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Multimodality in transport accidents: challenges and opportunities

Multimodalidad en accidentes de transporte: desafíos y oportunidades

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Abstract

Advances in air transport accident investigation have been prodigious and have made a major contribution to the safety of the industry. This has allowed aviation to climb successive rungs on the safety ladder as a result of accident analysis. This article summarises, in a necessarily summarised way and from an international perspective, how the pillars that contributed to aviation's success have become challenges to maintaining the contribution of accident investigation in the face of the minority and incipient -but growing and irreversible- trend towards the integration of multi-modal investigation bodies, while outlining the opportunities for improvement that such challenges present.

Resumen

Los avances en la investigación de accidentes en el transporte aéreo han sido prodigiosos y su contribución a la seguridad de la industria ha sido preponderante. Esto permitió que la aviación trepase sucesivos peldaños en la escalera de la seguridad operacional, producto del análisis de accidentes. Este artículo compendia, de manera forzosamente resumida y desde una perspectiva internacional, cómo los pilares que contribuyeron al éxito en la aviación se han convertido en desafíos para mantener la contribución de la investigación de accidentes ante la minoritaria e incipiente –pero creciente e irreversible– tendencia a la integración de organismos multimodales de investigación, a la vez que bosqueja las oportunidades de mejora que tales desafíos presentan.

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Introduction

Advancements in aviation accident investigation have been remarkable, and their contribution to the safety of the industry has been significant. This has allowed aviation to climb successive steps in safety through accident analysis.

This article compiles, in a necessarily summarized manner and from an international perspective, how the pillars that contributed to aviation's success have become challenges to maintaining the contribution of accident investigation in the face of the minority and incipient—but growing and irreversible—trend towards the integration of multimodal investigation bodies, while outlining the improvement opportunities that these challenges present.

One fundamental consideration to keep in mind when transferring experiences between modes of transportation is that the successful path taken by aviation investigation and, especially, accident analysis didn't come without its flaws. The lessons from aviation achievements may not always be transferable to other means of transport, but the lessons from its failures certainly are.

A note before addressing the matter: this article does not concern conceptually with the collection of evidence during the investigation but with the analysis of the evidence collected after the investigation. This is because the challenges for multimodality do not arise from the investigation itself, which is essentially practiced as it was a hundred years ago, but from the transformation of the collected evidence into information that contributes to the safety of transport operations[1].

The (Im)probable Cause

Historically, the foundational notion of aviation accident analysis has been the probable cause. This notion and its perpetuation are, like many others, a legacy of the American system to aviation, and its transfer to other modes of transportation is a fait accompli. It was first used in aviation in 1934, in an amendment to the Air Commerce Act of 1926, which was the starting point for the regulation of air transportation in the United States. The clause has legal connotations: in U.S. criminal law, probable cause is the standard that defines the reasons authorities must provide to justify the detention of a suspected criminal or the search of private homes. The standard aims to limit the power of authorities and promote the lawful collection of evidence, observing appropriate procedural forms.

[1]More comprehensive treatment of the topic can be found in "La causa improbable. Una crónica de la contribución de la aviación civil al análisis de accidentes de transporte en el siglo XXI" by Daniel Maurino and Juan F. Mangiameli (2022). This book is available in ePub format on Baja-Libros.com offering insight into the contribution of civil aviation to the analysis of transportation accidents in the 21st century.

"The challenges for multimodality do not arise from the investigation itself but from the transformation of the collected evidence into information that contributes to the safety of transport operations."

One can argue good intentions in applying the standard to transportation accident analysis, such as explicitly defining the authority of investigators, promoting protocol-based evidence collection, justifying the analysis, conclusions, and safety recommendations, etc. However, the result has been controversial, and the controversy has not been exhausted. This is because the application of the standard to transportation accident analysis fits into the intersection of issues with safety, technical-operational, legal, juridical, and cultural dimensions. Nevertheless, it would be a mistake to completely discard the notion of probable cause as a comprehensive framework for accident investigation. There is consensus in the international safety professional community about the validity of retaining probable cause applied to the analysis of technical system failures, where anomalies speak clearly and rarely repeat, making each accident something new. However, there is also consensus that probable cause, as applied to the analysis of failures in sociotechnical systems, becomes improbable when applied to the analysis of sociotechnical system failures, where anomalies speak in whispers, ambiguities, and repetitions, resulting in no new accidents.

The fundamental argument against applying probable cause—or its contemporary version, the root cause—to the analysis of sociotechnical system failures can be summarized in three considerations:

- The clause conveys extreme simplification and is a framework that distorts and fails to reflect the real complexity of the multitude of factors converging in the triggering of accidents in the sociotechnical system.

- Even the best-worded statement of probable cause does not say much about why the accident occurred; it diverts attention from the multiple and diverse factors always present in the causal chain and channels it toward a single factor.

- Like any technical statement specifically oriented toward a single conclusion, the clause can be interpreted by those who are not integral to the

investigation, by those who know the end of the story but not its course, and by the public media as if the statement of a single factor leads to assigning responsibility to the one who caused the accident.

Many countries, in addition to the United States, retain the clause, and the United States has entrenched itself in an immovable position justified by the fact that the clause arises from federal law. Due to the influence of the United States at the global level, probable cause endures, both institutionally in organizations and individually in accident investigators. Opposing the use of the clause are countries such as Argentina, Australia, Canada, Finland, France, Japan, the Netherlands, Norway, New Zealand, the United Kingdom, Singapore, and Sweden, which have abandoned the notion of probable cause and have adopted clauses such as "factors related to the accident," "risk factors," "factors related to causes," "other risk factors," etc.

A first specific challenge and opportunity for improving the multimodality of accident analysis is clearly expressed through a battle cry that originated in aviation back in the 1980s: "down with probable cause!"

Difference Between Investigation and Analysis

All modes of transportation collect safety data. In the case of aviation, data collection is substantial and stored in computerized repositories with tremendous potential for optimizing the management of stored data. However, transforming this substantial volume of safety data into actionable information through analysis is another story. Some propose that aviation is an industry rich in data but poor in information. This is a systemic condition that transport accident analysis cannot ignore. The collection of evidence about the facts and circumstances surrounding an accident generates data that the subsequent analysis must transform into actionable information for the purpose of formulating safety conclusions and recommendations. These are two connected but distinctly different activities within the same process: investigating (collecting evidence) is finding the puzzle pieces, and analyzing is putting the puzzle pieces together coherently. Nevertheless, in most—if not all—investigation bodies, both activities are performed by the same professionals, assuming that the competencies for analysis are congruent with the competencies for evidence collection. This is a fallacious presumption.

Training in aviation—and in transportation in all its modes—for the development of professional competencies for evidence collection (finding the puzzle pieces) is extensive. It is the central axis of safety professional training, offered by official bodies, universities, and industry organizations, with an offering accessible to all budgets. In contrast, training for the development of specific professional competencies for accident analysis (assembling the puzzle pieces coherently) does not have a similar offering and is typically limited to material analysis. The reason is a historical continuation: the absolute priority of transport accident investigation during the precontemporary era—the era of technical system failure analysis, from the 1950s to the 1970s—was the improvement of technology, and evidence analysis was based exclusively on knowledge of exact sciences, which was common among investigators. Under this approach, competencies for evidence collection and analysis overlapped. The landscape is quite different when it comes to analyzing failures in sociotechnical systems, where knowledge of exact sciences contributes but is not sufficient on its own, demanding a multisectoral, multidisciplinary approach and, therefore, multiple and different competencies.

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The fundamental problem that hinders training to develop the necessary professional competencies for accident analysis under the sociotechnical approach is that—at least in aviation—neither the position's profile nor the task analysis of the aviation safety analyst have been formally defined. Throughout its history of institutionalized dialogue, the aviation industry has not reached a consensus on the competencies, profile, or tasks of the safety analyst.

A second specific challenge and opportunity for improving multimodal accident analysis lies in reaching a consensus across different modes of transportation regarding the profile of the safety analyst and the associated competencies, formalizing task analysis, and developing training curricula to facilitate the effective alignment between the activities of evidence collection and analysis, all integrated within the overall accident investigation process.

Reactive vs. Proactive

The distinction between reactivity and proactivity is a term that emerged as a result of the introduction of Safety Management Systems (SMS) into the aviation industry in 2005. This differentiation was considered necessary because, up until then, accident investigation—a reactive process—had been the primary source of safety information. It was initially intended to raise awareness without sparking controversy. However, the issue and the associated debate have persisted. Like the concept of probable cause, this terminology has also been transferred to other modes of transportation.

It's evident that accident investigations are reactive since they cannot begin until after an accident has occurred. After all, what would they investigate otherwise? However, whether accident investigations are reactive or proactive is neither inherently good nor bad. It doesn't imply merits or demerits but simply describes their nature. Engaging in a debate about the merits of proactivity versus the demerits of reactivity, or vice versa, is unproductive. The real issue here is the confusion between the nature of the accident investigation process and the institutional attitude of the investigative body responsible for it. The fact that the process is inherently reactive doesn't mean that the institutional attitude of the accident investigation body should also be reactive.

Some accident investigation bodies—though not many—have recognized this difference and have taken measures to prevent institutional inertia during periods between accidents when the body is not called upon to perform its specific function. These organizations utilize their data repositories, for example, to conduct multi-theme safety analyses at the national system level, develop information regarding safety priorities, coordinate studies on specific safety issues, etc., which are then shared with a broader range of government and industry organizations to find macro-level solutions. These organizations have institutionalized an internal department, permanent and independent of the investigation activities, for data mining and the development of safety information. In this way, even though the accident investigation process is inevitably reactive, the institutional attitude of the body reflects a healthy integration of reactivity and proactivity.

A third specific challenge and opportunity for improving multimodal accident analysis is raised: the development of consensus guidelines for the formalization of internal structures within accident investigation bodies to support data mining—without forgetting that the specific function of the body is investigation—and to foster a proactive institutional attitude. It goes without saying that the likelihood of successfully addressing this challenge depends largely on the resolution of the previous challenge.

Cooperation between Technical and Judicial Investigations

Cooperation between technical and judicial investigations is a thorny issue in accident analysis, given the particular nuances of each mode of transportation and closely related to the actual degree of independence and autonomy of the investigative body. Finding a solution for harmonious cooperation between two activities with such disparate purposes (one focused on not determining responsibility or assigning blame, the other on determining responsibility and assigning blame) is a significant challenge. In aviation, the international regulatory support for cooperation between technical and judicial investigations of accidents is established by the International Civil Aviation Organization (ICAO) in Annex 13 (Aircraft Accident and Incident Investigation) to the Convention on International Civil Aviation, as well as in the Manual on the Protection of Safety Information (Doc 10053), which provides supporting material for implementation.

The global landscape in this regard is heterogeneous. In some jurisdictions, ICAO's regulations and supporting material on this topic have been adopted as long as they are compatible with the prevailing legal code. In others, the issue has been sidestepped. This should not be surprising since the matter combines legal, sociopolitical, technical-operational, and cultural dimensions more than the application of probable cause to the analysis of sociotechnical systems. The problem in advancing on this issue is that, at least in aviation, the solutions proposed by ICAO invariably originate from countries with common law legal systems, which represent less than one-third of the world. In the remaining more than two-thirds of the rest, civil law legal systems prevail. The compatibility between the two systems is relative, based on the defining characteristic of each: common law arises from precedents that can

be binding; civil law arises from explicit, transcribed codes that are publicly accessible. Under common law, a judge may make binding decisions based on precedents; under civil law, a judge must decide based on the relevant explicit code, and precedent can be used as reference but is never binding.

Why highlight this detail? Because aviation experience indicates that, for reasons that go beyond the scope of this article, common law is more amenable than civil law to formalizing protocols that coordinate technical and judicial investigations of accidents. The dilemma is evident, at least in aviation: the solutions proposed by ICAO for the majority derive from legal systems that are in the minority and have recognized differences from the legal systems that are in the majority worldwide. This complicates the transfer of solutions between the two systems and, more importantly, their real effectiveness. Therefore, attempting to coordinate technical and judicial investigations after an accident in jurisdictions with civil law legal systems using solutions originating from common law legal systems may have little merit. The foregoing should not be interpreted as resignation but rather as an argument in favor of contextualized solutions rather than copied ones. The formalization of protocols for coordinating technical and judicial investigations after accidents in jurisdictions with civil law legal systems should consider three realities of these jurisdictions:

- The participation of the judicial authority in the investigation after an accident is inevitable and prominent.
- Under the rule of law, denying access to information to the judicial authority is not permissible.
- It should be assumed that the final report of the accident investigation will be used by the judicial authority as a matter of course.

From these three realities, efforts to formalize coordination between technical and judicial investigations after an accident in jurisdictions under civil law must operate within the possibilities and limitations of each jurisdiction, rather than attempting solutions incompatible with the system or fantasizing about modifying it. For example, it should be attempted to reach a consensus on a protocol for the limited involvement of judicial authorities immediately after an accident, establish explicit guidelines for access to investigation data that are time-sensitive for each authority, produce final reports that describe and explain without subjective language, etc.

A fourth specific challenge and an opportunity to improve the multimodality of accident analysis is presented: the consensual development of standards for formalizing coordination between technical and judicial investigations of accidents among different modes of transportation in jurisdictions under common law, based on a contextualized assessment of the possibilities and constraints of the prevailing legal code, avoiding the copying of solutions.

Effectively Communicating the Message

All modes of transportation have their own jargon. In aviation, for instance, the distinctive feature is the use of abbreviations: control tower becomes TWR, aerodrome becomes AD, flight level becomes FL, and so on. This is inconvenient for someone reading a technical aviation document without a filter, and the fact that the abbreviations are of English origin doesn't help either. Furthermore, the predominant profile among aviation professionals, and in transportation in general, is oriented towards the exact sciences rather than humanities. Finally, until recent times, the average formal education level of technical and operational personnel, at least in aviation, was at the secondary school level. The combination of the above factors results in a professional profile, on average, that favors technical content in writing and telegraphic brevity in communication.

> ***"The collection of evidence about the facts and circumstances surrounding an accident generates data that the analysis must then transform into actionable information for the purpose of formulating conclusions and safety recommendations."***

Naturally, the final report of a type of accident investigation drafted by professionals with the characteristics described in the previous paragraph can only reflect them. A non-exhaustive exercise in quality control would reveal the following aspects to improve in the writing of a type of accident investigation report:

- Telegraphic sentences and writing errors.
- Excessive technical jargon and unexplained abbreviations.
- Presumption of the reader's knowledge of technical issues related to the facts and circumstances.
- Lack of context that allows for an understanding of facts and circumstances.
- Excessive detail in data and parsimony in analysis.
- Qualitative adjectives, including value judgments, at the expense of neutral description

- Repetition of factual content in the analysis.
- Obscure connection between analysis and conclusions.
- Ambiguity in safety recommendations.

The final report of an accident investigation is the main product of the accident investigation agency, as well as a public document that must be widely accessible. Its writing should facilitate understanding of the facts, circumstances, analysis, and conclusions that arise from it. Its content should be accessible to the widest spectrum of society. However, the writing style of the typical accident investigation report makes it manifestly inaccessible to those who are not experts in the field. Attention to the writing and editorial correctness of the final accident investigation report is not a minor issue: a good idea communicated poorly loses its value. It is not uncommon for the effort, the product of evidence collection and analysis, to see its potential devalued by shortcomings in the communication of the message, which is transmitted incompletely or not at all. There are alternatives –non costly– to address this challenge, the most obvious of which is the incorporation of professional editors into the accident investigation agency.

A fifth specific challenge, and an opportunity for improving the multimodality of accident analysis, is as follows: the accident investigation agency should institutionalize mechanisms to ensure editorial correctness and readability of the final report for the widest audience.

Finally, Regarding Multimodality Itself

Accident investigation originated in aviation with the aviation industry itself. In the absence of other guiding sources, aviation initially adopted techniques and procedures from judicial and police investigations, gradually adapting and innovating in favor of its own process for which it assumed ownership and responsibility. Other modes of transportation followed a similar initial path to aviation but with one key difference: they retained the judicial and police systems as the custodians of the investigation process. Consequently, in many jurisdictions, the responsibility for investigating accidents falls to court officials supported by transport experts for road and rail accidents, the coast guard for maritime accidents, and so on.

This situation began to change during the 1990s. Various jurisdictions started the institutional integration of accident investigations from various modes of transportation into a single organization, based on the one that had been investigating aviation accidents up to that point. This gave rise to the concept of a multimodal accident investigation agency. Consequently, these aviation accident investigation boards became, institutionally, multimodal transport safety boards. As a result of this situation, in October 1993, the United States, Canada, Sweden, and the Netherlands established a forum for institutional learning through the exchange of information between multimodal investigation agencies: the International Transport Safety Association (ITSA). A condition for joining ITSA is precisely that the requesting agency must be multimodal to contribute to the exchange of experiences between modes of transportation. Thirty years later, ITSA has 18 member countries out of the 193 United Nations member countries. This fact alone reveals the challenges to be overcome on the path to establishing multimodality in accident investigation agencies. Additionally, off-the-record sources suggest that in some of these 18 countries, the institutionalization of multimodality does not necessarily translate into multimodal practices in accident investigation.

> ***"A third specific challenge: the development of consensual guidelines to formalize to formalize internal structures within organizations and foster a proactive institutional attitude."***

Ultimately, the decision regarding the necessity and convenience of multimodality for the accident investigation agency should consider two factors: What is the problem in the local context of the country for which the multimodality of the accident investigation agency is a solution? Why is it considered necessary in the local context? It should be noted that introducing multimodality without a clear purpose, as an end, rather than to an end, could jeopardize the credibility of the accident investigation process. The specific goal should be established explicitly in advance because the fact that multimodality works and is a solution in one context does not necessarily mean it will work and be a solution in others.

A sixth and final specific challenge, and an opportunity for improving the multimodality of accident analysis, is as follows: each jurisdiction must assess the real need for the multimodality of the accident investigation agency. This is an individual challenge for each jurisdiction, and the decision should not be based on what is done elsewhere but rather on the needs and constraints of each context. If decided upon, copying solutions should be avoided, and multimodality should be established considering local needs and constraints.

CONCLUSION

The resolution of the challenges to multimodality in accident analysis outlined in this article is a significant factor in reaffirming the accident investigation process as one of the key components of transport industry safety. These challenges do not arise from the process itself but rather from the actions of the agencies responsible for carrying it out, including their personnel. They are a result of the impact that the evolution of accident analysis thinking, and practice has had at an institutional level. In this regard, it is appropriate to conclude with a basic guideline: if there are criticisms of accident investigations in transport, they should be directed towards the agencies responsible for them rather than towards the process itself.

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Recently, he served as a project manager for the Spanish Aviation Safety Agency (AESA) and the National Civil Aviation Administration (ANAC) of Argentina in the implementation of their respective SSPs. He also advised the Argentine Civil Aviation Accident Investigation Board (JIAAC) on accident analysis and safety information management, as well as in the transformation of JIAAC into the current multimodal accident investigation agency, the Argentine Transportation Safety Board (JST). He is an Honorary Professor at the Transportation Institute (IT) of the National University of San Martín (UNSAM).

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