident such as a prescient warning.

Software Acquisition

Safety-critical software must meet both system specifications and safety-critical performance requirements. At the FAA, development of software is determined through policy in the Acquistion Management System (AMS) (FAA, 2019). The objectives of the AMS are to increase the quality, reduce the time, manage the risk, and minimize the cost of delivering safe and secure services to the aviation community and flying public. Data to support these objectives are collected across the acquisition life cycle, including an Operational Safety Assessment and Preliminary Hazard Analysis. Guidance for collecting human factors and human performance data during acquisition of safety-critical software is provided in the Safety Risk Management Guidance for System Acquisitions (SRMGSA) (FAA, 2018). Safety data are also obtained by operational testing of software prior to its implementation. Controllers and maintenance experts use representative operational scenarios to validate that the software is an effective and suitable design solution that meets operational needs (FAA, 2019).

Safety issues may also be identified after deployment in the field through post implementation reviews. These reviews provide an everyday operational perspective beyond what can be accomplished in a testing laboratory environment. Reviews can also draw on security, efficiency, environmental (e.g., noise abatement), and other important parameters and data sources as part of identifying and mitigating potential safety issues.

The FAA applies a safety risk management process to all acquisitions that impact the NAS. From development to operational deployment, data are important in determining whether an acquisition supports service that is at least as safe as what is currently being used. The addition of functionality through automation and procedures augments safety by providing more effective and efficient service. Data would be used to validate no decrease to safety while some of that same data could be used to validate efficiency gains.

Aviation

The International Civil Aviation Organization (ICAO) published the 2017-2019 Global Aviation Safety Program which defined safety data as:

> A defined set of facts or set of safety values collected from various aviation related sources, which is used to maintain or improve safety. Note. Such safety data is collected from proactive or reactive safety-related activities, including but not limited to: a) accident or incident investigations; b) safety reporting; c) continuing airworthiness reporting; d) operational performance monitoring; e) inspections, audits, surveys; or f) safety studies and reviews.

FAA

The continuing mission of the FAA is to provide the safest, most efficient aerospace system in the world. FAA established the national policy for safety management (FAA, 2016) which defines safety as the state in which the risk of harm to persons or property damage is acceptable.

Aviation has many stakeholder groups, the most important being the flying public. Each group monitors and improves safety levels in their areas of responsibility: commercial carrier companies, aircraft manufacturers, air traffic service delivery providers, and so forth. All depend on safety data collected by various means and from a variety of sources, pertaining to avoiding adverse outcomes.

Continuous improvements in aviation technologies, procedures, etc., have led to a level of safety such that accidents have become very rare events compared to traffic levels. To accomplish this, the FAA relies on multiple data sources to assess and monitor its programs, initiatives, plans and strategic goals.

The FAA collects and stores large amounts of data from real-time operations. However, FAA published system performance indicators that identified only three types as ATO safety metrics: number of runway incursions and surface incidents and en route losses of standard separation (FAA, 2018).

It's reasonable then to assume that the safety data label could apply to all types of aviation data, given that the goal is avoiding unsafe conditions and outcomes for its stakeholders. Here safety may be the primary use but with categories collected for other uses, similar to the nuclear industry, such as equipment outages, personnel training results, voluntary reporting systems, and oversight activities. Defining data primarily used for safety versus, for example, effeciency is helpful for several reasons, including, specificity of terms, support for efforts to standardize and harmonize data-based safety oversight tools and methods, and reducing conflicting interpretations by stakeholders.

AOV

The FAA Administrator established AOV in 2004 (FAA, 2006) making AOV responsible for independent oversight of the ATO. The order directs AOV to use safety data to fulfill its mission and responsibilities and gives examples of data types. The order also makes ATO responsible to collect, track, and analyze safety data, and to report safety data to AOV upon request. Examples identified include: ATC incident and accident rates, NAS equipment maintenance issues, flight inspection issues, results from safety risk assessments, and results from ATO internal oversight, evaluation, and quality assurance programs. Collected from different types of ATO operations, these data may contribute to the three FAA reported safety metrics.

In 2011 Press undertook to operationally define ATO safety data as it might pertain to AOV activities, e.g., surveillance, compliance and verification. In 2004 Press had advised that any definition should prevent multiple interpretations. For example, it must be representational, unique, and meaningful of the target. He identified several challenges and prescribed solutions based on the idea that safety data cannot be defined without also including its ulterior use.

ATO

The ATO performance indicators published by the FAA characterized air traffic operations (2018) and included three to indicate the safety of the NAS based on number of runway incursions and losses of airborne separation. The metrics for runway incursions were limited to the Core 30 Airports showing counts from Fiscal Year (FY) 2013 through 2017. Incursions were categorized by type of incident. The Loss of Standard Separation Count was shown for en route centers from FY 2013 through 2017.

Other categories of data could potentially intersect to influence safety and thus could be used in safety analyses and so also considered as safety data. For example, the report also includes numbers representing system efficiency, such as NAS delays, diversions, go-arounds, and cancellations, and numbers from traffic management initiatives, such as those used to manage traffic volume, excess demand and airport acceptance rates. As part of research on human performance in provision of air traffic services, Cardosi & Yost (2000) reported using safety data in a study of controller and pilot errors. They used incident and accident reports from ATO operations, the Aviation Safety Reporting System (ASRS), and the National Transportation Safety Board (NTSB).

In 2013 Kimble proposed to improve integration of ATO safety-related data. Examples listed included: ATC operational data from automated NAS systems; ATC personnel data, e.g., training, certifications, and proficiency; voluntary safety reporting programs; radar, voice, and facility communications data; weather; and facility logs (ATO, 2013).

Discussion

After considering how the term *safety data* was used in these high-reliability industries, it seems that the the common denominator is safe human performance but the industry's goals and respnsibilities seem to determine whether data related to safety is the primary goal, an equivalent goal or a secondary concern. For example, a business would use one set of data to track workplace safety and another set to evaluate product safety. The goal of analysis would determine which data are used as primary, equivalent, and secondary safety data rather than safety data vs. not safety data.

So, is *safety data* a ubiquitous term, an unnecessary term, or a useful term? Certainly, its use is pervasive. It's short, to the point, and satisfying in a sentence. Synonyms seem more clumsy, wordy or redundant, e.g., well-being, secure, safe-keeping. The answer to the question: "What is not safety data?" seems to be that it depends on the industry, the industry's production and outcome goals, and the industry's responsibilitues for avoiding harms to persons, places and things.

Disclaimer

The views expressed herein are those of the authors and do not reflect the views of the Federal Aviation Administration.

References

International Civil Aviation Organization. (2016). Global Aviation Safety Plan. Doc 1004 (pp. ix). Montréal, Quebec, Canada. Retrieved from https://www.icao.int/safety/Pages/GASP.aspx

Kimble, T. (2013). Operational Analysis and Reporting System (OARS) Program. Presented at Integrated Safety Risk Assessment Advisory Committee Meeting. Washington, DC.

Cardosi, K & Yost, A. (2000). Controller and pilot error in airport operations: A review of previous research and analysis of safety data. DOT-VNTSC-FAA-00-21 Office of Aviation Research, Washington, DC

Chemical Safety Board. (2017). Strategic Plan, 2017-2021. Washington, DC: U.S. Chemical Safety and Hazard Investigation Board. Retrieved from https://www.csb.gov/assets/1/6/csb_strategic_plan1.pdf

Chemical Safety Board. (2013). Chemical Safety Board Investigation Report, West Fertilizer Company Fire and Explosion, Final Report 2013-02-I-TX. Washington, DC: U.S. Chemical Safety and Hazard Investigation Board.

Federal Aviation Administration. (2019). Acquisition Management Policy. Washington, DC: Federal Aviation Administration. Retrieved from https://fast.faa.gov/docs/acquisitionManagementPolicy/AcquisitionManagementPolicy_4.pdf

Federal Aviation Administration. (2018). Safety Risk Management Guidance for System Acquisitions (SRMGSA). Washington, DC: Federal Aviation Administration.

Federal Aviation Administration. (2018). Air Traffic by the Numbers. Washington, DC: Federal Aviation Administration.

Federal Aviation Administration. (2016). Safety Management System (Order 8000.369). Washington, DC: Federal Aviation Administration.

Federal Aviation Administration. (2006). Air Traffic Safety Oversight Service (Order 1100.161). Washington, DC: Federal Aviation Administration.

Nuclear Regulatory Commission. (2018). Research Activities 2018-2020, NUREG-1925, Rev. 4. Washington, DC: Nuclear Regulatory Commission. Retrieved from https://www.nrc.gov/docs/ML1807/ML18071A139.pdf

Press, J. (2011). A data definiton framework for air traffic safety oversight. Washington, DC: Federal Aviation Administration.

Press, J. (2004). A measurement framework for air traffic safety metrics. DOT/FAA/CT-TN04/10. Washington, DC: Federal Aviation Administration.