

The Advantages of an Exhaustive Analysis of Polyfragmented Victims of Air Crashes Based on a Specific Case Study



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Abstract

This article presents a recent air crash that occurred in France (a private, single-engine jet with a pressurized cabin, with six people on board, operating under “instrument flight rules” and falling at an extremely high speed), causing significant fragmentation of the bodies of its passengers and of the aircraft and scattered debris. The comprehensive procedure known as the “recovery-triage” of the bodies and various genetic analysis tools made it possible to identify quickly all the occupants of the aircraft and to return them largely to their families. A study comparing geolocation and the weighing of fragments of human remains, described here for the very first time, also made it possible to determine the aircraft’s final trajectory, its impact on the ground, and the exact positions of the occupants in the aircraft. Lastly, a statistical analysis (Dirichlet distribution and Wilcoxon test) also allowed us to design a procedure for sampling the number of body fragments to be analyzed to obtain the best identification results. This method therefore allows victims’ bodies to be rapidly returned to their families and provides information, under certain conditions, about the position of the occupants of an aircraft. The aeronautical value of forensic work on air crashes is once again demonstrated. This work may provide a foundation for further reflection on the recommendations to adopt, not only about small plane crashes, but also where identical disasters of greater magnitude are concerned.

Keywords: Air crash; Identification; Victim Disaster; Index fragmentation

Abbreviations: PM: Post-Mortem; AM: Ante-Mortem; DVI: Disaster Victim Identification

Introduction

An aircraft crash is a transport accident that is often dramatic because of its violence and suddenness, and because of the often-large number of deaths it engenders. In addition to the technical examination of the aircraft that is carried out in order to understand the origin of the crash and how it actually happened, the examination of the bodies of the victims, and the analysis of their injuries by medico-legal specialists are intended to provide eagerly awaited answers concerning victims’ identities, as well as details on the origin of the accident and the modalities of the ground impact of the cabin. Following the crash of a medium-capacity aircraft, where the remains of the victims were all severely fragmented, we sought to determine whether the comprehensive analysis of all human tissues, including the manner in which they

were dispersed on the ground, could shed light on the position of the occupants in the aircraft, as well as on the dynamics of its fall.

Background Information

Every year in France, there are approximately 15 fatal accidents involving aircraft crashes. The prosecutor in charge of the initial investigation often classifies such events as “manslaughter”. From the very beginning of the investigation, all the surfaces on which there are scattered debris are counted by the police who “seal off the area”, meaning that access for anyone who is not part of the investigation is restricted. The objective is to preserve all traces and clues resulting from the aircraft accident while awaiting the arrival of the specialized units of the gendarmerie, including

the air transport investigators. The success of a disaster victim identification (DVI) mission depends largely on the group to which the committed specialists belong and on the management of operational principles (drafted in the form of protocols).

For instance, the manner in which the collection of the bodies is designed must make it possible to examine quickly the human elements, based on the objectives of the investigation (the search for evidence to try to explain the crash), an action that is equally mandatory where aircraft crashes resulting in major fragmentation are concerned. We can draw an analogy with field medicine, where the triage of the wounded is successfully used to manage the initial number of victims by classifying them according to categories, based on the injured and those requiring care; this concept is applicable to the management of mass disasters where systematic decisions must be taken regarding the fragments found.

Regarding the identification of *vitae-mortem* (AM) forensic team works in the traditional manner (DNA samples taken from relatives, contact with victims' dentists to obtain odontograms, research on jewelry and / or prostheses worn) in order to collect all the useful items to compare with the data collected by the post-mortem (PM) forensic team, after the completion of the medicolegal autopsies. A judicial requisition is also sent to the National Agency for Secure Credentials (ANTS) to access victims' fingerprints, collected when they obtained their passports or national identity cards (fingerprints, like DNA and dental specificities, are classified as "primary" identifiers according to INTERPOL) [1,2].

Recommendation for the "Triage" of Fragments of Body Remains

Prior to the post-mortem examination, the personnel in charge of data collection must establish a system for tracing the body elements. This system must consider the severity of the fragmentation and the extent to which the tissues are commingled. It is also necessary to develop an intuitive index system for sorting the fragments of human remains, and to determine, according to the violence of the crash, what is referred to as "fragments not readily identifiable". Some time is also needed to clarify the recommendations for the collection of DNA samples. The staff responsible for these recommendations must be convinced that the establishment of these protocols, drafted without delay, will have significant and lasting consequences both for the staff in charge of the investigation and for the bereaved families.

Human Remains Tracking System

Searching for and executing a system for tracking remains is essential to ensuring the integrity of the chain of custody and the management of a considerable amount of data, throughout the identification procedure. This system must be basic and sequential and must disallow unnecessary duplication. It must

also be simple to use and to understand, and easily adaptable to the different situations encountered in a simple accident, as well as being operational in events involving major fragmentation. Lastly, it must remain unchanged once the operations begin (changes are a source of confusion and increase the risk of errors). This system must interfere neither with the systems used for other incidents, such as ante-mortem data or material evidence, nor with the classification system used daily within the local morgue in the area where the event occurred.

"Fragments not Readily Identifiable"

All human fragments, irrespective of whether they are identified or not, are subject to scientific, ethical, and legal considerations. Before they begin their operations, investigators must know whether their objective is to identify all victims or all fragments. The evolution in the field of DNA techniques now allows biologists to identify (in theory at least) and to re-associate fragments previously little considered as being exploitable. However, the existence of these sequencing tools must not result in a comprehensive analysis. The term "fragments not readily identifiable" thus includes tissues that do not give positive results after their analysis or where the analysis is not considered to be ethically acceptable at the time of collection.

This set is therefore made up of organic materials in which the scientific criteria normally required reflects the total absence of a possible identification through a specific individual character and/or provides no information as to the origin of the death or crash. From a scientific point of view, the need for this group is dictated by the state of the tissues (significant fragmentation, degree of thermal modification, and severe decomposition), irrespective of whether an open or closed disaster context (list of victims known and unchanging) is concerned and despite the quality of the ante-mortem information collected. The expectations of the families and the considerations of the investigators are clearly different [3].

The recommendations for the classification of these groups must therefore be clearly defined if the tissues are highly fragmented (i.e., very numerous) and must consider laboratories' capacities to analyze the samples (concept of "threshold" of DNA profiling [limited to simple samples or a minimum mass]). These recommendations are also accident-dependent (natural disaster, terrorist attack...) and, once determined, should only be changed if the examining magistrate wishes to identify, in a second phase, those tissues that were initially not recognized. However, assuming that this is the choice taken, a small percentage of human tissue will remain unidentifiable. Perimortem factors, such as putrefaction, fire, contact with amplifying inhibitors, and decomposition, destroy DNA or lower its quality, making it uninterpretable for identification.

Intuitive Sorting Classification

The large number of fragments of human remains found on the ground must be classified according to their potential for identification or their investigative value. To this end, systematic, simple, and objective sorting is required. In practice, a table such as the one below appears quite suitable for this task (Figure 1). The numeric values assigned to each fragment are based on the presence of attributes that are useful for the identification procedure. The fragments with high probative value are the most

easily identifiable, or useful for understanding aircraft crashes, and are thus the priority elements for a detailed examination. This referencing must be designed as an “incident-specific” sorting tool because, like the state of the fragments, the reliability of the list of victims and the relevance of the ante-mortem (AM) data have an impact on the final identification. (In principle, AM data leads to the identification procedure, which is why investigators must take into consideration the relevance of these data).

Value	Footprint	Dental	DNA	Morphological	Personal effects
	Primary Identifier	Primary Identifier	Primary Identifier	Secondary Identifier	Secondary Identifier
High Value = 2	Good quality Feasible	Fragments with extensive care	Numerous and high quality samples allowing a complete STR or MtDNA sequence	Specific, unique feature (prosthesis, tattoo, scars ...)	Specific and associated with a fragment (engraved wedding ring)
Average Value = 1	Partial but achievable	Absence of care	Decomposed elements Thermally modified and/or small sample providing a partial profile	Anatomically identifiable fragment but without specific characteristics	Non-specific (shoe and sock with a foot)
Null Value = 0	Not printable	Absence of tooth	Charred bone Fibro-fatty tissue Sample size that is too small	Fragment that can be associated with only one anatomical set (skin, muscle, bone, etc.)	Non-associated with a human fragment

Figure 1: table of potential and positive identification characteristics of the so-called primary and secondary identifiers.

If DNA samples are taken from all the tissues found, the classification system can be modified to indicate the priority samples. Morphological methods (etching, dentistry, etc.) are based on the physical examination of tissues rather than on molecular identification strategies. Prior to the biological methods used today, tissues that could not be identified by standard examinations were considered unidentifiable during severe fragmentation. Advances in genetics now mean that most human tissues collected are considered “potentially identifiable”. Systematic evaluation and “prioritization” therefore ensure that resources are managed effectively. This choice of organization is an essential component during major identification operations [4].

Concept of Fragmentation Index

The state of the human tissues found, especially in cases of major fragmentation, undeniably influences the management of the disaster and the identification of the victims, including during

the phases of “reconciliation” (i.e., re-association) of the body parts before the handing over of the bodies to the families. The fragmentation index is defined as the ratio between the number of human items collected and the number of victims involved in the crash. It can thus be used to give an overall account of the severe impact of the aircraft [examples: IF = 1.0 (no fragmentation); IF = 38.9 in the case of the crash of Value Jet flight 592 DC-9 hitting the ground at an angle of 70-80° and a speed of 675 feet/sec.

Although this concept represents the raw data of the shock, it is also largely dependent on the collection strategy and on the protocols used to analyze the post-mortem data. Recovery operations carried out by experienced personnel must be based on proven protocols adapted to the reality of the event, at the risk of introducing biases that may modify this index (Dirkmaat, 2012). Autopsy protocols could also influence this index. Therefore, those responsible for post-mortem data must be allowed to decide, according to the objectives set, which items should be

excluded, although there is the known risk of downplaying the fragmentation index. Like the table of characteristics above, the FI should remain a practical tool to compare the severity of fragmentation among accidents involving numerous victims to anticipate the potential manoeuvres and the expected results [5].

As the number of passengers and fragments increases, identification experts must also make binding decisions depending on legal constraints (e.g., cost and time required for DNA expertise) and on staff availability, time and the environment (crash site: sea, mountain, etc.). A literature analysis of data on 13 recent crashes suggests that there is no direct relationship between the number of deaths and the time it takes to identify them when the “number of fragments” parameter is not considered (a single fragment is sufficient for “minimum” identification). However, there is a significant relationship with the time taken to identify victims when the FI is considered (the lower the FI, the faster the identifications). Thus, assessing the severity of the fragmentation of the bodies has a direct impact on the management of the resources of the investigation (the number of people involved and the time required to collect the data also increases with the number of victims involved) and helps in the effective identification of the bodies.

Practical Method of Recovery and Sampling Operations

Concerning the method of recovering fragments of human remains, the conventional process requires that, after the

installation of a grid on the ground adapted to the scope of the event, combing operations should be carried out with the objective of identifying all the human elements, initially highlighted with a yellow flag. A second phase of combing operations is undertaken outside the grid (up to a few hundred meters if necessary) in search of even more distant elements. One or more teams, composed of at least one forensic pathologist and one biologist, then examine all the tissues identified. When the possibility of identifying these tissues through genetic analysis is high (depending on their size, mass, or anatomical nature), the yellow flags are replaced by red ones. Conversely, if it is considered that the remains have low DNA extraction power (for example, extremely degraded or small-sized tissues), the yellow flag is left in place.

Personal belongings (identity cards, jewelry, and so on) (marked “E” for element) are also marked with a red flag from the outset. Aerial shots are then taken on an area-by-area basis (using a drone). In the third phase, all yellow flags are geopositioned using a high-accuracy GPS receiver. A final number is assigned to them and this becomes the seal number (inscribed with a permanent marker on the flags). The number takes this form: Name of the zone concerned – the title “PM” for post-mortem – number in the order of collection – precision on the sample collected (B for whole body; P: body part; T: tooth or teeth; E: personal element) (e.g. A1-PM-01-P would mean the first element collected in zone A1, comprising a body fragment). A photograph of each fragment (photo 1) is taken, in situ, before the fragment is removed and then packaged in a plastic bag for freezing, with the label bearing the number placed within it (Figure 2).



Figure 2: Fragment of human remains classified as “red flag” and numbered.

The “red flag” elements are then transported to the field laboratory (in a tent), or to the local morgue, ideally by refrigerated transport if this laboratory is far from the crash site. The post-mortem team carries out descriptive examinations and then takes biological samples for the purposes of analysis. If possible, they indicate the type of anatomical part analyzed and the mass and nature of the injuries, if possible (type of fracture, burn, foreign bodies, etc.). These cellular samples can be taken either by direct body sampling (bone, muscle), or by using the standardized personal sample kit (FTA® sample). The swab is loaded with biological material and then transferred to a special type of blotting paper.

The swab and the FTA® paper are then left to dry in the open air for approximately 10 minutes and then both are placed in the same airtight envelope. Another sampling technique, by mini-brush, using the CHEMUNEX® kit, is also possible. Once this collection work has been completed, the samples are permanently sealed with the reference number. The number 1 is added after the nature of the element collected for sampling for the laboratory, and the number 2 for the fragment refrigerated while waiting for the results (eg: A5-PM-031-B2 for a whole body recorded in 31st position in zone A5, refrigerated, A5-PM-031-B1 being the number of the sample addressed to the laboratory).

The “yellow flag” elements are all recorded individually in separate zones and then weighed as well. The objective is not to analyze them a priori (except in the case of the non-identification of a passenger, for example), but to remove any biological fragment from the area affected by the crash. These “yellow” elements are sealed, by zones, from the PC-terrain and then transported to the morgue for refrigeration, while awaiting their fate (analysis, burial, etc.) based on the decision of the magistrates. If fingers are found as the PM teams are collecting remains, the forensic fingerprint experts attempt to restructure the fingertips and carry out postmortem fingerprinting for comparison. Concerning dental elements, dental surgeons also perform X-rays and post-mortem odontograms for comparative reasons as well [6].

Example of the Crash Airplane of a TBM 700

The aircraft, which was on a domestic flight and was carrying one pilot and five passengers, crashed while flying at an altitude of 18,000 feet. The recorded data showed that it fell at an average speed of about 30,000 feet/min, or 600 km/h. It was flying in cruise control mode and had reported no problems. The impact occurred in a sown field. The soil, which was very wet and greasy, also had many small stones distributed homogeneously. The crash pulverized the plane, and the elements (both human and structural) were dispersed across a zone extending approximately 120 m by 200 m. The projected elements were small in size and large quantities. The weather at the scene was unfavorable, with possibly icy conditions, but the exact cause of the accident was unknown.

The Recovery of the Bodies

The scope of the area and the amount of debris necessitated the installation of a 50-meter grid with pathways. The second phase of combing operations, which was undertaken outside the grid, led to the discovery of a hand with a ring, approximately 200 meters away, on the outskirts of this grid. All the “red flags” were geo-positioned by a surveyor by means of a high-accuracy GNSS 1200 LEICA GPS receiver and as expected, a seal number was inscribed by felt on the flags. The “yellow flag” elements were all collected on an area-by-area basis, placed in a sealed bag and transported to the morgue.

Given the extreme fragmentation of the bodies, there was neither a description of lesions nor a coding of the injuries of the human remains collected. Moreover, there were no radiological examinations other than dental elements found. In a local and adapted morgue, the human elements were then anatomically described, one specimen was collected and sent to the DNA analysis laboratory, and the other elements were re-packaged, sealed and stored at low temperature pending the results (samples were taken using both the standardized FTA® kit and the CHEMUNEX® kit) (Figure 3).

zone	Red wght (kg)	Yellow wght (kg)	Total Wght kg	% Red Weight	% Yellow Weight	Yellow flags	Red Body remains	All remains	% red Body remains	% yellow Body remains
A1	18,1	0,5	18,6	97,31	2,69	11	8	19	41,31	58,69
A2	51,3	37,3	88,6	57,90	42,10	848	111	959	11,58	88,42
A3	36	0	36	100,00	0,00	0	54	54	100,00	0,00
A4	0,2	0	0,2	100,00	0,00	0	2	2	100,00	0,00
B1	40,4	7,2	47,6	84,87	15,13	164	65	229	28,43	71,57
B2	21,8	24,4	46,2	47,19	52,81	555	63	618	10,20	89,80
B3	11,8	7,3	19,1	61,78	38,22	166	11	177	6,22	93,78
C2	1,3	0,5	1,8	72,22	27,78	11	5	16	30,56	69,44
total	180,9	77,2	258,1	70,09	29,91	1755	319	2074	15,38	84,62

Figure 3: Masses and body remains collected by zone.

Concerning Identification

In just over two days, a total of 2,074 fragments of human remains were collected, of which only 319 were “red flag” elements. Among them, 21 (6%) were unusable (mixed DNA profiles) because of commingled organic tissues. The fragmentation index (defined as the ratio between the number of human items collected and the number of victims involved in the crash) was approximately 53, which reflects the extreme severity of the shock. In total, we found 258 kg of body matter for an estimated total ante-mortem mass, for the six victims, of about 425 kg (about 61%). 1755 “yellow flag” (masse jaune) elements were collected for a mass of 77.2 kg (30% of the AM mass).

These were all small (< 25cm²) and/or of low mass (<100 gr). The descriptive assessment of the collected elements allowed us to note the absence of two feet out of 12 and the presence of 23 fingers out of the 60 sought. Gene-identifying results were obtained from less than 15% of the total fragments collected (298/2,074) but were based on 70% of the total mass discovered (180 kg). On average, only 40% of the weight of ante-mortem bodies was identifiable for an average weight of 710 grams/fragments identified. The four occupants at the rear were found at about half of their weight. The two occupants at the front of the aircraft were found at a quarter of their weight (Figure 4).

Victim	Red mass	Number of remains	Percentage mass found	Important remains > 1kg	Heavier remains	Average mass per item	Average mass without items > 1kg
1	26,5	21	48,2 %	3	14	1,2	0,41
2	42,4	80	58,9%	8	6,6	0,53	0,25
3	43,9	81	43,9%	3	10,6	0,54	0,31
4	34,3	48	44%	3	10,6	0,71	0,25
5	19,1	43	26,5%	2	4,9	0,44	0,22
6	17,5	43	25%	3	3,8	0,40	0,20

Figure 4: Masses and body remain collected by identified victims.

Concerning the Positioning of the Bodies

We took the utmost care in detailing the 180 kg of “red flags” on an area-by-area, and an individual, basis. There were 22 elements weighing more than one kilogram, for a total weight of 103 kg, i.e., a little less than half of the mass collected per victim. The “yellow flag” fragments were considerably greater in zones A2, B1, B2 and B3, i.e., the zones closest to the impact. The identified remains were positioned on a map of the air crash (Figure 5).

Mass and color/passenger scale representation of identified remains

- A first calculation, referred to as the “mean point of dispersion”, was calculated by performing the arithmetic mean of latitudes and longitudes, in relation to the number of body parts of the same identified individual.
- A second type of calculation, involving the mass of the identified fragments, was also undertaken, thus acting as a multiplier of the weighted average point. We then obtained the average of all these weighted positions associated with each of the victims and then recorded the coordinates on an orthogonal plan.

Example:

$$([\text{long.1} \times m_1] + [\text{long.2} \times m_2] + [\text{long.3} \times m_3] + \dots) = \text{longitude weighted mean}$$

$$\Sigma m$$

$$([\text{lat.1} \times m_1] + [\text{lat.2} \times m_2] + [\text{lat.3} \times m_3] + \dots) = \text{latitude weighted mean}$$

$$\Sigma m$$

- A final and similar calculation was made, but only on the basis of the 22 fragments weighing more than 1 kg.

Results

Thanks to the photographs taken by the passengers themselves during the flight and found among the material elements of the investigation, the exact position of the occupants was known. We noted that, by calculating the positions weighted by the mass of the remains (ii), there was a relationship between the position of the passengers on the photos and what had been reported about our cartography. This “average” of the positions of the occupants on the ground is even stronger when only the remains weighing

more than 1 kg are considered. This graphic transposition of the “average” bodies on the ground therefore allowed us, in this case, to highlight a perfect correspondence between the position of

the occupants of the aircraft during the impact and the overall distribution of the human remains identified (Figure 6,7,8).

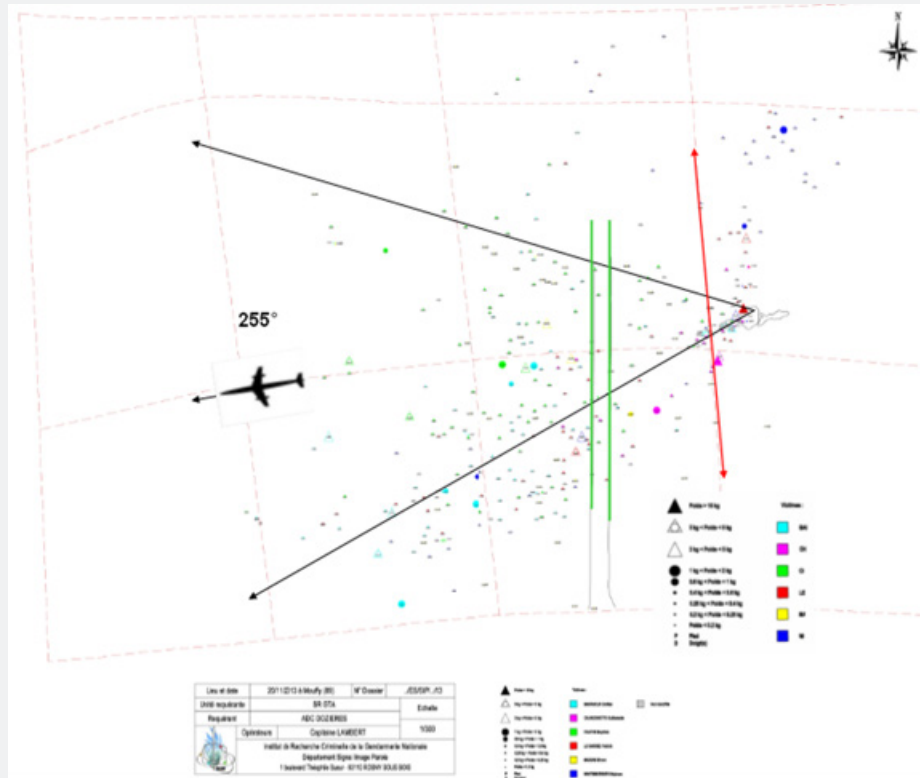


Figure 5: Cartography.

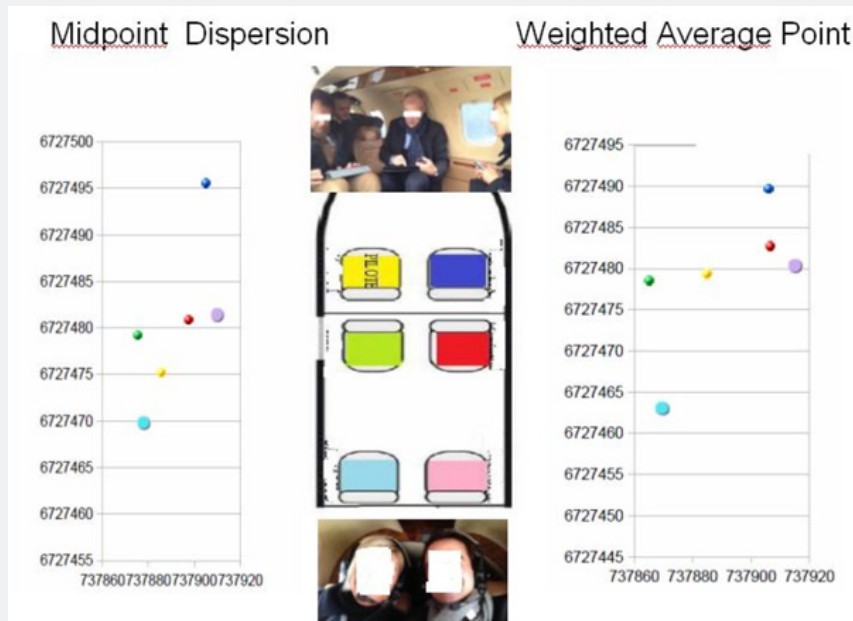


Figure 6: Graphic transposition of the “average” bodies on the ground and photo of the position of the occupants of the aircraft during the impact.

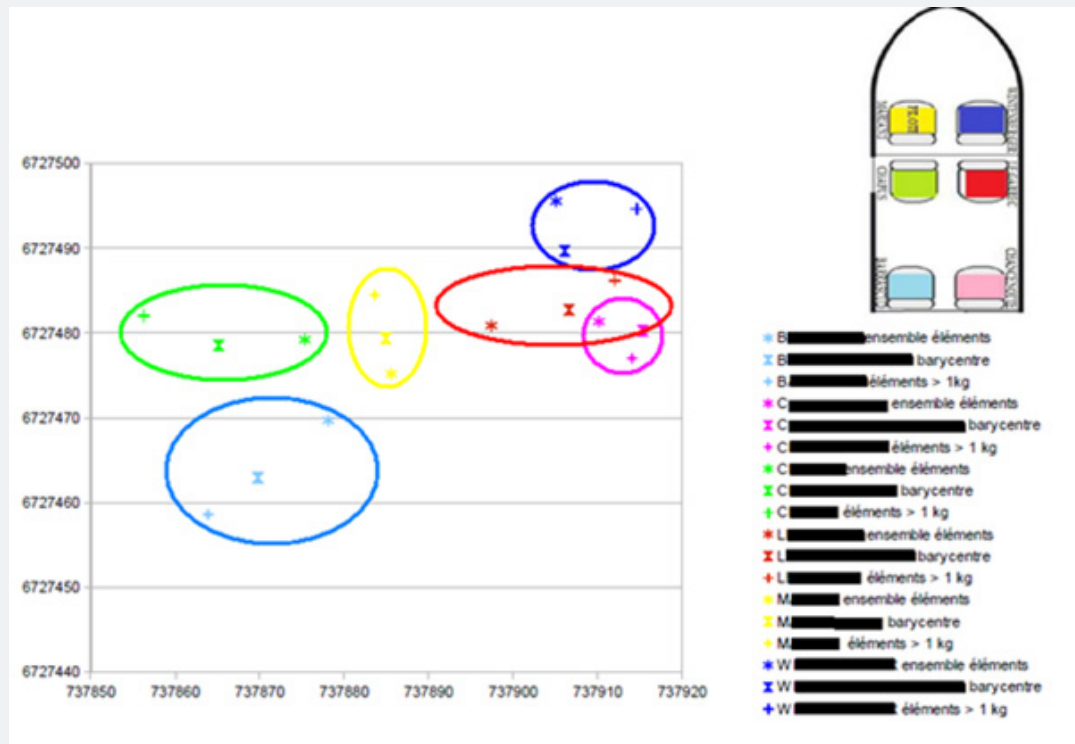


Figure 7: number written in relation to the seats corresponds to the fragments identified per passenger.



Figure 8: Comparison between the "barycentre" mean points and the mass mean points > 1 kg.

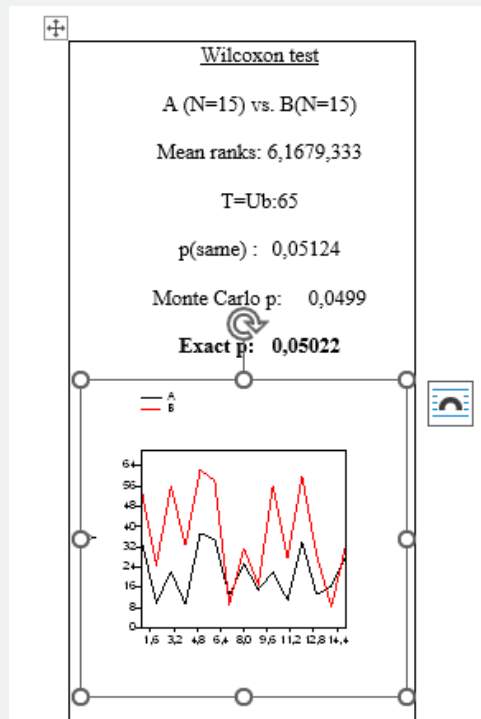


Figure 9: Wilcoxon statistical test.

(Comparison of two measurements of a quantitative variable performed on the same subject).

Discussion

This recent accident, involving a private, single-engine jet weighing about three tons, pressurized, with six people on board, falling at high speed (500-600 km/h), led to a fragmentation and to a significant scattering of human and aircraft elements. About the identification of victims, in addition to the technical difficulty of sampling each human remains, the problem also lay in the extremely high number of collections (more than 2,000 in our case) and in the exhaustive or non-exhaustive nature of a systematic DNA sample. Indeed, this part of the forensic work is the priority of our department's missions because we must always bear in mind that the announced list of an aircraft's passengers may be false (there are fewer draconian security measures within the so-called alternate aerodromes, or an additional person may be added or removed from the passengers' list at the very last moment).

In addition, it is also important to ensure that there are no other ground casualties during the impact. The processes of recovery and sorting of the bodies were progressive and were traced at each phase of the protocol (two-color flag method). Regarding injuries, it seemed unnecessary, because of the extreme severity of fragmentation, to try to "tally" human lesions, which were all based on diffuse fractures and pulverized and fragmented tissues. The obvious cause of death in this case was polytrauma

immediately after the shock. However, given the uncertainty of the origin of the event, a careful examination of the tissues was necessary to search for specific elements (burns, foreign bodies, suspicious wounds, etc.).

Regarding the positioning of the victims in the cabin at the time of the ground impact, the photos taken during the flight by the occupants made it possible to analyze accurately the graphic distribution of the human remains and to calculate their respective masses and the ground conditions (flat, intermediate ground without vertical obstacles). The photos allowed us to describe the victims' exact position in the aircraft and to determine the plane's course. It is along this axis that all projected debris were found, in the shape of a cone originating from the wreck and oriented in this way. This positioning was also demonstrated by working only with the 22 fragments weighing over 1 kg and confirmed mathematically using the Wilcoxon statistical test (comparison of two measurements of a quantitative variable performed on the same subject) (Figure 9).

Conclusion

The need to find and identify the victims of a disaster has given rise to strong concerns among public authorities in view of the means that they can commit, the capacities and limitations of science, and the expectations of families and the entire country. Indeed, the identification operations reflect these authorities'

capacities, or lack thereof, in the management of a crisis that is emotionally significant. The common questions raised concern, first, the resources allocated to the identification mission and, second, how families' requests for the repatriation of their loved ones will be honored. The magistrates in charge of the avionics and the forensic investigation must also know, as soon as possible, the amount of resources released for their future investigations, the estimated cost of the entire operations, and by when these investigations should be terminated.

Other questions that arise include the ability to trace the bodies and the circumstances in which the searches must be interrupted, either because of risky conditions or inaccessibility. All responses, however, depend intrinsically on the nature of the crash, the families' wishes (individual and collective), their cultural beliefs about death, and the expectations of each society with regard to what responses science can provide, depending on whether the necessary tools and techniques are available. While scientists make every effort to complete their task, various taphonomic factors prevent some identifications. Thus, outstanding remains with strong characteristics (dentitions, imprints, etc.) are directly associated with the corresponding bodies, once these bodies themselves have been identified. However, when fragmentation is involved, there is no body to recognize. Isolated tissues can thus contain a single characteristic data, or reveal or fail to reveal a DNA profile. When a single element contains a single characteristic allowing it to be attached to a single deceased, then it can be said that the body has been identified.

Consequently, families must be informed of the presence of unidentified remains and participate, as far as possible, in the decision on the final fate of these remains. While families expect to identify their loved ones rapidly when whole bodies are returned, those in charge of investigations must inform them as soon as possible that the bodies returned bear no relation to reality and help them to understand the dramatic reality of such an event. This difficult but necessary "re-adjustment" activity allows families a better understanding of the reasons why identification missions are long and difficult. One of the most difficult decisions for those responsible for the investigation is to determine whether to identify all the victims or all the remains, and thus to determine the extent to which the re-associations should be made. This decision depends largely on the results of the DNA analyses carried out and on their technical limitations, but the budget allocation and the time permitted for the analyses must also be considered. In the case of an open population (where the number of deaths is unknown – for example, the September 11 attacks), all the remains found must be subjected to a DNA analysis, which is the only way to obtain a complete list of all the deceased.

Even if it is given that not all samples provide usable DNA, this process must be carried out because it is the only method that can help to identify all the bodies. In the case of a closed population, where the list of missing persons is known, consultation may help to determine the maximum number of remains to be identified for each deceased. In such cases, one can determine a "scientifically acceptable limit value at risk of x%" when analyzing exceedingly small remains found, but only when the population has been identified with certainty. However, the families' wishes (often maximalist) must not be overlooked, and these are often opposed to scientific and legal processes of identification, instead seeking the fullest possible return of the remains of their loved ones.

Victims' associations must also be informed of all these issues and must be able to understand, with all due transparency, the decisions taken by the authorities during identification operations. Bereaved families require and deserve frank interviews. Although these interviews may be difficult, they are essential for a better acceptance of the complex process of pain caused by the disaster. The transparency of political leaders also allows the society to understand that, even in death, people are respected rather than neglected. While forensic experts and investigators undertake this work for legal reasons, this choice is also made because of the ethical and moral comfort that they bring to all their fellow human beings.

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