CHAPTER 4

Major Decisions

Once the parameters of a mass fatality DNA identification program are set by the policymakers, the laboratory director will be responsible for determining the nature and extent of the laboratory's response. It is important for the laboratory director to answer (with input from all agencies and departments that are likely to be involved) the questions presented in this chapter—and to keep in mind that these issues are interrelated. For example, the duration of the recovery effort can affect the quality and type of samples, which in turn may affect the number of DNA tests that may be needed to generate a profile.

The medical examiner's primary goal in most situations will be to identify the victims and issue death certificates. In a natural disaster, the effort is largely humanitarian, including identifying the victims so that their remains (and necessary documentation) can be returned to their families. However, when a mass fatality results from criminal activity, the identification effort has humanitarian and investigative components. In a criminal matter, the ME may expand the goals to include identifying the perpetrators and assisting with the law enforcement investigation.

How important is DNA to the identification effort?

The degree to which human remains are fragmented or degraded determines the value of DNA analysis in the identification process. Intact, large body parts lend themselves to identification by less costly methods, such as X-ray, dental examination, and fingerprints. However, DNA analysis is the only viable method for identifying severely fragmented or degraded remains. Even when whole bodies are recovered, DNA analysis still may be the best approach when materials that are necessary for other modalities—for example, dental records or verified body identification by friends or relatives—are unavailable. Remains often are identified by multiple methods, which may or may not include DNA. For example, only approximately 25 percent of the identifications of airline crash victims are generally made by DNA exclusively.

Will every person or every fragment be identified?

The answer to the question of whether every victim or every fragment of remains will be identified frames the scope of the DNA identification effort. Obviously, intact bodies will require fewer DNA tests than fragmented remains, although decomposing bodies may not easily yield full profiles.

There were two reasons that we were able to complete the 265 victim identifications from American Airlines flight 587 in just 6 weeks. First, the infrastructure was already in place because of the World Trade Center identification effort and there was no extra ramp-up time needed in the laboratory. Second, our goal with respect to the airline crash was to identify all the victims rather than all the remains, so we knew when our job was over.

Howard Baum

For example, in an airplane crash with 50 victims, in which each victim's remains are fragmented into 100 pieces, the identification effort undoubtedly would end sooner if the goal is to identify each victim, rather than each fragment of human remains. Everyone—the public, the policymakers, and the laboratory personnel—needs to understand the answer to the important question: *"When are we finished?"*

If the policy is to identify all of the victims, DNA analysis would stop as soon as the last victim is identified—which means that some human remains may never be analyzed or returned to the families. However, when the goal of the effort is the attempted identification of all fragments, the work of the laboratory likely will be greater.

It is important to consider that, if a mass fatality incident is so large and devastating that it affects the psyche of a community, a country, or the world, the scope of the identification effort may be broadened to help acknowledge the breadth of the emotional ramifications. After the 9/11 attacks, for example, the Mayor of New York City directed the Office of the Chief Medical Examiner to do everything humanly possible to identify every fragment of human remains. This policy resulted in new DNA analysis techniques and approaches; any biological fragments that could not be identified were preserved for potential analysis with future technologies.

DNA analysis can be the most reliable and robust of the identification modalities. Although it may be a second choice to dental and fingerprint analysis when such evidence exists, DNA evidence still should be collected in case dental and fingerprint records are not available.

Robert Shaler

The absence of policies guiding the number of DNA tests that will be attempted on severely compromised samples can have enormous consequences. In planning for a future mass fatality, policymakers should consider the impact on the public if technologies at the time are insufficient to obtain DNA profiles on all remains. Lessons learned from the World Trade Center (WTC) identification effort suggest that policymakers need to understand that the broadest testing scale can add years to a DNA identification effort.

What is the minimum fragment size that will be identified?

Policies also need to be established at the beginning of the effort that define "minimum fragment size" for DNA testing. A policy that has as a goal "all remains tested" may mean that many fragments may fail to yield results. In this situation, the DNA effort would take longer and be more costly—and, although families would be more likely to receive more of their loved one's remains, they may be unprepared for the fragmentary condition of the remains or the length of time it takes to identify them.

Decisions must be made regarding the minimum fragment size on which identifications will be attempted, the number of attempts that will be made to identify each fragment, and the statistical threshold that must be met before results are conveyed to the ME. These decisions are fundamental to a laboratory's strategic planning. Planning—including preliminary meetings between the laboratory director, the forensic anthropology staff, and the ME—is critical, because it allows each entity to understand the perspective of the others in the emotionally charged environment following a mass fatality incident.

From the laboratory director's perspective, the minimum fragment size—typically, 1 to 10 centimeters—should be based on three criteria:

(1) maximizing the probability that all victims are identified;

(2) recognizing the emotional needs of the victims' families and friends; and

(3) providing forensically relevant information.

Defining the acceptable minimum fragment size affects every aspect of the identification effort: how remains are collected at the incident site, how they are processed in the morgue, the number of samples that ultimately appear on the DNA analyst's workbench, and the likelihood of a successful DNA profile.

How difficult will it be to identify everyone?

The laboratory must make a preliminary decision regarding the DNA technologies that will be used. For example, can all identifications be made with standard forensic Short Tandem Repeat (STR) markers? Will mitochondrial DNA (mtDNA) play a role and, if so, to what degree will the ME rely on mtDNA results to make an identification? Longer recovery efforts usually result in more DNA degradation, and this, in turn, affects marker choices. Also, the decision to expand marker sets beyond those typically used by the forensic laboratory will be driven by environmental conditions at the incident site and the resulting DNA degradation, and by the scope and duration of the DNA effort.

Whether an incident is "closed" or "open" has a significant impact on the statistical options for making DNA identifications (see chapter 12, *Statistical and Other Issues.* In a "closed" incident, the laboratory director should determine whether a list of victims is available—for example, in an airline disaster, the passenger manifest. Although it is important to keep in mind that the manifest might be incomplete or incorrect, the majority of the victims would still be known.

An "open" incident is one in which the number of victims—or their identities—is largely unknown. After the WTC attacks, for example, the final list of victims was not determined until months later, and even then, officials believed that there were up to 20 additional, unknown victims. It should also be kept in mind that open incidents are prime candidates for insurance fraud. There are people who may try to file fraudulent life insurance claims. In the WTC attacks, for example, a police investigation was performed with respect to every reported victim, and cases of fraud were still being uncovered more than 6 months after September 11, 2001.

It is possible for a closed incident to become open. If a plane crashes into a neighborhood, for example, the victims on the ground would change a typical "closed" event to "open," because it would not be known who was on the ground.

How long will the recovery effort last?

In addition to policies defining minimum fragment sizes and the number of retestings to obtain data that meets statistical thresholds, the location and size of a mass fatality incident largely determines the duration of the recovery effort and the DNA identification of victims. Remains from an airline crash on land generally are collected in about 2 weeks. In contrast, remains from the WTC were collected over a 10-month period. The end of remains recovery may prompt a decision about how much longer the laboratory will continue to perform the DNA analysis.

The degree of fragmentation should determine the minimum fragment size. Because of the extreme fragmentation of remains of World Trade Center victims, the minimum was approximately the size of a thumb.

Robert Shaler

Generally, remains are processed as they are accessioned into the morgue. In cases with a large number of victims and/or fragmented remains, it usually is not possible to collect all the remains before the identification process begins—although waiting until all samples have been collected and coordinated may be better (more effective and efficient) from the DNA analyst's perspective. However, this likely will not be an acceptable approach, because the public, including the victims' families and public officials, may expect the identification effort to begin at once and proceed rapidly.

Two basic metrics for estimating a laboratory's workload are the number of samples received per month, and the number of months in the recovery effort. In addition, the public, the press, policymakers, and victim advocacy groups may have expectations of the duration of the recovery and identification processes. In airline disasters, for example, people may expect the entire process—from collecting samples at the disaster site to making identifications in the laboratory—to be completed within 1 to 3 months. The public also may expect the laboratory to complete its work within 1 month of receiving the last sample from the incident site. Chapters 7 and 8 of this report provide tools for understanding and responding to these expectations.

In addition to considering the human remains, the laboratory also must consider the reference samples. People concerned with finding their loved ones want to respond quickly, so personal items and biological references may begin arriving at the laboratory very shortly after the incident. If no plan exists prior to a mass fatality incident for collecting

You have no control over the condition of the remains, so setting criteria about what you will and won't test becomes an important framework that allows the identification process to move forward.

Jack Ballantyne

reference samples—and sending them in "batches" to the laboratory—Federal, State, or local first-response agencies may help set up family assistance centers. The number of batches and how frequently they are sent to the laboratory will depend on the efficiency and duration of the reference collection process. In turn, the accuracy and completeness of information associated with the reference samples depend on the collection plan.

Assuming funding, can the laboratory do the work?

After considering the role that DNA will play in an identification effort, the type(s) of DNA analysis needed, and the duration of the recovery effort, the laboratory must determine the analytical processes. Ultimately, it must be decided whether a laboratory has sufficient capability and capacity to do the work. To assess this, several key variables—described in exhibit 3—should be considered.

Exhibit 3: Key Variables in Assessing Laboratory Workload

Variable	Description
Number of victims	Generally, this is a straightforward estimate in the case of airline disasters that do not involve populated areas because the laboratory has access to the passenger manifest (although babies may not be included on the manifest). This estimate is more difficult for incidents that take place in office buildings, stadiums, etc. because the number and identity of victims are not known until long after the incident occurs.
Number of recoverable fragments	It is important to distinguish between the degree of fragmentation and the number of recoverable fragments. In the World Trade Center incident, there was an incredible degree of fragmentation, with an average of only seven recovered fragments for each victim. Based on historical data, there are approximately five to eight fragments recovered per victim in airline disasters. Therefore, for general planning purposes, 10 would be a good estimate to use.
Percentage of samples to be reworked	Some percentage of samples will need to be reanalyzed before they yield usable DNA profiles; 20 percent is a conservative estimate.
Number of personal items per victim	An estimate of the number of personal items will be provided for each victim. Historically, this is between five and eight. Note that usually not all of the items collected are analyzed; there should be a process to identify those items most likely to yield useful results.
Percentage of personal items to be reworked	Some percentage of personal items will not yield usable DNA profiles. Historically, 20 percent is a good estimate. When this occurs, the items are either reanalyzed or one of the other personal items is analyzed.
Personal items quality control samples	The laboratory should be prepared to reanalyze some percentage of all personal items samples as a quality control mechanism; 5 percent is common practice.
Number of kinship samples	Historically, three or four relatives per victim is a reliable estimate of the number of kinship samples. Note that buccal swabs nearly always produce complete DNA profiles, so it is not necessary to estimate rework.

Exhibit 4, an Estimated DNA Analysis Workload Worksheet, can be used to help predict the labor and material resources required for the DNA analysis.

Currently, most forensic DNA laboratories are proficient in STR analysis, proven to be a powerful tool in many mass fatality incidents since the 1990s. For example, DNA identifications in three airline disasters—Swiss International Air Lines flight 111 (September 2, 1998), Alaska Airlines flight 261 (January 31, 2000), and American Airlines flight 587 (November 12, 2001)—were made exclusively with STRs; no other technologies were needed to identify every victim.

STRs are particularly informative on well-preserved soft tissue and bone samples. Analysis of the compromised remains after the WTC attacks demonstrated that STRs also work with

Exhibit 4: Estimated DNA Analysis Workload Worksheet

Human Remains

1. Enter the estimated number of victims. ____________

2. Enter the estimated average fragmentation per victim. *(For airline disasters, this value usually ranges between five and eight; ten is a conservative estimate.)* ____________

3. **Expected number of human remains to analyze.** Multiply lines 1 and 2. ____________

4. **Total number of human remains to analyze, including rework.** Multiply line 3 by the number 1.2. ____________

Personal Items

5. Enter the estimated number of personal items collected per victim (typically between five and eight). ____________

6. **Expected number of personal items to collect, store, and track.** Multiply lines 1 and 5. ____________

7. Enter the estimated number of personal items to be analyzed per victim (typically between two and four). ____________

8. **Expected number of personal items to analyze.** Multiply lines 1 and 7. ____________

9. **Total number of personal items to analyze, including rework and quality control.** Multiply line 8 by the number 1.25. ____________

Kinship Samples

10. Enter the estimated number of biological relatives per victim (typically between three and four). ____________

11. **Expected number of kinship swabs to analyze.** Multiply lines 1 and 10. ____________

12. **Expected number of kinship swabs to collect, store, and track.** Multiply line 11 by the number of swabs collected (between two and six). ____________

degraded tissue and bone fragments if the DNA extraction process is optimized. However, STRs alone are often not sufficient for identification when samples are severely compromised. In those situations, additional methods—such as mtDNA sequencing or Single Nucleotide Polymorphisms (SNP)—are likely to be necessary to generate sufficient genetic markers to reach a statistical threshold.

> **One of the important decisions that must be made within the first 48 hours of a mass disaster event concerns the establishment of family assistance centers. This is extremely important, because the manner in which personal effects and kin samples are collected affects the efficacy of the entire identification effort.**
>
> ***Robert Shaler***

The DNA identification response to a mass fatality incident demands forensic casework skills and high-throughput genotyping or databasing, whether from the public and/or private sectors. Because there are differences between STR genotyping for medical or research purposes, laboratories that can perform high-quality clinical or research STR genotyping should be used only after careful consideration.

DNA from human remains in a mass fatality incident—and personal reference sample items—are collected from many different sources, each requiring chain-of-custody protocols not typically used by clinical or research laboratories. To increase the probability of obtaining full profiles from the personal effects samples, DNA should be extracted using forensic casework extraction protocols. Likewise, full polymerase chain reaction (PCR) volumes usually are necessary to develop complete profiles from the victim samples.

On the other hand, kinship samples are more uniform and lend themselves to standardized high-throughput processes that are used (although perhaps with different protocols) by forensic databasing laboratories and some nonforensic genotyping laboratories. Forensic databasing laboratories often have sophisticated information technologies for tracking samples and avoiding mixups. In addition, forensic databasing laboratories often are more experienced than forensic casework laboratories with outsourcing work to private laboratories.

Depending on the mass fatality event, kinship samples, for example, might be analyzed by high-throughput clinical laboratories that are willing to implement appropriate protocols (assuming that the kin are those of the victims, not kin of those suspected of being perpetrators of the mass disaster). This procedure focuses the most rigorous forensic protocols on the limited and compromised victim samples. And, although mass fatalities from natural disasters may fall outside the parameters of a forensic investigation, laboratory directors and MEs should weigh all potential issues before departing from chain-of-custody and other forensic procedures.

However, most mass fatality events likely will require a forensic approach for at least some of the samples. In these instances, as previously noted, laboratories that can perform high-quality clinical or research STR genotyping will have to modify their protocols and analysis methods. For example, clinical and research laboratories may not typically use the same (or any) molecular ladders as size standards for allelic interpretation. It is important to ensure that all laboratories involved in the DNA analyses use protocols that permit standardized evaluations of victim profiles. Standard STR forensic DNA marker analysis is based on well-established and comprehensive procedures that enable profile frequencies to be calculated from existing and well-validated databases.

Culture and practices can vary among forensic and nonforensic laboratories. If they are not addressed at the beginning of a mass fatality DNA identification effort, these differences can lead to communication problems. A laboratory director also should keep in mind that some terms—"acceptable molecular ladder," "acceptable positive and negative controls," and "standard reaction volume," for example—may need to be fully defined when a nonforensic vendor laboratory is used.

In addition to the actual DNA analysis, the laboratory may also be responsible for some of the following activities:

- Sample accessioning and tracking.
- Making identifications and resolving metadata problems.
- Quality control.

- Interacting with families and the media.
- Long-term sample storage.

If these activities are overlooked during the development of a mass fatality plan, resource shortfalls likely will occur.

Generally, after a DNA profile is generated, it should take about the same time to evaluate the data for an identification as it takes in a paternity/biological relationship case analysis. [Note: Although more than a quarter of a million parentage tests are performed annually in the United States, biological relationship testing, such as paternity analysis, is rarely performed in forensic laboratories. Because many of the laboratories that perform such tests use some of the same STR loci that are used by U.S. crime laboratories, it may be prudent to consult with experts in parentage testing when preparing a mass fatality response plan. The American Association of Blood Banks is responsible for accrediting the Nation's parentage-testing laboratories.]

The laboratory director must consider the impact of a mass fatality incident response on the laboratory's primary mission. Capacity issues must be addressed in the context of routine, crime scene casework or, in the case of a databasing laboratory, convicted offender analyses. As resources are redirected to a mass fatality identification effort, backlog and turnaround times are likely to increase for regular casework. Even though local police and officers of the court may support the laboratory's role in the mass fatality incident response, they may still expect their cases to be completed in a timely manner. Plans for managing both a mass fatality incident response and routine casework should be developed before the need arises.

The duration of the recovery effort also has major implications for a laboratory's capacity. A rapid recovery effort (1 to 3 months) creates a spike in the laboratory's workload; however, because of the short duration of such a response, the laboratory may be able to quickly recover. Also, local law enforcement professionals and officers of the courts may be more tolerant of delays if they occur for only a short period of time.

With respect to more lengthy recovery efforts, the arrival of samples may be uneven, and the laboratory may be able to absorb the additional workload without affecting turnaround time on routine casework. However, a prolonged DNA identification effort may drain people and resources—and good planning can help mitigate disruption if a laboratory receives a large number of samples over an extended period of time.

What is the funding source?

It would be rare for a State or local forensic laboratory to have sufficient funding to cover the expenses associated with DNA testing in a mass fatality incident response. The Federal Emergency Management Agency (FEMA) is the primary source of Federal funding for mass fatality incidents; see chapter 3, *Before the Incident,* for a discussion of FEMA assistance.

Usually, FEMA is prepared to support new equipment purchases. Laboratory directors may already have equipment lists as part of their normal budgetary responsibilities—and it saves time to have those lists scaled-up and updated for presentation to FEMA as quickly as possible.

If the response is to be funded out of State or local budgets (or both), without additional Federal support, there may be more stringent limitations on equipment purchases or resources to enhance DNA analysis capabilities. In this situation, decisions about minimum fragment size and retesting policies also will be influenced by fiscal restraints. Laboratory managers will need to make sure that the ME is aware of the fiscal impact on the ability to make identifications.

The agency responsible for an identification effort (for example, the National Transportation Safety Board (NTSB) in an airline crash, the ME, or the laboratory director) may—after evaluating the issues of capacity, capability, mission, and funding—decide that the project is not feasible for the State or local laboratory. In that case, other resources may be sought; for example, the NTSB may request assistance from the Armed Forces DNA Identification Laboratory (see chapter 3, *Before the Incident*).