Civilian Airliner Accident Investigations in the U.S. and France and Their Impact on Aviation Safety

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Abstract

When an airliner crashes for reasons other than terrorism or an intentional act, two kinds of investigations follow: a technical investigation that seeks to answer the question of why the accident occurred and how it can be prevented from recurring in the future; and a criminal investigation which seeks to determine whether any laws were broken that may have led to the accident, and determine which parties might be responsible. The International Civil Aviation Organization's 1951 Annex 13 to the 1944 Convention on International Civil Aviation describes the gold standard that signatory countries including the U.S. and France seek to follow for investigating aviation accidents and preventing future ones. Through the examination of the relationship between technical and criminal aviation accident investigation methods in the United States, a common law country, and France, a civil law country, it becomes evident that the primacy of technical investigators and their clear division from criminal investigators in the United States more closely affirms the main objective of ICAO Annex 13, namely to investigate without apportioning blame or liability. By contrast, the French system affords primacy to the criminal investigators and requires the technical investigators to work closely with them, and to assist them as needed. This shift in priorities compromises the gold standard of Annex 13.

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1. Introduction

Although they are rare, airliner accidents captivate the traveling public. When these crashes cause casualties, they become national tragedies and lead people to ask why the accident occurred. There are two kinds of aviation accident investigations that can be launched after an unintentional civilian airliner accident. First, there is the technical investigation which seeks to answer the question of why the accident occurred and how it can be prevented from recurring in the future. The other is a criminal investigation which seeks to determine whether any laws were broken that may have led to the accident occurring and if so determine which parties are to blame. However, these investigations center on the same crash site and the relationship between them depends greatly on the country in which the accidents occurred.

The International Civil Aviation Organization's 1951 Annex 13 to the 1944 Convention on International Civil Aviation-describes the international standards and recommended practices for investigating civilian aviation accidents. As signatories to Annex 13, the document represents the gold standard for investigating civilian aviation accidents that France, the United States, and the rest of the world should strive to follow. The main purpose of Annex 13 is to use the investigation of an unintentional airliner crash to prevent future aviation accidents, which means that technical investigators should be given priority to conduct their investigations. However, when criminal investigators are given primary jurisdiction to conduct investigations, the main goal of Annex 13, using investigations to prevent future accidents, is undermined for two main reasons. First, tensions between both investigations end up hampering the technical one and people involved are less likely to openly cooperate with any investigations if they are under investigation for fear of self-incrimination. Through the examination of the relationship between technical and criminal civilian aviation accident investigation methods in the United States, a common law country, and France, a civil law country, it becomes evident that the primacy of technical investigators and their clear division from criminal investigators in the United States more nearly affirms the main objective of ICAO Annex 13, which is to prevent future aviation accidents and incidents and not allow the investigations to apportion blame or liability, than the French system which affords primacy to the criminal investigators and requires the technical investigators to work closely with and assist them.

First, the various reasons why American society affords primary jurisdiction of unintentional airliner accidents investigations to technical investigators and French society affords primary jurisdiction of unintentional airliner accident investigations to criminal investigators will be discussed. Then, various important differences between the U.S., which follows common law, and France, which follows civil law, will be examined. Next, ICAO and Annex 13 to the Chicago convention will be described. Then, American and French aviation technical and criminal investigative agencies relevant to this thesis, the relationships that exist between them, and how these all compare to Annex 13 will all be explored in detail. Finally, four case studies, ValuJet Airlines Flight 592, Trans World Airlines Flight 800, Air France Flight 296, and Air France Flight 4590 will be examined to illustrate examples in support of this thesis. These four case studies were specifically selected because they all were civilian airliner accidents that were ultimately determined to have been caused by unintentional actions, but nonetheless resulted in criminal investigations. To provide an even comparison, two case studies from the U.S. and two from France were included. Namely, all the case studies highlight how the United States has adopted a clearer legal separation of its technical and criminal investigators of unintentional airliner accidents than France in accordance with Annex 13. The U.S. also more closely mirrors Annex 13 than France because it affords its technical investigations primary jurisdiction of unintentional airliner accidents. Finally, the main mission of these technical investigators is the prevention of future airliner accidents which is also the central goal of Annex 13.

2. Primary Jurisdiction of Unintentional Airliner Accident Investigations

2.1 United States

It is first necessary to explain why the U.S. affords it technical investigators primary jurisdiction in investigating unintentional airliner accidents as opposed to France, which affords its criminal investigators primary jurisdiction in investigating unintentional airliner accidents. The main reasons for the differences between the two countries are societal attitudes on the conception of justice related to unintentional accidents, the structure of the public hearings for investigations, the criminal justice systems for victims in both nations, views on punishment for offenders in both nations, and past tensions between technical and criminal investigators during past investigations (Foreman 14).

The United States delegates primary jurisdiction to technical investigators because of the rich history of America's technical investigators, the National Transportation Safety Board (NTSB). The NTSB was established in 1967 in accordance with Annex 13 to conduct technical investigations of airliner accidents amongst other transportation-related accidents (The Investigative Process). The sole goal of the agency is improving transportation safety. Further, the Board is well known for its transparency during investigations, regularly holding press conferences and releasing factual information updates as the investigation is conducted (The Investigative Process). However, no speculation is ever introduced as to the exact cause of the accident until after the investigation is completed (The Investigative Process). All of these reasons strengthen the public perception of the NTSB. As a result, the American public tends to favor a technical investigation and its ability to prevent future aviation accidents as the most just outcome as opposed to criminal prosecutions.

The most important component of an NTSB investigation to build up public trust are its public hearings. These public hearings are generally held as part of a major accident investigation such as an airliner accident (The Investigative Process). The main purpose of public hearings is to "gather sworn testimony from subpoenaed witnesses on issues identified by the Board during the course of the investigation and to allow the public to observe the progress of the investigation" (The Investigative Process). The latter is very important because it lets family members and victims know that the accident they care about is being thoroughly investigated, which also affords them some closure about how the investigation will prevent further accidents from occurring in the future.

The United States also reserves criminal charges for egregious intentional conduct in the wake of an unintentional aviation disaster as opposed to errors or omissions (Nemsick and Passeri). As a result, criminal investigations into unintentional airliner accidents in the United States are much less prevalent than other countries, like France, and rarely result in any charges being filed (Nemsick and Passeri). The latter can be partially attributed to the fact that the United States does not allow victims to file criminal charges as they can in the very unique French criminal justice system (Foreman 15). Therefore, American prosecutors do not feel any pressure to file charges before victims do as in France (Foreman 15).

Another reason the U.S. affords technical investigators primary jurisdiction in the wake of an unintentional airliner accident is because the U.S. criminal justice system favors much harsher sentences than the French system. Similar to the French system, a defendant may be sentenced in the U.S. Federal criminal justice system to imprisonment, probation, community service, or pay restitution or a fine (Federal Criminal Justice Process). Unlike in France, U.S. judges are bound by minimum sentencing laws that force them to sentence defendants to at least a certain amount of time in prison for certain offenses (Frase 276). Further, suspended prison sentences in the U.S. Federal criminal justice system were abolished in 1987 (Federal Criminal Justice Process). This means that federal defendants in the U.S. after 1987 must serve their entire prison sentences behind bars (Federal Criminal Justice Process). Therefore the U.S. Federal criminal justice system does not afford defendants a chance to serve part of their prison sentences outside of heavily guarded facilities as is widely utilized in the French system.

Finally, the 1996-2000 investigation of Trans World Airlines Flight 800 caused significant tensions between the NTSB and U.S. criminal investigators, the Federal Bureau of Investigation. As will be mentioned in the case study below, the FBI quickly took the lead in the investigation although no foul play was eventually determined to have caused the crash. The NTSB's technical investigation was significantly hampered and aviation safety put at risk. As a result, regulations were amended to clarify the relationship between the NTSB and FBI ensuring the NTSB always has primary jurisdiction in the wake of an unintentional airliner accident. ICAO Annex 13 seeks to not allow technical and criminal investigations to get too closely intertwined.

2.2 France

France gives its criminal investigators primary jurisdiction of unintentional airliner crash investigations. French prosecutors routinely conduct involuntary manslaughter investigations in the wake of airliner accidents even if there are no indications of foul play involved (Foreman 14). Victims and their families of airliner accidents in France "hindered by the glare of the media…move from 'a need to know and understand what happened' to 'a need to see someone held responsible, blamed in public and punished" (Foreman 14). As a result, "the nature of the criminal trial in France…is no longer to punish those who are guilty of serious wrongdoing, but to satisfy the public and the victims who have become the central point of focus (for the media and public)" (Foreman 15). As a result, the French public prefer punitive justice in the wake of an unintentional accident, not technical investigations which do not apportion blame.

These societal changes are amplified by the lack of public hearings from France's technical investigators, the *Bureau d'Enquêtes et d'Analyses* (BEA) (Foreman 15). The lack of public hearings robs French victims and their family members of the transparency and closure afforded by the NTSB's public hearings. Additionally, the French legal system also does not allow lengthy hearings or proceedings in civil court (Foreman 15). However, criminal proceedings in France do give victims and their families hearings and proceedings over weeks or months with countless witnesses, experts, and evidence presented (Foreman 15). Further, the French criminal justice system allows victims to file their own criminal charges which often forces prosecutors to seek criminal charges (Foreman 15).

Another important reason why France favors criminal investigators having primary jurisdiction is because their criminal justice system favors more lenient forms of punishment than in the U.S. French judges have a wide range of potential sentences to impose in the wake of a person being convicted of a major offense such as involuntary manslaughter (Elliott 51). These include the standard punishments such as imprisonment, fines, community service, probation, and other the restriction of some rights such as the right to drive or possess weapons (Elliott 53). However, French law also allows judges to impose suspended sentences where if the defendant successfully serves a period of probation or community service, their prison sentence is ultimately waived (Frase 276). Further, the French system gives judges wide latitude to decide appropriate punishment for defendants based on the facts of individual cases (Frase 276). As a result, French judges normally impose more lenient prison sentences than the maximum for offenses (Frase 276). Finally, when defendants are sentenced to prison, they regularly qualify for programs that allow them to spend part of their sentence outside prison (Elliott 51). These programs aim to reduce prison overcrowding and rehabilitate the defendant (Elliott 51).

Finally, the French public is wary of technical investigators in the wake of the 1988 crash of Air France Flight 296. Immediately after the accident, BEA investigators took the aircraft's flight recorders to Paris for analysis (Foreman 16). As will be described in more detail during the case study below, five people, including the pilot, were indicted on a variety of criminal charges in the wake of the crash (Mateou and Michaelides-Mateou 58-59). Part of the pilot's defense at his trial was that the BEA had caved into the pressure from Airbus and modified the aircraft's flight recorders to hide defects with the brand-new jet (Foreman 16). Although the BEA's reputation has significantly recovered from the Flight 296 investigation and no wrongdoing or tampering was ever uncovered, the law was amended so that all wreckage, including the flight recorders, the crash site, and witnesses remain in the custody of French judicial investigators (Foreman 16). Any examinations of these pieces of evidence by the BEA requires the permission of the judicial investigators and courts (Foreman 16).

3. U.S. Common Law and French Civil Law Differences

It is next necessary to explain the differences between the American and French legal systems. The United States uses the common law tradition which is derived from early British law, while France uses the civil law tradition which is derived from Roman law. While similar in some respects, common law in the United States differs greatly from civil law in France in several areas. The important ones for the scope of this thesis are: the basic differences between statutory construction in U.S. common law and codification in French civil law; the role of judges in both systems; and proximate causation with regards to the crime of involuntary manslaughter.

3.1 U.S. Common Law

Generally speaking, the main difference between United States common law and French civil law is the interpretation of statutes and the nature of their codification. The U.S. common law tradition tends to support the construction of statutes when a statute contradicts another, when a statute contradicts itself, or when a statute is unclear due to its scope or application. The U.S. common law system does not try to construct statutes to make them all-inclusive of a certain area of law (Steiner 40).

The U.S. common law system is very different from the French civil law system in that U.S. judges are given the ability to play active roles in interpreting the statutes before them as opposed to the French civil law system of just applying the statute or statutes in question to the facts of the case. The U.S. common law system is more concerned with rendering decisions that are practical based on established precedent rather than applying the virtues of logic like the French system (Steiner 140). This practice is encouraged in the U.S. common law tradition to prevent the usurping of power by the legislative or executive branches. The courts also establish the constitutionality of various statutes and actions conducted by the legislative and executive branches on a regular basis at both the state and federal levels of government. Also, judges in the United States are only allowed to oversee the adversarial process between lawyers. American judges are not vessels of the Justice Department as investigating judges are of the Ministry of

Justice in France. Further, there is no American equivalent to French investigating judge (Elliott 34).

In the U.S. common law system, the crime of involuntary manslaughter applies only to individuals that had a proximate causation in the negligent or reckless death of an individual (Elliott 62). Therefore, the only action that is considered to have caused the homicide is the individual that committed the proximate or nearest in time to the harm caused (Elliott 62). This theory of causation significantly limits the number of individuals that can be charged in connection with an involuntary manslaughter offense (Elliott 62). For example, only a driver whose reckless behavior directly caused a motor vehicle accident may be charged with involuntary manslaughter even if other factors and individuals ultimately contributed to the accident.

3.2 French Civil Law

The French civil law system encourages lawmakers to craft legislative statutes that can later be codified comprehensively (Steiner 40). This method is done as to allow as many statutes as possible to be codified as to be comprehensive and authoritative (Steiner 40). The French civil law tradition encourages this codification of statutes so that the law in a certain area can easily be applied to many different situations (Steiner 41). As a result, if a case arises that does not conform to the codified statutes, this would require judicial interpretation, something the civil law system seeks to discourage.

When crafting legal opinions in certain cases, French civil law judges are much more tightly bound to French code than those of the U.S. common law system are to statutes. The French legal system views judges as applicators of the law who are tasked with deductive reasoning when approaching a case (Steiner 140). Because French judges are bound by this method of reasoning, they begin with the applicable statutory law and follow the logical steps to reach at the least an acceptable logical conclusion (Steiner 140). Following along with this method of syllogistic reasoning is the foundation of French civil law which essentially holds that statutory law is supreme and judges are bound to be passive implementers of those statutes through predictable and sound logical deductions (Steiner 140). Further, these opinions are solely based on legal arguments that explain exactly how a statute or statutes are applied to a case rather than a policy argument on the language of the code (Steiner 182).

The French criminal justice system also centralizes the role of the *juge d'instruction* or investigating judge (Steiner 292). The French investigating judges are members of the judiciary who are independent of the prosecutor's office (Steiner 292). However, they are tasked with examining all the evidence collected during the police and prosecutors' preliminary investigations and potentially obtaining additional evidence to determine whether the accused should stand trial (Steiner 292). The investigating judges can also collect additional evidence through using arrest warrants, intercept warrants for communications such as phone lines, and even personally question the person being accused (Steiner 292). Additionally, the investigating judge directs the investigation to prevent abuse of the broad powers afforded to the public prosecutor's office and acts as the court of first instance before a suspect's case is potentially referred to a trial court (Elliott 35). At the conclusion of the investigating judge's inquiry, they may decide to either refer the defendant to a trial court or discontinue the process of prosecution (Steiner 293).

French criminal courts favor the 'equivalence of conditions' theory of causation (Elliot 62). Therefore, in the context of fatal accidents where there is no intent to harm, "the courts regularly state that there need not exist between the fault and the damage, 'a direct and immediate causal link,' nor that the wrongful conduct of the defendant be the 'exclusive cause' of the harm" (Elliott 62). As a result, many people could theoretically be charged with involuntary manslaughter for the death of one individual. All that must be shown is the causal link for defendants is 'certain,' and that it does not violate the doctrine of 'adequate cause,' which prevents the imposition of criminal liability in cases where the conduct that indirectly and involuntarily caused harm would be unfair to impose (Elliott 62). This concept is highlighted in the 1988 crash of Air France Flight 296 where multiple people, in addition to the flight crew and the director of the airshow where the crash occurred, were tried and convicted of manslaughter (Mateou and Michaelides-Mateou 58-59).

4. ICAO and Annex 13 to the Chicago Convention

Before examining the American and French civilian aviation accident investigation institutions, it is necessary to describe ICAO and Annex 13 to the Chicago Convention. The International Civil Aviation Organization, or ICAO, is a UN specialized agency that was formed in 1944 (icao.int). The organization was specifically created to manage the administration and governance of the 1944 Convention on International Civil Aviation, also known as the Chicago Convention for the city where it was written (icao.int). ICAO works directly with the Chicago Convention's 192 member states which include the United States and France, as well as civilian aviation industry groups, to form international civil aviation Standards and Recommended Practices or SARPs as well as policies that all support, "a safe, efficient, secure, economically sustainable, and environmentally responsible civil aviation sector" (icao.int). The SARPs and policies are then utilized by ICAO Member States to ensure that their own civilian aviation operations and regulations conform to international norms (icao.int). The two most important chapters to the Chicago Convention in the context of this thesis are Article 26 and Article 38. Article 26 requires that, when an accident to an aircraft occurs within the terms of the convention and occurs within a state that is a party to the convention, the State where the accident occurred will investigate the circumstances of the accident based on procedures recommended by ICAO (Annex 13 x). Article 38 obligates signatory States to file a report in writing if there are any differences between their national regulations and practices and the International Standards held in the convention (Annex 13 xi). Article 38 also invites States to notify ICAO of any differences between their national regulations and the International Recommended Practices held in the convention (Annex 13 xi).

Annex 13 to the Chicago Convention was originally promulgated in 1951 (Annex 13). The annex, "lays down the international standards and recommended practices relating to aircraft accident and incident investigation" (Mateou and Michaelides-Mateou 34). Specifically, Annex 13 utilizes SARPs which provide a common reference for countries to follow when conducting investigations (Mateou and Michaelides-Mateou 34). The main goal of the SARPs in Annex 13 is to, "standardize the procedures of reporting aircraft accidents and incidents; to establish procedures ensuring the participation of experts in accident and incident investigation; and to ensure the expeditious publication of important safety and airworthiness information" (Mateou and Michaelides-Mateou 34). These SARPs comprise the gold standard for conducting airliner accident investigations. The ultimate goal of Annex 13 is that countries will use the information gleaned from a successful investigation to help them prevent future disasters. This is why it is necessary for countries to comply as closely as possible with the SARPs put forward in Annex 13.

These SARPs that comprise Annex 13 were recognized when Annex 13 was adopted as the recommended ICAO procedures for conducting accident and incident investigations in accordance with Article 26 of the Chicago Convention (Annex 13 x). Further, signatory countries to the Chicago Convention are required and invited respectively to inform ICAO of differences between their national regulations and practices with the standards and recommended practices contained within Annex 13 (Annex 13 xi). Standards in Annex 13 are required to be adhered by whereas recommended practices are not technically required. When a country has differences to Annex 13 in its own regulations and practices, they file the differences in a document attached to the annex known as a Supplement.

There are two chapters of Annex 13, 3 and 5, that are important to the context of this thesis. Chapter 3 of Annex 13 handles general provisions of the annex and has two relevant sections. First, § 3.1 a standard, states, "The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents…it is not the purpose of this activity to apportion blame or liability" (Annex 13 § 3-1). This principle is essential for technical investigations because their main objective is to prevent future accidents through obtaining as much evidence as possible. If investigations look to establish blame, those directly involved with crashes will be less likely to cooperate and thus make it difficult to make changes necessary to prevent future accidents. The next section of Annex 13 relevant to this thesis is § 3.2 also a standard, says "a State shall establish an accident investigation authority that is independent from State aviation authorities and other entities that could interfere with the conduct or objectivity of an investigation" (Annex 13 § 3-1). The independence of a technical investigation branch is important because it prevents undue influence from interested parties interfering with an accident investigation.

There are also several sections of chapter 5 on Investigations that are important for this thesis. First, § 5.4.1 which is a standard, states, "any investigation conducted in accordance with the provisions of this Annex shall be separate from any judicial or administrative proceedings to apportion blame or liability" (Annex 13 § 5-3). However, the note to this section admits that, "coordination between the two processes would likely be required at the accident site and in the gathering of factual information" (Annex 13 § 5-3). The note leaves open the obvious question though of how far assistance with the gathering of factual information may go before the technical investigators are basically assisting the criminal investigators with apportioning blame.

Next, § 5.4.3 a recommended practice, states, "a State should ensure that any (technical) investigations conducted under the provisions of this Annex have unrestricted access to all evidential material without delay" (Annex 13 § 5-3). Section 5.6, a standard, goes hand in hand with § 5.4.3 and states, "the investigator-in-charge shall have unhampered access to the wreckage and all relevant material…and shall have unrestricted control over it to ensure that a detailed examination can be made without delay by authorized personnel participating in the investigation" (Annex 13 § 5-3). Although § 5.4.3 is only a recommended practice, both sections make clear that a technical investigation should have primary access to evidence since it could prove important to preventing future accidents. Perhaps the most important section of Annex 13 to this thesis is § 5.4.4, a recommended practice, which states, "a State should ensure cooperation between its accident investigation authority and judicial authorities so that an investigation is not impeded by administrative or judicial investigations or proceedings" (Annex 13 § 5-3). Also, § 5.10 states, "the State conducting the investigation shall recognize the need for coordination between the investigator-in-charge and the judicial authorities…particular attention shall be given to evidence" (Annex 13 § 5-4). Again although § 5.4.4 is a recommended practice, to protect the flying public, both sections make clear that technical investigations must take priority over criminal investigations.

As previously mentioned, signatory countries to Annex 13 are required by ICAO to submit any differences between the standards listed in the document and their own country's national regulations and practices. However, a country is only invited, and not required, to cite differences between the recommended practices in Annex 13 and its own national regulations and practices. The United States did not submit any differences in relation to any of the standards or recommended practices mentioned above (Supplement to Annex 13). However, France did submit a notification in the Annex 13 Supplement in relation to §§ 5.4.1, 5.6, and 5.10 (Supplement to Annex 13). The statement reads that France, in accordance with recommendation § 5.4.1, "(conducts) an investigation separate from any (technical) investigation under the provisions of this Annex when the judicial authority deems that there is a possible criminal offence" (Supplement to Annex 13 12). Further, following § 5.10, French law, "establish(es) the relationship between the two investigations and allows the investigator-in-charge unhampered access to the wreckage and all relevant documents so as to be able to perform the necessary examinations and work without delay" (Supplement to Annex 13 12). However, the statement concludes that the country does differ in regard to § 5.6 which relates to the investigator-in-charge having unrestricted control over the wreckage and evidence (Annex 13 § 5-3). The supplement states, "(French law) does not grant him/her (the investigator-in-charge) total control over the wreckage and documents, the latter of which generally remain under the control of the judicial authority" (Supplement to Annex 13 12). Case studies examined for this thesis will show how this control contributes to the assignment of blame by judicial investigators working closely with the technical investigators in France.

5. U.S. Technical and Criminal Civilian Airliner Accident Investigative Agencies

The technical aviation accident investigation body in the United States is the National Transportation Safety Board, or NTSB. The NTSB was originally created by Congress in 1967 to conduct technical investigations of all civil aviation accidents, as well as major accidents in other forms of transportation in the United States (The Investigative Process). The core component of the NTSB is its "Go Teams" (The Investigative Process). While on duty, Go Team members are ready to respond to accidents across the country from Alaska to Florida twenty-four hours a day (The Investigative Process). The purpose of these teams is basic yet effective "begin the investigation of a major accident at the scene, as quickly as possible, (by) assembling (a) broad spectrum of technical expertise that is needed to solve complex transportation safety problems" (The Investigative Process). The team's work continues at the Board's Washington headquarters (The Investigative Process). This work, which can take a year or longer, forms the basis of later analysis of evidence and data to write a draft report of the accident (The Investigative Process). In addition, public hearings are held for major accident investigations to gather sworn testimony from subpoenaed witnesses and to present an investigative update on the progress of the investigation to involved parties, families of the victims, and members of the media (The Investigative Process). Once the entire Safety Board reviews the draft and it is reviewed by other parties to the investigation, the Board convenes in Washington to determine the probable, or most likely, cause or causes of the accident (The Investigative Process). In addition, "safety recommendations may be issued at any time during the course of an investigation" (The Investigative Process). To maintain strict independence of outside influence, the NTSB is not an agency of the Department of Transportation (DOT), which includes various sub agencies of the DOT like the Federal Aviation Administration (The Investigative Process). Last, the Board does not possess any binding regulatory or enforcement powers (The Investigative Process). Also, because the main mandate of the NTSB if to focus on improving transportation safety, no factual information analysis or a probable cause conclusion from a Board's aviation accident report may "be entered as evidence in any court of law" (The Investigative Process).

The primary criminal aviation accident investigation body in the United States is the Federal Bureau of Investigation or FBI. The FBI is the principal investigative wing of the U.S. Department of Justice (What is the FBI). The Bureau also describes itself as an, "intelligence-driven and threat-focused national security organization with both intelligence and law enforcement responsibilities" (What is the FBI). The FBI has the authority and responsibility to investigate certain crimes that fall under their federal law enforcement jurisdiction (What is the FBI). While the initial response to an airliner crash in the United States and securing the scene usually falls under the jurisdiction of local law enforcement, if criminal acts associated with the crash are suspected, most of the investigation is handled by the FBI (officer.com). The main reasons that the FBI has this jurisdiction is because aviation is predominantly governed by federal law and because it has more experience and resources to deal with major accident scenes than the local authorities typically do. There are some incredibly rare instances where state authorities have filed criminal charges in the wake of an unintentional airliner accident, such as the 1996 crash of ValuJet Flight 592. However, in those instances, the state authorities worked more closely with their federal law enforcement counterparts, principally the FBI, as opposed to their technical counterparts, namely the NTSB (oig.dot.gov). While the NTSB generally has the lead in investigating airliner accidents in the United States, if it is determined with probable certainty that an aviation accident is an intentional, criminal act, the FBI has the lead jurisdiction (Criminal Aviation Investigations). Once this determination is made, the FBI will dispatch a, "Fly-Team," which is like the NTSB's "Go-Team" (Criminal Aviation Investigations). The team is led by an Investigator-in-Charge and includes other FBI special agents and support staff trained in criminal investigations related to aviation (Criminal Aviation Investigations). Even if it does not have the lead in the investigation or suspect foul play, the FBI may still assist the NTSB by providing evidence collection teams and family assistance teams for family members (Halbert). In addition, the FBI could become involved later in an investigation if additional evidence or facts uncovered by the civil investigators point towards criminal intent (Halbert).

Federal charges in relation to unintentional aviation accidents that occur in the United States are rare. Should they be filed, as in the 1996 case of the ValuJet Flight 592 crash, the FBI follows the general steps of the federal criminal justice process to investigate the accident and file charges (Federal Criminal Justice Process). Once a federal law enforcement agency concludes that a crime was committed, they have three options: FBI special agents can make an arrest without obtaining an arrest warrant, obtain an arrest warrant for a person, or delay making an arrest until obtaining additional evidence necessary to prove a suspect's guilt (Federal Criminal Justice Process). To obtain further evidence before prosecuting an individual or company, special agents can apply for a search warrant from a magistrate or judge, "to search a particular site for relevant evidence" (Federal Criminal Justice Process). The special agents may also request a subpoena from a federal grand jury once one is convened (Federal Criminal Justice Process). A grand jury is "an impartial body of citizens drawn from the community that has the responsibility to investigate whether a crime has been committed and by whom" (Federal Criminal Justice Process). To accomplish its goal, grand juries routinely issue subpoenas to obtain evidence and compel witness testimony (Federal Criminal Justice Process). If the grand jury, at the end of its investigation, concludes that there is probable cause to believe that a certain individual committed a crime, then the jury will issue a charging document formally known as an indictment (Federal Criminal Justice Process). Once an indictment is issued, FBI special agents will then arrest the suspect and place them in custody pending the start of court proceedings (Federal Criminal Justice Process). Once the suspect makes an initial court appearance to determine bail, the suspect is formally arraigned to learn the charges against them (Federal Criminal Justice Process). At this stage if the suspect pleads guilty, then they will be either held or released on bail terms to await their sentencing hearing (Federal Criminal Justice Process). Otherwise, if the suspect pleads not guilty, they will be given a trial date in front of either a judge or a jury to determine their guilt or innocence (Federal Criminal Justice Process).

6. French Technical and Criminal Civilian Airliner Accident Investigative Agencies

The technical aviation accident investigation body in France is the *Bureau d'Enquêtes et d'Analyses* or BEA. The BEA was established in 1946 and is directly attached to the French Ministry of Transportation (Mission). However, the organization has its own budget distinct from the rest of the Ministry of Transportation (Mission). Also, to maintain its independence during the conduct of its technical investigations, the BEA cannot receive or request instructions from the Ministry of Transportation (Mission). Like the NTSB, the BEA's sole purpose for technical investigations is to prevent future accidents and incidents (Mission). The BEA's methods and steps for conducting an aviation accident investigation are also comparable to those of the NTSB. The first step of the BEA's investigation is their identification, preservation and gathering of evidences, facts, and other data related to an accident (Conduct of an Investigation). Next, detailed examinations and research are conducted into all the information gathered from the accident (Conduct of an Investigation). Last, after several months to years of investigative work, the BEA presents its conclusion which includes, “the determination of the causes and/or contributing factors” (Mission). The BEA may also decide to issue safety recommendations to the French Ministry of Transportation or other bodies as a result of its findings (Mission). Further, the establishment of causes by the BEA does not apportion blame or administrative, civil, or criminal liability for causing an accident. The BEA states that its technical investigations are conducted separately from any French judicial inquires (Mission). However, “investigators work in concert with the representatives of the judicial authorities,” and are required to share all their evidence, data and conclusions with them as well (Conduct of an Investigation). Unlike in the United States, where NTSB reports are shielded from being admissible in criminal courts, there is no such prohibition on BEA reports in France (Relles and Solomon 423). On the contrary, BEA final reports are “attached to the criminal investigation file as a matter of course” (Foreman 16).

When an aircraft crash occurs anywhere within French territory, criminal investigations are regularly launched in addition to the technical investigation launched by the BEA (Relles and Solomon 422). Criminal and technical investigators routinely work side by side at airliner accident sites in France (Conduct of an Investigation). Local police, either the national police in urban areas or the gendarmes in rural areas will be first on the scene (Elliott 17). However, after the initial emergency response, the *Gendarmerie des Transports Aeriens* or Air Transport Gendarmerie, take over the investigation (Relles and Solomon 423-424). One of the main tasks of the Air Transport Gendarmerie is to assist in the investigation of airliner crashes (Relles and Solomon 424). Because an airliner crash is a major catastrophe that has usually harmed large numbers of people and caused damage to property, the Air Transport Gendarmerie may begin an expedited criminal investigation (Relles and Solomon 424 and Elliott 18). The benefits of launching an expedited criminal investigation are that it allows the French police to, "search property without the owner's consent, seize any object capable of revealing the truth, hear witnesses, and place a suspect in police custody" (Elliott 18). This is an important concept in light of an aviation accident because flight crews and others that may be directly or indirectly involved in the crash are put under immediate judicial scrutiny. Even if it is abundantly clear that no intentional or criminal actions took place in an aviation accident, "in France, it is routine for prosecutors to …ultimately to file charges for involuntary manslaughter against any aviation professional-from pilots to maintenance mechanics to chief executives of aviation regulatory authorities-involved in the accident" (Relles and Solomon 422).

Once this information is received at the Public Prosecutor's Office, it may request a judicial investigation to determine if criminal prosecution is warranted (Elliott 34). The specific purpose of a judicial investigation is to, "build on the work undertaken during the police investigation, in an effort to discover the truth and determine whether the case should be referred for trial" (Elliott 34). It is compulsory for the Public Prosecutor's Office to seek a judicial investigation for serious offenses, such as an airliner crash (Elliott 34). This stage of the French criminal procedure is directed by an investigating judge (Elliott 34). Investigating judges are particularly indispensable during major investigations, like airliner accidents, "where expert reports are required" (Elliott 34). Over the course of a major airline crash investigation in France, the wreckage and documents remain under the direct control of judicial authorities (Mateou and Michaelides-Mateou 110). Consequently, the BEA investigator in charge of an aviation accident in France, "is not granted total control over the accident wreckage and all relevant documents," while they remain with judicial authorities (Relles and Solomon 423). As a result, prohibiting the BEA from having total control of the wreckage unnecessarily complicates its technical investigations. Unlike in the United States where the FBI has experience dealing with aviation accident investigations, the judicial investigators in France rely on working closely with the BEA to interpret data, such as the BEA processing flight recorder information under the custody of the judicial investigators, and other pertinent facts to the investigation (Safety Investigation/Judicial Investigation). Although these investigations are technically separate under French law, since judicial investigators rely on information provided by the BEA, it undermines the ability of its technical investigation to remain consistent with the main objective of ICAO Annex 13 (Safety Investigation/Judicial Investigation).

7. Legal Relationship Between Technical and Criminal Airliner Accident Investigators in the U.S.

It is next necessary to examine the legal relationship between technical and criminal airliner accident investigators in the U.S. and France before they can be compared to Annex 13. The legal relationship in the U.S. between the NTSB and FBI is governed by 49 U.S. Code of Federal Regulations § 831.5 and 49 U.S. Code § 1131(a)(2). Section 831.5 has specified since 1967 that the NTSB has priority over all aviation accident investigations in the United States in accordance with Annex 13. Further, § 1131(a)(2)(A) states that, "an investigation by the Board…has priority over any investigation by another department, agency, or instrumentality of the United States Government" (49 U.S. Code § 1131). As a result, the FBI usually only launches a criminal investigation at the onset of a plane crash if there are clear, suspicious circumstances that surround the accident (The Investigative Process). However, after bureaucratic infighting between the NTSB and the FBI that occurred over the course of the 1996 to 2000 Trans World Airlines Flight 800 crash investigation, the NTSB requested better clarity from the U.S. Congress to ensure that it continues to have investigative priority (twa800.sites).

In 2000, § 1131(a)(2)(B) was amended to state that, "If the Attorney General, in consultation with the Chairman of the (NTSB), determines and notifies the (NTSB) that circumstances reasonably indicate that the accident may have been caused by an intentional criminal act, the (NTSB) shall relinquish investigative priority to the (FBI)" (twa800.sites). Further, in 2005, the NTSB and FBI agreed on a Memorandum of Understanding that states, "in the immediate aftermath of a transportation accident, the NTSB is the presumptive lead investigative agency and will assume control of the accident scene" (twa800.sites). While the Memorandum does not preclude the FBI from conducting its own parallel investigation to the NTSB, it does ensure that investigative priority remains with the NTSB and the FBI, "must coordinate (all of) its investigative activities with the NTSB investigator-in-charge" (twa800.sites). Last, the Memorandum states, "this procedure is intended…to ensure that neither NTSB nor FBI investigative activity unnecessarily complicates or compromises the other agency's investigation" (twa800.sites). The Memorandum significantly improved the relationship and coordination between the NTSB and FBI after the TWA Flight 800 investigation (twa800.sites). Today, the NTSB and FBI conduct joint exercises, have designated liaisons for both agencies to coordinate information flows between agencies and on-scene operations, and lastly call upon one another's laboratories and other technical experience and assets (twa800.sites).

8. Legal Relationship Between Technical and Criminal Airliner Accident Investigators in France

When a serious civil airliner accident or incident occurs within French territory, the legal relationship between the criminal investigators and technical investigators in France is subject to the conditions of Regulation (EU) No. 996/2010 of the European Parliament (Art. L. 1621-2). Since France is a member of the European Union, it is bound by laws passed by its elected legislative body, the European Parliament. First, the regulation states that, "Member States should…safety investigation authorities are allowed to carry out their tasks in the best possible conditions in the interest of aviation safety" (Regulation No. 996 § 20). Section 20 concludes, "the safety investigation authorities should therefore be granted immediate and unrestricted access to the site of the accident and all the elements necessary to satisfy the requirements of a safety investigation should be made available to them, without compromising the objectives of a judicial investigation" (Regulation 996 § 20). This section is interesting because it highlights how the European Union puts criminal and technical investigators on the same level as each other, as opposed to giving the technical investigators priority. However, Regulation No. 996 does state that technical investigators must conduct their investigations independent of judicial or administrative proceedings and must not apportion blame or liability for accidents (Regulation No. 996 Article 5 § 5).

Regulation No. 996 further discusses the important relationship between criminal and technical investigations. As previously described, French law allows the judicial authorities to seize all evidence they deem important to an accident investigation (Supplement to Annex 13 12). Regulation No. 996 states in this case that, "the investigator-in-charge shall have immediate and unlimited access to and use of such evidence" (Regulation No. 996 Article 12 § 1). This is vital to ensuring that a technical investigation is conducted successfully. Further, the regulation makes note that, "member states shall ensure that safety investigation authorities on one hand, and other authorities likely and other authorities likely to be involved in the activities related to the safety investigation, such as the judicial…cooperate with each other through advance arrangements" (Regulation No. 996 Article 12 § 3). Regulation 996 states that these arrangements should include, "access to the (crash) site, preservation of and access to evidence, initial and ongoing debriefings of the status of each process, exchange of information, appropriate use of safety information, and resolution of conflicts" (Regulation No. 996 Article 12 § 3). The note to § 3 states that the agreements are necessary to ensure the independence of the technical investigation while allowing it to be conducted diligently and efficiently, which again are necessary to conducting a successful investigation (Regulation No. 996 Article 12 § 3). In 2014, France complied with § 3 by approving advance agreements between the Ministries of Justice and the Interior to ensure coordination between the BEA and judicial investigations (Safety Investigation/Judicial Investigation).

9. Comparison of the Legal Relationships in the U.S. and France to Annex 13

Now that the legal relationships between technical and criminal airliner accident investigative organizations of the U.S. and France have been described, it is next necessary to compare them to the language of Annex 13 to highlight how the U.S. more closely complies with the central goals of the annex than France. Because Regulation 996 is intended to encompass the domestic laws of the twenty-eight countries of the European Union, it is purposely written to give more deference to the legal traditions of the member nations including France. Nowhere in Regulation 996 does it state that technical investigators will have the primary jurisdiction while conducting an unintentional airliner accident investigation as intended by Annex 13. Instead, the regulation simply requires E.U. member nation's technical and criminal investigators to have a symbiotic relationship. As a result, France's current practice of allowing the Air Transport Gendarmerie and various judicial investigators to have primary control of an airliner accident investigation, while allowed under Regulation 996, goes against the spirit of Annex 13. This tradition forces the BEA to closely cooperate with its criminal counterparts, who control all the evidence, crash site locations, and witnesses, to be able to conduct its technical investigations.

The fact that BEA reports can be entered into evidence in French courts also hurts the independence of its investigations (Relles and Solomon 423). As the case studies will show, this close relationship both hampers the technical investigators and makes witnesses less likely to cooperate. The United States' 49 U.S. Code of Federal Regulations § 831.5 and 49 U.S. Code § 1131, are much more supportive of the technical investigations that follow unintentional airliner crashes than the French code. This is largely because the U.S. forces criminal investigations to take a back seat to the NTSB unless criminal conduct or intentional acts are initially suspected or later uncovered during an investigation (twa800.sites). Although the case studies will show that this has not always been true, important changes to § 1131 were made as a result of past cases where criminal investigators took primary control, hampered technical investigators, and caused witnesses to be less cooperative. As a result, the current language of § 1131 brings the United States in closer compliance with the ideals of Annex 13 than France and E.U. Regulation 996.

10. Case Studies

Four case studies will now be examined at length to highlight how the United States more closely complies with Annex 13 than France. These four crashes and investigations were all selected because they highlight two examples each in the U.S. and France of civilian airliner accidents caused by unintentional actions that resulted in criminal investigations. First, the 1996 crash of ValuJet Airlines Flight 592 shows how the United States reserves criminal prosecutions for egregious intentional conduct regarding an unintentional airliner accident, such as the falsification of maintenance records, as opposed to unintentional errors on the part of flight crews, but also how because it shows how criminal investigations cause witnesses to be less cooperative. Next, the 1996 crash of Trans World Airlines Flight 800 highlights how criminal investigations can significantly hamper technical investigations and subsequently endanger the flying public. Most importantly, the United States took legislative action in the wake of this investigation to ensure the NTSB always has the lead in unintentional airliner accidents to more closely mirror Annex 13. The crash of Air France Flight 296 in 1988 illustrates how France conducts criminal probes of airliner crashes even if it is clear the accident is only caused by an unintentional error rather than criminal conduct, which both hampers the technical investigators and causes witnesses to be less cooperative. This routinely leads people associated with crashes to be criminally charged which complicates technical investigations and undermines the goal of Annex 13. Last, the crash of Air France Flight 4590 in 2000 again shows how the French system will prosecute individuals associated with unintentional airliner crashes just because of their unintentional errors. However, in this case, most of the defendants were Americans that had never set foot in France let alone intended to cause a crash. Again, this crash investigation complicated the technical investigation and hence worked against the goals of Annex 13. Please refer to the Annex on page 61 for more detailed descriptions of the background information and technical investigations related to each flight.

10.1 Case Study 1: ValuJet Airlines Flight 592

The first case study examined in this thesis is that of ValuJet Airlines Flight 592. On a warm, late-spring day in 1996, the Douglas DC-9 was flying what should have been a short hop from Miami to Atlanta when it slammed into the Everglades just minutes after takeoff (In-Flight Fire 1). The crash was ultimately discovered to have been precipitated by an inflight fire that was caused by the improper packaging of oxygen generators, which are used to supply passengers with oxygen in the event of an emergency decompression. The NTSB placed the blame for the packaging of the oxygen generators on SabreTech, an aviation contract company that packaged the generators; ValuJet for not properly overseeing its contractor; and the Federal Aviation

Administration for not giving ValuJet enough oversight for their operations (In-Flight Fire x). This case is important for the thesis because the crash of Flight 592 marked the first-time criminal charges were brought against individuals in the United States for an accidental airline crash (Phillips). In addition, "SabreTech was the first American aviation company to be criminally prosecuted for its role in an American airline crash" (Mateou and Michaelides-Mateou 61). Flight 592 most importantly shows how the United States is reluctant to file criminal charges in an unintentional aviation disaster unless the errors that contributed to the accident are particularly egregious, as they were in the case of ValuJet. Further, criminal charges in the United States are principally reserved for actions related to an accident that constitute intentional conduct, "such as the falsification of maintenance records or aircraft documents," as will be shown assisting in leading to the crash of Flight 592 (Nemsick and Passeri). Last, the accident highlights how criminal investigations cause those associated with accidents to refuse to cooperate with investigators for fear of self-incrimination (Holland).

On May 11, 1996, a ValuJet Airlines Douglas DC-9-32, registered N904VJ, was scheduled to operate Flight 592 from Miami International Airport to William B. Hartsfield International Airport in Atlanta, Georgia (In-Flight Fire 1). Onboard the DC-9 that day were 105 passengers, 2 pilots, and 3 flight attendants (In-Flight Fire 1). The aircraft also carried 4,109 pounds of cargo, including company-owned materials or COMAT, for the roughly hour and a half flight to Atlanta (In-Flight Fire 1). According to the shipping ticket, the COMAT consisted of two main tires and wheels, a nose tire and wheel, and five cardboard boxes that were marked, 'Oxy Cannisters "Empty",' (In-Flight Fire 2). Flight 592 pushed back from its gate at 1:40 PM and took off about twenty minutes later at 2:03 PM (In-Flight Fire 2). About seven minutes into the flight and while the pilots were in the process of climbing in the DC-9 to its next assigned altitude, they heard an unidentified sound (In-Flight Fire 2). A few seconds later, the departure air traffic controller was advised by the captain that, “we need, we need to go back to Miami” (In-Flight Fire 2). This was quickly followed three seconds later by unknown people shouting, “fire,” multiple times in the background followed distinctly by another unknown male voice at 2:10:27 stating, “we’re on fire, we’re on fire” (In-Flight Fire 2). Only a mere seven minutes after takeoff ValuJet Airlines Flight 592 was on fire and in the midst of a critical situation.

Meanwhile the situation onboard the aircraft was rapidly deteriorating as the cockpit voice recorder picked up a flight attendant shouting that the aircraft was, “completely on fire” (In-Flight Fire 3). The flight began heading in a southerly direction while the controller got on the phone with emergency services in Miami, which he then relayed to the crew (In-Flight Fire 3). The controller then asked the crew to make another heading change which was acknowledged by the First Officer (In-Flight Fire 3). This transmission would be the last time anyone would have contact with the doomed flight (In-Flight Fire 3). The controller again instructed the flight to change its vector but received no response (In-Flight Fire 3). Seconds later, and only about ten minutes after the aircraft had taken off, Flight 592 impacted the Everglades in a steep, right bank (In-Flight Fire 3). Tragically, all 110 people onboard the DC-9 were killed instantly in the crash (In-Flight Fire 20).

The National Transportation Safety Board quickly launched a technical investigation to determine why ValuJet Flight 592 had taken its deadly plunge into the Everglades. The nature of the air traffic controller’s statements and recordings of the conversations between them and the flight crew of Flight 592 quickly made it apparent that some type of onboard fire had brought the aircraft down. However, because of the DC-9’s high speed impact and the remote nature of its crash site, the NTSB was not able to recover the entire aircraft (In-Flight Fire 100). Through tedious efforts, they were able to recover enough of the aircraft to prove that the fire had begun in the forward cargo compartment (In-Flight Fire 100). This was easily determined since this area of the aircraft, and the other locations directly above it, had experienced the worst fire and heat damage (In-Flight Fire 100).

Interestingly, the NTSB found the only area of the forward cargo compartment that was breaching due to the extreme heat and stress from the fire was the ceiling right above where the oxygen generators had been loaded (In-Flight Fire 100-101). What the investigators subsequently discovered was that the five cardboard boxes marked, ‘Oxy Cannisters “Empty”,’ were actually unexpended chemical oxygen generators that had been improperly packaged (In-Flight Fire 101). Specifically, the investigators found the safety caps to prevent the chemical reaction that initiated their firing were not properly installed on any of the oxygen cannisters; lanyards for preventing their spring-loaded firing mechanisms were not installed; and lastly, the oxygen generators were not safely packaged to prevent them from being unintentionally discharged during transport (In-Flight Fire 101). Based on the physical evidence of damage to the forward cargo compartment, scientific tests conducted by the NTSB proving the oxygen generators could easily produce a fire, and the lack of other substances being present in the forward cargo compartment capable of producing a fire, the investigators concluded that the improperly packaged oxygen generators had caused the fire which led to the crash (In-Flight Fire 101).

The NTSB concluded that the fire was likely initiated long before the plane ever took off from the ground (In-Flight Fire 102). The most likely sequence they uncovered was that one of the oxygen generators was likely activated during the cargo loading process (In-Flight Fire 102). The investigators found that the chemical reactions of the oxygen generators being fired, which are exothermic and therefore generates substantial heat, coupled with the airtight design of the cargo compartment, the nearby combustible materials such as the aircraft tires all contributed to the initiation and propagation of the fire (In-Flight Fire 102). As a result, the NTSB discovered that the extreme heat from the fire destroyed flight control cables, electrical wires, and even began to melt the floor supports (In-Flight Fire 107). The Board concluded that the last dive which caused the aircraft to crash was likely caused by a loss of flight control systems, the collapse of the cockpit floor, the incapacitation of the crew, or some combination that all resulted from the intense nature of the fire (In-Flight Fire 107).

The NTSB concluded that the COMAT cargo of the oxygen generators and aircraft tires onboard Flight 592 did not alert either the ramp agent or the First Officer that accepted the shipment (In-Flight Fire 104). The simple reason was that none of the five cardboard boxes full of oxygen generators loaded onto the flight had any hazardous material markings or labels and the shipping ticket of the cargo indicated that the oxygen generators were empty (In-Flight Fire 104). The Board also uncovered that SabreTech had removed and improperly stored the oxygen generators from three used MD-80 series aircraft purchased by ValuJet (In-Flight Fire 11) However, they never intended for them to be shipped back to ValuJet on a commercial flight (In-Flight Fire 15). The cardboard boxes containing the generators were then mistakenly taken to SabreTech's shipping center to help clean out a storage area in preparation for a visit from a potential customer (In-Flight Fire 18). Because no hazardous materials labels were affixed to the temporary packaging, a shipping clerk dispatched the boxes to travel back to the ValuJet headquarters in Atlanta onboard flight 592 (In-Flight Fire 19)

Almost immediately after the technical investigation began into the crash of ValuJet Flight 592, the Federal Bureau of Investigation and other federal law enforcement agencies began to assist with the recovery efforts for the flight (baltimoresun.com). Numerous agencies initially became involved because of the difficult nature of pulling the remains of the DC-9 from the Everglades (baltimoresun.com). However, within days of the crash, the media's attention had already turned its focus on the oxygen generators that were loaded into the cargo hold of Flight 592 (baltimoresun.com). While it was still unclear just six days after the crash as to whether the generators had caused the crash or could even start a fire by themselves, their presence had already peaked the interest of investigators (baltimoresun.com). There was initially much confusion over the nature of the oxygen generators, namely whether they were functional at the time of the crash or empty and who had loaded them onto the flight and for what reason (baltimoresun.com). Gregory Feith, a senior investigator at the NTSB was quoted as saying, "we're now trying to clarify the chain of custody of the canisters" (baltimoresun.com). He continued, "there is a discrepancy right now amongst people and paperwork about whether the canisters were full or empty" (baltimoresun.com). However, scrutiny was also quickly being placed onto ValuJet for transporting the oxygen generators in the first place (baltimoresun.com). An unidentified FAA official was quoted as stating, "oxygen generators…are considered hazardous materials when carried as cargo…(and) ValuJet was not authorized to carry hazardous material" (baltimoresun.com). The Attorney General at the time of the accident, Janet Reno, stated that although no evidence of sabotage had been discovered to explain the crash, "the FBI, just as a routine matter, is involved in this, as in other crashes" (baltimoresun.com).

Just three months after the crash of ValuJet Flight 592, more than 50 agents from the Federal Bureau of Investigation raided the SabreTech maintenance facility at the Miami International Airport (Friedberg and Kaye). The agents seized several boxes of employee and maintenance records from the building (Friedberg and Kaye). In addition, the FBI and other federal law enforcement agencies contacted SabreTech employees when they left their employment to ask relevant questions (Holland). While the U.S. Attorney's Office in Miami declined to be interviewed at the time, unnamed sources close to the FBI's investigation reported that they were investigating "whether SabreTech employees made false statements about whether the oxygen generators were empty or charged" (Friedberg and Kaye). In addition, the source mentioned that the FBI was investigating whether internal company documents mislabeled the canisters as being shipping with the safety caps (Friedberg and Kaye). As the NTSB later uncovered, and the SabreTech president Steven D. Townes had admitted during a congressional hearing a month after the crash, the work card for the oxygen generators removed from the MD-80s specified that safety caps had been installed even though the company did not have any (Friedberg and Kaye). Townes attempted to walk back the false representation by saying that the mechanics had "made a good-faith attempt to provide an equivalent level of safety" by cutting the lanyards around the generators and taping them (Friedberg and Kaye). Nevertheless, the admission coupled with additional evidence against the company proved enough for an indictment.

The raid on August 9, 1996, ended up being one of the first steps in a lengthy and complicated criminal investigation into the crash (Candiotti). Various agencies assisted in the investigation, including the FBI, U.S. Department of Transportation's Office of Inspector General, the Environmental Protection Agency's Criminal Investigations Division, Florida prosecutors from the state Attorney General's Office, U.S. Department of Justice Federal Prosecutors, and others (Candiotti and oig.dot.gov). The investigation was hampered by "numerous difficulties including trouble locating witnesses and documents as well as the massive destruction of the aircraft at the crash site" (Candiotti). At the end of a nearly three-year investigation, separate criminal charges from both the State of Florida and the United States

Federal Government, were filed on July 13, 1999 (Phillips and oig.dot.gov). The first set of charges came from the Florida State Attorney's Office in Miami-Dade County (Phillips). The indictment charged SabreTech with 110 counts of third-degree murder, 110 counts of manslaughter, and one count of unlawful transportation of hazardous waste (Phillips). "This crash was completely preventable," remarked the state attorney for Miami-Dade County, Katherine Fernandez Rundle who continued, "it was a crime" (Phillips). In addition to the indictment being significant for its connection to an unintentional airline disaster, the charges were also significant because murder indictments against a company are rare in the United States (Phillips).

Just hours after the state indictment was announced, a federal grand jury also indicted SabreTech, its vice president of maintenance, Daniel Gonzalez, and two of its mechanics, Eugene Florence and Mauro Valenzuela, on a variety of charges (Phillips). The twenty-four count indictment included the following allegations (*U.S. v. SabreTech*). Count 1 charged all defendants with conspiracy to make false statements on aircraft maintenance records (*U.S. v. SabreTech*). Count 2 charged Gonzalez with knowingly and willfully making a false statement on a maintenance record (*U.S. v. SabreTech*). Count 3-4 charged SabreTech, Florence, and Valenzuela with knowingly and willfully making false statements on ValuJet maintenance records (*U.S. v. SabreTech*). Counts 7, 9, 11, 13, 15, 17, 19, and 21 charged SabreTech with willfully transporting hazardous materials by air without complying with packaging, marking, and labeling requirements of hazardous materials regulations (*U.S. v. SabreTech*). Counts 8, 10, 12, 14, 16, 18, 20, and 22 charged SabreTech with both willfully and recklessly causing the oxygen generators to be transported by air (*U.S. v. SabreTech*). Count 23 charged SabreTech for willfully failing to train its employees in accordance with hazardous materials regulations (*U.S.*

v. SabreTech). Last, count 24 charged SabreTech with willfully placing destructive devices on an aircraft (*U.S. v. SabreTech*). Two days after the grand jury handed down the indictment, the three individuals that were charged surrendered to the FBI at its headquarters (Shain). Mauro Valenzuela told reporters, "it wasn't our call…it wasn't my responsibility" regarding the forms he signed stating that the oxygen generators had been properly capped (Shain). He continued, "it wasn't my intent (to falsify documents)…I was told to" (Shain).

After trial in 1999, a federal jury acquitted SabreTech of all counts except the eight counts related to the reckless allowance of the oxygen generators to be transported by air and the one count of willful failure to train its employees in accordance with hazardous materials regulations (*U.S. v. SabreTech*). The jury also acquitted Florence and Gonzalez of all charges (*U.S. v. SabreTech*). Interestingly, Mauro Valenzuela fled after his bail hearing and remains on the FBI's Most Wanted List to this day (Mcardle). After an extensive sentencing hearing, the Federal District Court sentenced SabreTech to pay a fine of $2 million and pay additional restitution of $9,060,400 (*U.S. v. SabreTech*). After the conviction, SabreTech appealed both the conviction and sentence to the United States Court of Appeals for the Eleventh Circuit (*U.S. v. SabreTech*). In 2001, the Eleventh Circuit vacated the conviction on the eight counts of the reckless allowance of the oxygen generators to be transported by air (*U.S. v. SabreTech*). However, the appeals court upheld the one count conviction of the willful failure of SabreTech to train its employees in accordance with hazardous materials regulations (*U.S. v. SabreTech*). The Eleventh Circuit then remanded the case back to the District Court to resentence SabreTech on the one count (oig.dot.gov). The District Court resentenced SabreTech to a fine of $500,000 dollars and three years of probation, which was the maximum allowed under Federal sentencing guidelines for the failure to train count (oig.dot.gov). SabreTech ultimately settled the state criminal charges in 2001 with a plea agreement that required the company to pay an additional $500,000 dollars to organizations that promote aviation safety (Nemsick and Passeri).

Although few of the criminal charges filed in the crash of ValuJet Flight 592 against SabreTech and the three other individuals resulted in convictions, the accident and its investigation are still important for this thesis. First, the investigation illustrates that in certain circumstances the United States has filed criminal charges in the wake of unintentional airliner accidents, which in theory runs contrary to the ideals of ICAO Annex 13. However, these instances are rare and, when they do occur, the NTSB's technical investigation always takes priority to any criminal investigations of an unintentional crash (Nemsick and Passeri). For example, the NTSB was able to issue its report into the accident in August 1997, long before any criminal charges were filed by either the federal or state authorities (In-Flight Fire Title Page). When the FBI or other law enforcement agencies do decide to file charges, they are principally reserved for intentional conduct related to the accident, "such as the falsification of maintenance records or other aircraft documents," as opposed to prosecuting someone for their unintentional errors (Nemsick and Passeri). The most important fallout from the criminal investigation into the crash of Flight 592 is that, "potential criminal defendants in other transportation accidents have refused to cooperate in investigations," for fear of self-incrimination like the SabreTech mechanics (Holland). The NTSB needs answers to relevant question to further their technical investigations, so they can assist in the prevention of future accidents (Holland). However, the threat of criminal charges, "impedes cooperation by mechanics, flight crews, manufacturers, and others with the NTSB investigatory process" (Holland).

10.2 Case Study 2: Trans World Airlines Flight 800

The next case study is the crash of Trans World Airlines Flight 800 on July 17, 1996, off East Moriches, New York. Unlike the other three case studies examined in this thesis, no criminal charges were ever filed by the Federal Bureau of Investigation in relation to the crash. However, the explosion of the center wing fuel tank that precipitated the crash initially appeared to thousands of stunned onlookers to be the result of a bomb or missile attack on the aircraft. These reports caused the FBI to quickly take over the lead in the investigation from the National Transportation Safety Board although no physical evidence was ever located to suggest the crash was caused by criminal activity. This case study is important to the thesis because it shows how technical investigations can easily be hampered when criminal investigations take priority due to their competing interests. Further, Flight 800 highlights how the United States took notice of the difficulties during the investigation and prevented the missteps from reoccurring through passing a legislative amendment to the U.S. Code of Federal Regulations that clarifies the NTSB has primary jurisdiction over a commercial airliner accident in the United States. This important change has allowed the United States to more closely comply with the central goal of ICAO Annex 13.

On July 17, 1996, a Trans World Airlines Boeing 747-131, registered N93119, was scheduled to operate an international passenger flight from John F. Kennedy International Airport, New York, New York to Charles de Gaulle International Airport, Paris, France (In-Flight Breakup 1). On the day of the accident, the 747 had departed Athens, Greece and arrived at JFK about 4:31 PM local time (In-Flight Breakup 1). The flight crew of that flight reported to NTSB investigators that they observed no abnormalities with the aircraft (In-Flight Breakup 1). A scheduled crew change occurred at JFK while the aircraft was being refueled (In-Flight Breakup 1). To keep the crew and new passengers cool during the boarding process, the 747's auxiliary power unit and two of its three air conditioning packs were kept operational as it was a warm July night (In-Flight Breakup 1). On board the aircraft were 2 pilots, 2 flight engineers, 14 flight attendants, and 212 passengers (In-Flight Breakup 1).

After completing various instructions from Air Traffic Controllers, the 747 reached its initial assigned altitude of 13,000 feet about 17 minutes after takeoff (In-Flight Breakup 2). Three minutes later, the cockpit voice recorder picked up the captain remarking, "look at that crazy fuel flow indicator there on number four…see that?" (In-Flight Breakup 2). Less than a minute later Air Traffic Controllers advised the flight to climb another 2,000 feet (In-Flight Breakup 2). As the aircraft started climbing, the cockpit voice recorder picked up three additional sounds before the end of the tape: "the sound of a mechanical movement in the cockpit, an unintelligible word uttered by a crew member, and lastly a sound like recording tape damage noise" (In-Flight Breakup 3). The NTSB conducted a sound spectrum study of the cockpit voice recording and it additionally revealed, "a very loud sound," picked up for a fraction of a second immediately before the recording ended (In-Flight Breakup 3). Less than a minute after the cockpit voice and flight data recordings ended, the pilot of an Eastwind Airlines Boeing 737 radioed to Air Traffic Control that, "we just saw an explosion up ahead of us here…about 16,000 feet or something like that, it just went down into the water" (In-Flight Breakup 3). Numerous other pilots and countless other witnesses reporting hearing and/or seeing an explosion, accompanied by a large fireball, and lastly debris falling into the water (In-Flight Breakup 3). Some witnesses also reported seeing a fireball that resembled a flare moving upwards into the sky to the point that the large fireball appeared at which it broke into two separate fireballs before descending into the ocean (In-Flight Breakup 3). Emergency services dispatched to the ocean quickly located floating debris, while most of the debris field had already sunk to the ocean floor (In-Flight Breakup 4). Tragically the onboard explosion and subsequent crash of the aircraft had killed all 230 people on board the 747 (In-Flight Breakup 4).

The National Transportation Safety Board immediately began a technical investigation into the cause of the TWA Flight 800 disaster. Witness reports and the widespread distribution of wreckage quickly led the NTSB to conclude that, "TWA Flight 800 had experienced a catastrophic in-flight structural breakup" (In-Flight Breakup 256). The NTSB, along with other agencies involved in the recovery efforts quickly recovered the cockpit voice and flight data recorders and found both to be in good condition (In-Flight Breakup 58-59). The technical investigators concluded from the audio analysis of the CVR that, "a noise recorded on the (Flight 800) CVR in the last few tenths of a second before the CVR recording stopped was similar to the last noises heard on CVR recordings from other airplanes that had experienced structural breakups" (In-Flight Breakup 256).

Tests and examinations of the wreckage by both the NTSB's Metallurgy Structures and Sequencing Groups concluded that, "the initial event in the breakup sequence was an overpressure event within the CWT (center wing fuel tank)" (In-Flight Breakup 260). In addition, the groups concluded that, "because there was no evidence that a high-energy explosive device detonated in this (or any other) area of the airplane, this overpressure could only have been caused by a fuel/air explosion in the CWT" (In-Flight Breakup 261). To provide further evidence towards this conclusion, the NTSB conducted several tests under precise conditions that Flight 800 would have been flying on that warm July evening (In-Flight Breakup 261). This led the Board to determine, "the fuel/air vapor in the ullage of TWA Flight 800's CWT was flammable at the time of the accident" (In-Flight Breakup 261). While the NTSB exhaustively sought to find the exact source and location of ignition for the explosion of the center wing fuel tank, they were never able to conclusively determine either (In-Flight Breakup 294). However, the Board ultimately concluded that the energy for the explosion, "entered the CWT through the FQIS (fuel quantity indicating system) wiring" (In-Flight Breakup 294). The Board reached this conclusion for two reasons. First, the fuel quantity indicating system has the only wiring in the center wing fuel tank (In-Flight Breakup 279). Last, this was the exact, malfunctioning system that the captain had noticed just minutes before the explosion (In-Flight Breakup 2). The National Transportation Safety Board, "determines that the probable cause of the TWA flight 800 accident was an explosion of the center wing fuel tank (CWT), resulting from ignition of the flammable fuel/air mixture in the tank" (In-Flight Breakup 308). The report concluded, "the source of ignition energy for the explosion could not be determined with certainty, but, of the sources evaluated by the investigation, the most likely was a short circuit outside of the CWT that allowed excessive voltage to enter it through electrical wiring associated with the fuel quantity indication system" (In-Flight Breakup 308).

Although it was ultimately determined that the crash of Trans World Airlines Flight 800 was not caused by terrorism or another intentional act, the circumstances surrounding its plunge from the sky led many law enforcement agencies to initially suspect otherwise. Hence many federal agencies, led by the Federal Bureau of Investigation, began immediately afterwards a criminal investigation into the crash of Flight 800. Since the 747 was almost entirely full of fuel for its trip to Paris, the explosion of the aircraft was large enough to be widely observed and felt by many people who were out and about on the warm, July evening (Kleinfield). One witness named Kenneth Susskind interviewed in the immediate hours after the tragedy by *the New York Times* recounted, "there was like a sonic boom; then we saw a lot of smoke…a large cloud over the ocean" (Kleinfield). Mr. Susskind and numerous other witness statements provided to investigators in the hours after the tragedy made it quickly apparent that the aircraft had exploded and caught fire (Kleinfield). By the morning after the tragedy, the Federal Bureau of Investigation had taken the lead in the case on the sole basis of the witness reports which pointed to the possibility that the plane was deliberately downed (Kleinfield). Although the National Transportation Safety Board "is supposed to be the lead investigative agency into an aviation disaster until there is an official determination that a crime has been committed," that was not what happened during the TWA Flight 800 accident (Grunwald). Instead during, "the frenzied opening hours at the crash site, the law enforcement-oriented FBI was clearly the only agency with the resources to handle much of the work, and the science-minded safety board reluctantly took a back seat" (Grunwald).

Interestingly, *the New York Times* article, published not even twenty-four hours after the disaster, made clear that unnamed officials stated, "if indeed an explosion did occur aboard the jet, there were other possible causes (than nefarious actions)" (Kleinfield). James K. Kallstrom, assistant director in charge of the F.B.I.'s New York City field office was quoted in the article as saying, "(if terrorism was involved) the F.B.I. has jurisdiction to conduct this investigation based upon Federal statutes pertaining to destruction of aircraft, as well as the possibility of violations of other criminal laws" (Kleinfield). While it was far from clear what had happened at that stage of the investigation, an unnamed Federal official was quoted in the article as saying, "it doesn't look good,' meaning that the circumstances seemed to point to a terrorist act," before they had even recovered any physical evidence (Kleinfield).

As it became clear through the evidence that no criminal act was to blame for the crash of TWA Flight 800, the criminal investigation ultimately took a backseat to the technical investigation and eventually closed the investigation without filing criminal charges in

November 1997 (Grunwald). However, the FBI's concurrent criminal investigation, "conflicted (with) and hampered the technical investigations being carried out by the NTSB" (Mateou and Michaelides-Mateou 104). Further, the secrecy of the FBI's investigation, "often resulted in the NTSB investigation being diverted (to) focus on various theories, delaying the (technical) investigation and draining their resources" (Mateou and Michaelides-Mateou 104-105). In May 1999, the U.S. Senate Judiciary subcommittee, which has congressional oversight of federal law enforcement agencies including the FBI, convened to hold hearings on the bureaucratic infighting that occurred over the course of the Flight 800 investigation (Grunwald). Senator Charles E. Grassley, the Republican senator from Iowa, chaired the hearing, and stated that the investigation was, "a model of failure, not success," and described the FBI's leadership in the investigation, "a disaster" (Walsh). Further, Senator Grassley stated that the FBI, "hindered the investigation and 'risked public safety' with its alleged attempt to suppress a report (by the Bureau of Alcohol, Tobacco, and Firearms) on the cause of the crash (Walsh). That report concluded that Flight 800 had crashed after a mechanical failure caused the central fuel tank to explode (Walsh). Andrew Vita, the ATF's assistant director of field operations at the time, testified that the FBI attempted to suppress the report being brought to the NTSB since it conflicted with their own theory on what caused Flight 800 to crash (Walsh). Testimony conducted in the hearing made clear that the FBI "had clung to the theory that a bomb or missile had downed the plane months after its own chief scientist on the case (and other agencies) had reached the opposite conclusion" (Walsh). That report never reached the NTSB and it took another eleven months before the FBI finally closed its case in November 1997 (Walsh). Last, the hearing uncovered other evidence of misconduct by the FBI's investigation including, “mishandling of evidence and an unauthorized invitation by an agent on the case to a psychic to view the wreckage and render an opinion” (Walsh).

The investigation of TWA Flight 800 makes clear why ICAO Annex 13 seeks to afford technical investigators primary jurisdiction when conducting an accident. Namely, the quest to hold people responsible for causing the accident makes it more difficult to prevent future accidents from occurring. This is because criminal investigations, which seek to apportion blame and not prevent future accidents, make it harder for the technical investigators to access evidence, witnesses, and wreckage. As shown in the case of TWA Flight 800, these difficulties subsequently drain the resources of the technical investigators and take them longer to figure out the technical reasons behind why an aircraft crashed. Most importantly, the accident prompted a 2000 amendment to 49 U.S. Code of Federal Regulations § 1131 in response to the difficulties of the TWA Flight 800 investigation that has clarified the relationship between the NTSB and FBI. These changes will prevent future conflicts between them and makes clear that the NTSB has primary jurisdiction over unintentional airliner accident investigations in the U.S.

10.3 Case Study 3: Air France Flight 296

The next case study is Air France Flight 296, the crash of a brand new A320 being flown on an airshow demonstration just days after it was delivered in 1988. The accident is relevant for this thesis because it became one of the most famous examples of how French judicial authorities will prosecute individuals that caused or were associated with an airliner crash even if their mistakes were unintentional. Namely five individuals associated with Flight 296 were successfully prosecuted for their roles in the tragedy: the pilot, the co-pilot, Air France's then-director of air operations, a security official for Air France, and the president of the Habsheim air club (Mateou and Michaelides-Mateou 58-59). Further, this accident highlights how the close cooperation between technical and criminal investigators undermines Annex 13 by causing those associated with an accident to become uncooperative with and even discredit the technical investigation for fear of self-incrimination.

On June 26th, 1988, a series of special flights were to be conducted by Air France on behalf of the Mulhouse flying club (Final Report 26 June 1988 4). On two of the round trips from Basle-Mulhouse, the crew of the Airbus A320, registered F-GFKC, were to conduct low flyovers of the Mulhouse flying club's airshow organized at the Mulhouse-Habsheim aerodrome (Final Report 26 June 1988 4). The round trips were not able to land at Mulhouse-Habsheim aerodrome because the airport was not large enough to accommodate an Airbus A320 and thus the aircraft was staged at nearby Basle-Mulhouse airport. Various departments of Air France assisted in the preparations for conducting the flyover which included filing various paperwork to the proper authorities and giving the crew the necessary information to conduct the flight safely (Final Report 26 June 1988 4). These preparations were supposed to specifically prepare for potential obstacles around the Mulhouse-Habsheim aerodrome and the necessary information to conduct the planned low-flyover of the aerodrome's runway (Final Report 26 June 1988 4). While the preparations included maps, visual flight charts, visual landing charts, a scheduled flight plan, and various other information about Mulhouse-Habsheim airport, the crew were provided with, "no instructions either concerning runway axis or height of (the) overflight (flyover)" (Final Report 26 June 1988 4).

The crew of Flight 296 successfully piloted the A320 with 6 crewmembers and 130 passengers onboard from Paris to Basle and then quickly briefed for the planned flyover of the Mulhouse-Habsheim aerodrome (Final Report 26 June 1988 5). For this leg the captain was designated as the pilot in command and based on the cockpit voice recordings, explained the flyby program to his copilot (Final Report 26 June 1988 5). He explained his intention to flyover the field twice, "first (conducting an) overflight at low speed, with landing gear and flaps extended, (also known as 'dirty' configuration) at a height of 100 feet, (and then an) overflight at high speed in clean configuration" (Final Report 26 June 1988 5). After taking off, the crew quickly reached their cruising altitude of 1000 feet within a minute and visually identified the aerodrome two minutes later (Final Report 26 June 1988 5). The aircraft began descending for the flyby at a rate of 600 feet per minute and quickly reached the targeted altitude of 100 feet for the flyby; however, the aircraft quickly passed 100 feet and continued descending at the same rate of descent before abruptly slowing to a descent rate of 50 feet per minute (Final Report 26 June 1988 6). The A320 then leveled off at 30 to 35 feet in near level flight, significantly less than initially briefed by the crew (Final Report 26 June 1988 6). Throughout the entire descent the crew maintained the engines at idle, even as the aircraft decelerated and began to pitch up near the very end of the flight (Final Report 26 June 1988 6). During the last five seconds of the flight before impact the engine controls were pushed to maximum thrust to initiate an emergency go around but it was too late for the flight (Final Report 26 June 1988 6). Only four minutes after the A320 had initially taken off the rear fuselage of the aircraft touched the trees at the end of the runway and the aircraft sank into the forest (Final Report 26 June 1988 6) The impact immediately started a fire which quickly penetrated the cabin (Final Report 26 June 1988 6). The aircraft's evacuation was immediately started on the left side of the A320 to avoid the raging fire (Final Report 26 June 1988 6). The quick evacuation resulted in 4 crew members and 93 passengers escaping without injury (Final Report 26 June 1988 Contents 2). Tragically, 3 passengers were killed in the ensuing fire and a further 2 crew members and 34 passengers were injured (Final Report 26 June 1988 Contents 2).

The BEA initiated a technical investigation into the crash and was able to conclude early on that there was no evidence of any mechanical or instrument failures on the aircraft (Final Report 26 June 1988 47). After ruling these factors out, the BEA turned its focus to the last possible causes for the accident, the failures during the preparation for the flight at Air France and more importantly how pilot errors caused the flight to crash.

The BEA concluded that the planning for Flight 296 was rushed and not prepared properly. They ultimately discovered several reasons that likely contributed to the plans being incomplete and hurried for release to the crew. First, the flight plans were drawn up last minute on a Friday afternoon by the employee responsible for its preparation (Final Report 26 June 1988 48). The Air France Airbus A320 likely did not address the flight planning sooner because of their workload related to getting the A320 into service since it was a brand-new type of aircraft for Air France (Final Report 26 June 1988 48). Last, the employee who prepared the flight plan likely assumed that he did not need to fill in every detail since Captain Asseline, "was perfectly capable of planning this flight himself given his (important) position in the company" (Final Report 26 June 1988 48).

The flight crew of the A320 also made numerous airmanship errors that led to the accident. First, the crew never considered getting more information regarding the topography and potential obstacles around the Habsheim aerodrome aside from the notes in the flight plan (Final Report 26 June 1988 49). This included neglecting to consider flying a reconnaissance flight above the aerodrome before Flight 296 and deciding to skip a safety briefing with the Habsheim airshow flight manager which would have given them detailed information about the terrain, runway used for the flyby, and the location of the crowd amongst other crucial details (Final Report 26 June 1988 49). The BEA also discovered that the pilots may have been more confident of performing the first flyby at a slow speed and reaching the limitations of maintain lift due to the added safety protections afforded by the Airbus A320's computer flight system (Final Report 26 June 1988 51). However, the crew discovered the hard way that it was possible to push their A320 beyond a safe flight envelope even with the added onboard protections afforded by the new aircraft's computers (Final Report 26 June 1988 51). Next, the crew were late in identifying the Habsheim aerodrome after takeoff which caused them to rush their descent to get the aircraft low enough to conduct the flyby (Final Report 26 June 1988 53). Finally, the crew's lack of experience flying over a grass strip aerodrome, the crew's potential false impressions regarding the height of the aircraft since the nose and cockpit section were much higher than the tail during the slow flyby, and the color of the tree line which possibly disguised its presence all contributed to cause the accident (Final Report 26 June 1988 55).

The BEA identified that Captain Asseline's over confidence likely contributed to the airmanship errors that led to the accident (Final Report 26 June 1988 56). The BEA discovered several reasons for the Captain's hubris. These included his extensive experience with A320 simulators and his development of the aircraft led him to believe that, "he knew the A320 better than most of his colleagues," his experience doing similar flybys in the aircraft's dirty configuration in the A320 simulator, albeit at a much higher altitude and hence more breathing room in case something went wrong (Final Report 26 June 1988 56). The BEA also concluded that the air show atmosphere and presence of female passengers close to the cockpit may have contributed to the crew's decision making (Final Report 26 June 1988 56). However, what ultimately sealed the fate of Flight 296 was the Captain Asseline's mistake to disconnect the autothrottle, a system used to automatically control the engine power on an airliner and bring the engines to idle power (Final Report 26 June 1988 56). While he believed that manually controlling the thrust was a safety measure, instead it dangerously slowed the aircraft and put the flight in an extremely precarious position (Final Report 26 June 1988 56). In the last possible seconds, Captain Asseline increased the engine power from idle to maximum thrust, but the engines needed approximately five seconds to obtain enough power to successfully power the aircraft to clear the tree line (Final Report 26 June 1988 57). Tragically the engines did get to 91% thrust but by that point that tail of the aircraft had already impacted the tree line and created additional drag which caused the aircraft to pancake into the forest (Final Report 26 June 1988 57).

On June 27, 1988, not even a full day after Air France Flight 296 had crashed, various officials were already pointing fingers directly at the flight crew (Greenhouse). At a news conference, “the French Minister of Transportation, Louis Mermaz, said the plane was flying extremely low when it passed the runway at a speed of about 170 miles an hour” (Greenhouse). Further, the minister was quoted as saying, "there is no evidence allowing us to call into question the proper functioning of the aircraft and the security of future flights of the A320” (Greenhouse). Also, parallel to the technical investigation into the crash by the BEA, a criminal investigation was also launched (Mateou and Michaelides-Mateou 58). The Public Prosecutor for Mulhouse, Jean Volff, stated the day after the accident, “the 30-foot altitude (for Flight 296’s flyby) was 'completely outside technical norms,' which he said called for passenger planes to operate at levels of at least 300 feet unless they plan to land” (Greenhouse).

Five people were charged with involuntary manslaughter and other crimes including unintentional injury and non-assistance to persons in danger by the Court of Colmar in France, which has jurisdiction over Mulhouse (Asseline contre la France and Mateou and Michaelides-Mateou 58). They were the two pilots, the president of the Habsheim air club, who organized the airshow, a security officer of Air France, and the head of flight operations for authorizing the crew to descend to 100 feet for the flyby instead of the maximum allowed altitude of 170 (Asseline contre la France and Mateou and Michaelides-Mateou 58). Various experts who testified during the trial as well as the court during its sentencing phase, “concluded that the crew did not intentional fly below the regulatory minimum…and therefore lacked the essential element of intention” (Mateou and Michaelides-Mateou 58). While the pilots were not held responsible for this action, the Director of the Operations of Air France who oversaw both the employee that prepared the flight plan for Flight 296 and the technical assistant to the A320 division, was held responsible for allowing the altitude to be flown under his watch (Mateou and Michaelides-Mateou 58).

During the trial, the prosecution relied heavily on the readout of information recorder by the A320’s flight recorders, the Cockpit Voice Recorder and the Flight Data Recorder (Mateou and Michaelides-Mateou 58). Most importantly, the information obtained from the recorders requires specialized support which was provided to the judicial investigators by the BEA. Captain Asseline, who shouldered most of the responsibility for the accident, has claimed both during the trial and ever since that the BEA forged data on the Flight Data Recorder and Cockpit Voice Recorder (Mateou and Michaelides-Mateou 58). Since the BEA immediately took the flight recorders to Paris for analysis, the captain claimed that this was done to shield supposed technical faults with the A320 and thus protect the reputation of the then-new aircraft in exchange for placing the blame on the crew (Mateou and Michaelides-Mateou 58 and Foreman 16). However, this has been vehemently denied by the BEA and, “the lower (trial) court did not accept the possibility that the flight recorders could have been tampered with and denied the request by Captain Asseline’s counsel to have the flight data recordings annulled” (Mateou and

Michaelides-Mateou 58). This debate damaged the reputation of the BEA and likely would not have occurred if the captain was not under criminal prosecution. Further, the crew would likely have been more forthcoming to the BEA about their apparent errors if they were not facing criminal charges.

On March 14, 1997, the Court of Colmar found Captain Asseline, First Officer Mazieres, and the other three defendants guilty of all charges (Mateou and Michaelides-Mateou 58). The court-imposed sentences of six months imprisonment and a further twelve months suspended on probation on the captain, twelve months suspended on probation for the copilot, and lesser prison sentences suspended on probation for the other three defendants (Mateou and Michaelides-Mateou 58-59). First Officer Mazieres accepted his sentenced and continued his employment at Air France (Mateou and Michaelides-Mateou 59). Since most of the blame for the accident had been placed on Captain Asseline, he appealed his sentence to the Appeals Court of Colmar in January 1998 (Mateou and Michaelides-Mateou 59). In April 1998, the appeals court found Captain Asseline again guilty of involuntary manslaughter and infliction of bodily harm and increased the original sentence to ten months in prison and a further ten months suspended on probation (Mateou and Michaelides-Mateou 59). The appeals court found that, "the succession of imprudent acts committed by the applicant (Asseline) on this flight is not admissible on the part of a seasoned captain who is aware of his responsibilities" (Asseline contre la France). As a result, the appeals court announced that this finding, "justifies the application of more severe sanctions than pronounced by the first judges (trial court)" (Asseline contre la France). Captain Asseline then appealed his case to the *Cour de Cassation*, the Supreme Court of France, to have his first trial annulled for his claim of the flight recorders being tampered with however his petition was dismissed on May 23, 2000 (Asseline contre la France and Mateou and

Michaelides-Mateou 59). Captain Asseline filed a further claim in 2000 to the European Court of Human Rights (Asseline contre la France). However, this claim was also denied since the court concluded that the French domestic courts had ample opportunity for the captain to argue against the inclusion of the flight recorders as evidence against him (Asseline contre la France).

The investigations into the crash of Air France Flight 296 ultimately provide several important takeaways for the context of this thesis. First, the criminal investigation highlights how France is not reluctant to file criminal charges against pilots and others associated with airliner accidents even if they had no intention of making the errors that led to the crash. Further, the controversy surrounding allegations that the BEA tampered with the A320's flight recorders shows how criminal investigations into unintentional airliner accidents scare those involved into not assisting technical investigators. Similar to how Captain Asseline acted, the pressure from criminal investigations could easily make other individuals under criminal investigation less likely to cooperate with the BEA and question their investigative methods. This will make it harder for them to get the entire picture about what caused an accident and will subsequently make it more difficult for them prevent future ones, which undermines the ultimate goal of Annex 13.

10.4 Case Study 4: Air France Flight 4590

The last case study is the crash of Air France Flight 4590 operated by an Aerospatiale/BAC 101 Concorde just seconds after takeoff from Paris in 2000 killing all onboard as well as four more on the ground. The crash was ultimately attributed to a sequence of events originating from a Continental Airlines aircraft losing a piece of its engine in front of the Concorde. Like Air France Flight 296, the accident of Flight 4590 is relevant to the thesis because it highlights how France is willing to prosecute individuals even remotely associated with an unintentional aviation disaster. Namely five individuals were charged with manslaughter in relation to the tragedy, two mechanics at Continental Airlines, two former engineers that designed the Concorde, the French civil aviation regulator that certified the Concorde as well as the company of Continental Airlines (Continental Ordered to Trial). Further, the accident underscores that when a criminal investigation into an unintentional airliner accident has primary jurisdiction, it hampers the technical investigation into the same accident.

On Tuesday, July 25, 2000, an Air France Aerospatiale/BAC 101 Concorde, registered F-BTSC, was scheduled to operate Flight 4590 from Paris Charles de Gaulle International Airport to New York John F. Kennedy International Airport (Accident on 25 July 2000 17). Onboard were nine crew members and one hundred passengers (Accident on 25 July 2000 17). After receiving clearance to depart Paris, the aircraft commenced its takeoff role (Accident on 25 July 2000 17). Just seconds before the aircraft had reached V1, (the speed at which an aircraft leaves the ground), the right front tire on the left main landing exploded after running over a piece of debris on the runway (Accident on 25 July 2000 17). The failure of the tire threw huge pieces of rubber against the underside of the left wing which caused one of the aircraft's fuel tanks, located just under the skin of the Concorde's wing, to rupture (Accident on 25 July 2000 17). A vicious fire quickly broke out and caused both engines on the left wing to begin losing power (Accident on 25 July 2000 17). Roughly 45 seconds later, the air traffic controller radioed to the crew that they had flames coming out of the left side of the aircraft (Accident on 25 July 2000 17). At nearly the same time, the number two engine on the left wing completely failed (Accident on 25 July 2000 17).

Immediately after this occurred, the first officer directed the captain's attention to the decreasing speed of the Concorde which was beginning to drop dangerously low (Accident on 25

July 2000 17). Just seconds later, the ground proximity warning system, or GPWS, began going off in the cockpit informing the pilots that the aircraft was flying dangerously close to the ground (Accident on 25 July 2000 18). Although the pilots fought bravely to gain control of the aircraft, engine 1 on the left wing began failing simultaneously and within seconds the aircraft impacted a hotel at, "*La Patte d'Oie*" in Gonesse just miles from the runway where it had taken off (Accident on 25 July 2000 18). Tragically all 109 people on board Flight 4590 were killed in the impact (Accident on 25 July 2000 18). In addition, another four people in the hotel were killed and six more had also been injured by the crash (Accident on 25 July 2000 18).

The BEA immediately initiated a technical investigation to determine what had caused the crash of Flight 4590. Aside from the wreckage of the landing gear assemble and rubber from the aircraft's tires, another strip of metal was located that was determined to have not come from the Concorde (Accident on 25 July 2000 61). In addition, a single part from the number 5 fuel tank was located, as were marks that signified some type of explosion had occurred (Accident on 25 July 2000 61-62).

Since the one piece of debris found on the runway from where Air France Flight 4590 had departed did not belong to the Concorde that crashed, the BEA began the investigation by trying to determine where it came from. The BEA concluded that the metal strip was likely a wear strip from a CF6-50 engine, the type used by Douglas DC-10 aircraft (Accident on 25 July 2000 102). The investigators also discovered that a DC-10 owned by Continental Airlines had taken off from the same runway as the doomed Concorde just two aircraft ahead and five minutes before (Accident on 25 July 2000 102). A closer examination by the investigators conclusively revealed that the position of the holes and length of the strip they had collected from the runway had come from the Continental Airlines DC-10 (Accident on 25 July 2000 108).

The BEA ultimately determined that the loss of the wear strip from the right engine of the Continental Airlines DC-10 was caused by a lack of rigorous maintenance procedures at the airline (Accident on 25 July 2000 171).

The BEA concluded that since the aircraft would have been about 1,700 meters from the start of its takeoff role when both items were recorded, it would have been exactly in the area where debris from the tire and the metallic wear strip from the DC-10 were recovered (Accident on 25 July 2000 161). The BEA determined that the most likely reason for the Concorde's tire to fail was that it had run over the wear strip dropped by the DC-10.

Once the BEA had determined that the tire failure on Flight 4590 was caused by the metallic wear strip from the DC-10, the investigation then shifted to determining how the tire failure had caused the fire onboard the aircraft. The investigators began by examining a 32 x 32 cm piece of the Concorde's lower wing which had not sustained any fire or major damage unlike most of the other debris located slightly further down the runway (Accident on 25 July 2000 109). Instead, this piece of debris had failed because of pressure from the inside of the fuel tank directed towards the outside causing it to rupture (Accident on 25 July 2000 109). After the initial shock of the impact against the skin that protected the fuel tank subsequently displaced a certain amount of fuel in the tank, a wave in the liquid caused another part of the skin lining the tank fail and be ejected from the aircraft (Accident on 25 July 2000 113).

The BEA then came up with two potential hypotheses to explain how fuel tank 5 caught fire as it was impossible for them to determine a definite conclusion due to the catastrophic damage to the Concorde after its impact with the hotel. The first potential explanation for the combustion is that the explosion from the tire failure had also damaged electrical cables near the main landing gear (Accident on 25 July 2000 120). This damage caused an electric arc by a short-circuit which produced enough energy to be compatible with igniting the vaporized kerosene flowing out of fuel tank 5 (Accident on 25 July 2000 120). The other potential hypothesis considered by the investigators is that the fire was caused by the leaking kerosene encountering the hot sections of the Concorde's engines (Accident on 25 July 2000 121). Once the fuel was ingested through several potential areas on the nacelle/engine assembly of the aircraft the fuel could have ignited on contact with the hot walls of the engine or on contact with the gas coming from the thrust nozzles at the rear of the aircraft (Accident on 25 July 2000 122). Either hypothesis adequately explains how Flight 4590 ended up on fire.

Another major question the BEA sought to answer in its technical investigation was why Flight 4590 had experienced several engine surges in engine 1 and 2, which led them to ultimately fail. A surge in an aircraft engine is best characterized as a sudden loss of thrust or power being produced by the engine. The BEA concluded that the ingestion of hot gasses by both engines most likely caused the initial and second surges (Accident on 25 July 2000 132). The aircraft's final engine surges were probably caused by the ingestion of debris breaking off the aircraft such as pieces of aluminum, glass fiber, or honeycomb from the Concorde's structure (Accident on 25 July 2000 133). The damage caused by this ingestion was severe, permanently damaged the engine, and ultimately sealed the fate of Flight 4590 (Accident on 25 July 2000 133).

The final piece for the BEA to explain why Air France Flight 4590 had crashed was what led the crew to ultimately lose control of the Concorde. Two reasons contributed to why the aircraft was beginning to leave controlled flight. The main reason was that because engines 3 and 4 on the right wing continued to operate normally throughout the duration of the flight (Accident on 25 July 2000 165). So, when engines 1 and 2 began experiencing surges and failing, the overcompensation of the engines on the right wing forced the aircraft into a tight left bank (Accident on 25 July 2000 165). In addition to the thrust asymmetry of the engines, the BEA also concluded that the fire was becoming so strong that it was starting to destroy vital control surfaces in the left wing (Accident on 25 July 2000 165). The BEA also concluded that even if all four engines on the Concorde had been operating normally, the damage to the aircraft's left-wing structure and flight controls by the fire would still have caused the flight crew to lose control (Accident on 25 July 2000 165). This led the BEA to conclude that as soon the flight left the runway, it was doomed.

Before discussing the chain of events that resulted in charges being filed by French prosecutors related to the crash of Air France Flight 4590, it is worth mentioning how the judicial investigators impeded the technical investigators from day one. Immediately following the accident, a French public prosecutor was appointed to lead the criminal investigation by the French judiciary, like Air France Flight 296's investigation (Mateou and Michaelides-Mateou 110). Throughout the entire course of the investigation, judicial authorities maintained control over the crash site, various maintenance records, other relevant documents, various pieces of wreckage, and the flight recorders (Mateou and Michaelides-Mateou 110). Since the Concorde was the brainchild of a joint British and French team, Annex 13 allows both countries of an accident aircraft's manufactures to participate as parties to the investigation (Mateou and Michaelides-Mateou 111).

The United Kingdom's technical investigation team, the Air Accident Investigation Branch (AAIB), appointed several accredited representatives and advisers (Mateou and Michaelides-Mateou 111). The AAIB's notes at the end of the BEA's final report for Flight 4590 make clear that, "the French judicial authorities presented major obstacles to the AAIB's investigation" (Mateou and Michaelides-Mateou 111). Specifically, the judicial investigators did not allow the AAIB to examine all items of the wreckage, such as the wear strip, parts of fuel tank 5, and elements of the wings and landing gears which were specifically manufactured in Britain (Mateou and Michaelides-Mateou 111). Also, some pieces of wreckage such as the flight deck controls were only allowed to be viewed very briefly by the AAIB (Mateou and Michaelides-Mateou 111). Further, the French judicial investigators did not allow the AAIB to be systematically involved in the examination of evidence (Mateou and Michaelides-Mateou 111). Last, the French judicial investigators withheld access to evidence for several weeks, severely restricted their access at the crash site, and refused to share photographic evidence from the runway that proved vital to understanding the sequence of events which led to the crash (Mateou and Michaelides-Mateou 111). The details gleaned from the AAIB investigators' statement illustrates how the supposed close cooperation between technical and criminal investigators in France usually ends up hampering the technical investigators and therefore making it more difficult to determine the cause of airliner accidents.

The criminal investigation into the crash of Air France Flight 4590 was markedly different from the other case studies since it did not result in charges until almost five years after the accident. The main reason the investigation took so long was because the negligence that contributed to the crash was not caused by people directly involved with the accident that day. Instead, French prosecutors alleged that the negligence came from Continental Airlines, two of its mechanics in Texas, two of the Concorde's designers who had been retired for years, and a retired French civil aviation inspector (Continental Ordered to Trial). As previously mentioned in French criminal law under the 'equivalence of conditions' theory, multiple people remotely related to a case of involuntary manslaughter may be charged with having contributed to the accidental death (Elliott 62). In 2004, after the results of both the BEA investigation and a French civil court finding Continental Airlines liable for most of the damages related to the crash of Flight 4590, a French public prosecutor announced that "there was a direct causal link between the plane hitting the strip of metal and the bursting of one of its tires" which led to the accident (US Airline Faces Concorde Inquiry). Just four months later in March 2005, a French investigating judge placed Continental Airlines under criminal investigation for involuntary homicide and injuries in connection with the crash (US Airline Faces Concorde Inquiry). Additionally six months later, a former head of the French Concorde program for the former French aviation company, Aerospatiale, Henri Perrier, was also put under investigation for involuntary manslaughter (Relles and Solomon 428).

After three more years of judicial investigations, French judicial officials announced in July 2008, nearly eight years after the accident, that five individuals as well as Continental Airlines, would face criminal manslaughter charges stemming from the crash (Five to Face Concorde Crash Trial). The two individuals from Continental Airlines charged were John Taylor, the mechanic who allegedly fitted the metal strip to the DC-10, and Stanley Ford who was a maintenance official from the airline who oversaw the work (Five to Face Concorde Crash Trial). The charged individuals from Aerospatiale, the former French aviation company that built the Concorde, included Henri Perrier, the former head of the Concorde program, and Jacques Herubel, the former chief engineer of the Concorde (Five to Face Concorde Crash Trial). Additionally, a former director of technical services at DGAC, France's civil aviation authority, Claude Frantzen, who certified the Concorde for flight, was also charged (Relles and Solomon 428). The complex criminal trial of the accused lasted from February to December 2010 and cost over $4.2 million to conduct (Relles and Solomon 428). At the conclusion of the trial, the court acquitted Ford, Perrier, Herubel, and Frantzen, but found Taylor and Continental airlines guilty of the manslaughter charges (Relles and Solomon 428). The airline was found liable because its, "defective maintenance" practices had placed the metal wear strip right in the path of the Concorde when it was on takeoff roll (Relles and Solomon 428). Continental was fined $300,000 and ordered to pay Air France $1.32 million in damages plus interest (Relles and Solomon 428). Last, mechanic John Taylor was sentenced to a fifteen-month suspended prison sentence and a fine for his role in manipulating and fitting the faulty wear strip to the Continental DC-10 (Relles and Solomon 429). Ultimately a French appeals court in Versailles struck down the convictions of Continental Airlines and mechanic John Taylor in 2012 (Clark). The court did not dispute the findings of the lower court that the metal wear strip falling from the Continental DC-10 had initiated the chain of events that led to the crash; rather, the court simply ruled that the criminal manslaughter charges were unjustified under the circumstances of the accident (Clark).

Although the criminal investigation into the crash of Air France Flight 4590 ended without any convictions being upheld, the case still provides a good example of how France routinely seeks criminal indictments in transportation accident investigations, regardless of whether the acts leading to the crash were intentional. The case also provides a textbook example of how criminal accident investigations with primary jurisdiction end up hampering the technical investigations. This ultimately leads to significant difficulties in reaching a technical conclusion to help prevent future crashes in France and goes against the core principle of Annex 13.

11. Conclusion

It is clear that the United States reserves criminal charges for egregious violations related to intentional conduct related to an unintentional airliner accident as opposed to the errors or omissions that directly caused the accident as in the case of ValuJet Flight 592. Further, the

United States recognizes that affording criminal investigators primary jurisdiction in conducting unintentional airliner accident investigations both scares those involved into not cooperating and generally hampers the technical investigators. As a result, criminal charges are rarely filed in relation to unintentional airliner accidents in the United States. Further, U.S. Code of Federal Regulations § 831.5 has afforded the NTSB primary jurisdiction over all unintentional airliner accidents since 1967. However, the legislative changes made to U.S. Code § 1131 after the investigation into the crash of TWA Flight 800 have worked to both clarify and ensure that the NTSB retains this jurisdiction. Taken as a whole, while not perfect, the U.S. complies closely with the central goals of Annex 13.

On the contrary, French law, in accordance with E.U. Regulation 996, affords criminal investigations primary jurisdiction in conducting unintentional airliner accidents and forces the BEA to both yield to and assist the criminal investigators. As a result, France regularly launches criminal investigations whenever a major airliner accident occurs, even if it is clear the accident was not caused by intentional actions. French law then allows the criminal investigators to maintain primary control of the evidence, crash sites, and witnesses. This hampers the BEA's technical investigations and forces them to obtain court approval before inspecting all of it for themselves. The primary jurisdiction of the criminal investigators and the regular nature of criminal charges also causes those involved with airliner accident to not cooperate fully with technical investigators for fear that their mistakes will lead to convictions down the road as in the case of Air France Flight 296. Further, like Captain Asseline, they may even attempt to question the investigative techniques of the technical investigators as a defense to criminal charges which can undermine their important work. More broadly, when criminal investigators have the lead, as in the case of Air France Flight 4590, technical investigators are easily hampered as in the case of the AAIB. As a result, it is again abundantly clear that France does not comply as closely with Annex 13 as the U.S.

Through the close comparison of how the U.S. and France conduct their technical and criminal investigations into unintentional airliner accidents, it becomes abundantly clear that the U.S. more nearly affirms the core goals of Annex 13 than France. Ultimately, this is necessary for preventing future accidents because Annex 13 is the gold standard for conducting investigations into airliner accidents to prevent their reoccurrence in the future. By following Annex 13 as closely as possible, it will make our skies safer for future generations to come.

Annex

ValuJet Airlines Flight 592 Description and Technical Investigation

On May 11, 1996, a ValuJet Airlines Douglas DC-9-32, registered N904VJ, was scheduled to operate Flight 592 from Miami International Airport to William B. Hartsfield International Airport in Atlanta, Georgia (In-Flight Fire 1). Onboard the DC-9 that day were 105 passengers, 2 pilots, and 3 flight attendants (In-Flight Fire 1). The aircraft also carried 4,109 pounds of cargo for the roughly hour and a half flight to Atlanta (In-Flight Fire 1). This load included passenger baggage, postal mail, and other company-owned material (COMAT) (In-Flight Fire 1). According to the shipping ticket, the COMAT consisted of two main tires and wheels, a nose tire and wheel, and lastly five cardboard boxes that were marked, 'Oxy Cannisters "Empty",' (In-Flight Fire 2). The ValuJet lead ramp agent in charge of loading the cargo recalled asking for the First Officer's approval for loading the COMAT onto Flight 592 (In-Flight Fire 2). He received this approval and neither the ramp agent nor the First Officer discussed the nature of the contents contained in the five cardboard boxes (In-Flight Fire 2). Flight 592 pushed back from its gate at 1:40 PM and took off about twenty minutes later at 2:03 PM (In-Flight Fire 2). About seven minutes into the flight and while the pilots were in the process of climbing in the DC-9 to its next assigned altitude, they heard an unidentified sound (In-Flight Fire 2). The sound was captured on the cockpit voice recorder at 2:10:03 PM and picked up the Captain's remark "what was that?" (In-Flight Fire 2). Just a mere twelve seconds later at 2:10:15 the Captain stated, "we got some electrical problem," quickly followed five seconds later by, "we're losing everything" (In-Flight Fire 2). At 2:10:22 the departure air traffic controller was advised by the captain that, "we need, we need to go back to Miami" (In-Flight Fire 2). This was quickly followed three seconds later by unknown people shouting, "fire," multiple times in the background followed distinctly by another unknown male voice at 2:10:27 stating, "we're on fire, we're on fire" (In-Flight Fire 2). Only a mere seven minutes after takeoff ValuJet Airlines Flight 592 was on fire and in the midst of a critical situation.

At 2:10:28, the departure air traffic controller assigned to Flight 592 advised the crew to contact Miami which was quickly returned by the First Officer who stated that the flight needed to return to Miami immediately (In-Flight Fire 2). About eight seconds later the controller asked the crew what the nature of their emergency onboard was, although in the cockpit the Captain replied, "fire," the First Officer radioed a more measured response to the controller in the form of, "uh smoke in the cockp(it)…smoke in the cabin" (In-Flight Fire 3). Meanwhile the situation onboard the aircraft was rapidly deteriorating as the cockpit voice recorder picked up a flight attendant shouting that the aircraft was, "completely on fire" (In-Flight Fire 3). The flight began heading in a southerly direction while the controller got on the phone with emergency services in Miami, which he then relayed to the crew (In-Flight Fire 3). At 2:11:49 the controller then asked the crew to make another heading change which was acknowledged by the First Officer (In-

Flight Fire 3). This transmission would be the last time anyone would have contact with the doomed flight (In-Flight Fire 3). At 2:13:18 the controller again instructed the flight to change its vector but received no response (In-Flight Fire 3). The controller tried again nine seconds later and received an unintelligible transmission that was intermingled with the transmission from another aircraft nearby (In-Flight Fire 3). At 2:13:42, just roughly ten minutes after the aircraft had taken off, Flight 592 impacted the Everglades in a steep, right bank (In-Flight Fire 3). Tragically, all 110 people onboard the DC-9 were killed instantly in the crash (In-Flight Fire 20).

The National Transportation Safety Board quickly launched a technical investigation to determine why ValuJet Flight 592 had taken its deadly plunge into the Everglades. The nature of the air traffic controller's statements and recordings of the conversations between them and the flight crew of Flight 592 quickly made it apparent that some type of onboard fire had brought the aircraft down. However, because of the DC-9's high speed impact and the remote nature of its crash site, the NTSB was not able to recover the entire aircraft (In-Flight Fire 100). Through tedious efforts they were able to recover enough of the aircraft to prove that the fire had begun in the forward cargo compartment (In-Flight Fire 100). This was easily determined since this area of the aircraft, and the other locations directly above it, had experienced the worst fire and heat damage (In-Flight Fire 100). Also, because the worst heat and fire damage was contained within the cargo compartment, this ruled out the fire being started by an electrical failure since no electrical wires run inside the cargo compartment (In-Flight Fire 100). Instead, the electrical wires are bundled between the cargo compartment and the exterior skin of the aircraft (In-Flight Fire 100). If the fire had started from the wires, the cargo compartment would have likely prevented most of the fire from breaching it (In-Flight Fire 100). As a result, the NTSB turned to the only other possible source of ignition for the fire, the cargo contained within the forward cargo compartment.

Interestingly the NTSB found that the only area of the forward cargo compartment that was breaching due to the extreme heat and stress from the fire was the ceiling right above where the oxygen generators had been loaded (In-Flight Fire 100-101). What the investigators subsequently discovered was that the five cardboard boxes marked, 'Oxy Cannisters "Empty",' were actually unexpended chemical oxygen generators that had been improperly packaged (In-Flight Fire 101). Specifically, the investigators found that the safety caps to prevent the chemical reaction that initiated their firing were not properly installed on any of the oxygen cannisters; lanyards for preventing their spring-loaded firing mechanisms were not installed; and lastly, the oxygen generators were not safely packaged to prevent them from being unintentionally discharged during transport (In-Flight Fire 101). Based on the physical evidence of damage to the forward cargo compartment, scientific tests conducted by the NTSB that proved the oxygen generators could easily produce a fire, and the lack of other substances being present in the forward cargo compartment capable of producing a fire, the investigators concluded that the improperly packaged oxygen generators had caused the fire which led to the crash (In-Flight Fire 101). The investigation then turned to the questions of how the fire started, how the oxygen cannisters ended up amongst the cargo of Flight 592, and lastly why the oxygen generators were improperly packaged in the first place.

The NTSB, through extensive investigative efforts, eventually determined that the noise captured on the cockpit voice recorder at 2:10:03 PM and acknowledged by the Captain's remark, "what was that," was likely caused by the rupture of one of the inflated aircraft tires that had been loaded into the forward cargo compartment with the oxygen generators (In-Flight Fire

102). Based on this finding, the NTSB concluded that the fire was likely initiated long before the plane ever took off the ground (In-Flight Fire 102). The most likely sequence they uncovered was that one of the oxygen generators was likely activated during the cargo loading process (In-Flight Fire 102). The investigators found that the chemical reactions of the oxygen generators being fired, which are exothermic and therefore generates substantial heat, coupled with the airtight design of the cargo compartment, the nearby combustible materials such as the aircraft tires all contributed to the initiation and propagation of the fire (In-Flight Fire 102). The investigators also concluded that although the fire was likely ignited before the flight had even taken off, there were several reasons why it took so long for the fire to be detected by the crew and passengers onboard. These included the airtight nature of the forward cargo compartment's liner which prevented any smoke from exiting it until it had been breached, the fact that the smoke would not have immediately entered the air in the passenger cabin, the fact that the oxygen generators likely produced a fierce, oxygen-rich fire that would not have been produced substantial smoke at first, and lastly the fact that the forward cargo compartment, known as a class D cargo compartment, was not required or equipped to carry a smoke detection system (In-Flight Fire 103). Last and most significant for the victims of Flight 592, class D cargo compartments, such as those on the DC-9 that operated Flight 592, were not required or equipped with a fire suppression system (In-Flight Fire 103). This meant that the pilots of Flight 592 had no means of extinguishing or even suppressing the fire that was burning beneath them (In-Flight Fire 103). As a result, the NTSB discovered that the extreme heat from the fire destroyed flight control cables, electrical wires, and even began to melt the floor supports (In-Flight Fire 107). The Board concluded that the last dive which caused the aircraft to crash was likely caused by a loss of flight control systems, the collapse of the cockpit floor, the incapacitation of the crew, or some combination that all resulted from the intense nature of the fire (In-Flight Fire 107).

The next important question addressed by the NTSB in its technical investigation was how the hazardous cargo of the oxygen generators ended up being loaded onto Flight 592 (In-Flight Fire 104). ValuJet lead ramp agents and flight crew members were trained on how to identify and reject cargo marked with hazardous material labels and check shipping tickets to be sure no other hazardous materials were undeclared (In-Flight Fire 104). However, the COMAT cargo of the oxygen generators and aircraft tires onboard Flight 592 did not alert either the ramp agent or the First Officer that accepted the shipment (In-Flight Fire 104). The simple reason was that none of the five cardboard boxes full of oxygen generators loaded onto the flight had any hazardous material markings or labels and the shipping ticket of the cargo indicated that the oxygen generators were empty (In-Flight Fire 104). Based on all the information provided to the ramp agents and flight crew members, "the Safety Board conclude(d) that their… acceptance of the COMAT shipment was not unreasonable" (In-Flight Fire 105). The bottom line is that based on everything known by the ramp agents or flight crew, they "would have had no reason to know or suspect that hazardous materials were being proffered for carriage aboard the airplane" (In-Flight Fire 105).

The last question the NTSB answered in its technical investigation of Flight 592's crash was how the oxygen generators came to be improperly packaged and marked as company material cargo in the first place. According to ValuJet, the airline contracted with 21 FAA-certified maintenance facilities and repair stations to conduct various services on their aircraft (In-Flight Fire 60). One of these companies was SabreTech in Miami, Florida (In-Flight Fire 60). The company was tasked by ValuJet of doing various maintenance and overhauls of its aircraft

(In-Flight Fire 61). Beginning in September 1995, SabreTech entered a new agreement with ValuJet to perform heavy-check maintenance, some of the most advanced maintenance work possible, on their aircraft (In-Flight Fire 61). Shortly after this agreement was reached, ValuJet purchased three MD-80 series aircraft and ferried them to the SabreTech facility in Miami for various modifications and maintenance functions (In-Flight Fire 4). One of the important tasks that SabreTech was required to do was to check the oxygen generators on all three aircraft to determine whether they had exceeded their lifespans of twelve years from their manufacture dates (In-Flight Fire 4). After inspecting the aircraft and reporting back to ValuJet, the airline decided that, since most of the oxygen generators were beyond their usable lives, SabreTech might as well replace all the generators of the three MD-80s (In-Flight Fire 6).

The ValuJet work card provided to SabreTech contained seven of the eight steps listed by Douglas Aircraft for performing maintenance on oxygen generators, but excluded the most important step, "store or dispose of oxygen generator" (In-Flight Fire 11). According to SabreTech mechanics that the NTSB interviewed, instead of following the proper procedures, almost all of the expired or near-expired oxygen generators first had the lanyards that secured their firing pins taped, then they were placed in cardboard boxes and lastly they were marked with a green "Repairable" tag, which were filled out with descriptions such as, "out dated, out of date, or expired" (In-Flight Fire 13 and 15). The mechanics had packaged the oxygen generators in the cardboard boxed very loosely without any additional support because they later explained that they did not assume that the boxes were to be the final packing containers for the generators (In-Flight Fire 15). While several of the mechanics conducting the work on the MD-80s were aware of the need for safety caps to prevent the accidental discharge of the generators, one supervisor at SabreTech told them that, "the company did not have any safety caps available"

(In-Flight Fire 15). Interestingly, the NTSB noted that the same supervisor had no recollection of the exchange when he was interviewed by the investigators (In-Flight Fire 15). Further mechanics were also given assurances by SabreTech supervisors and ValuJet technical representatives that they were aware of the need for safety caps and, "that it would be taken care of 'in stores" (In-Flight Fire 16-17). Again, none of the supervisors or the technical representatives recalled that particular exchange (In-Flight Fire 17).

The final piece of the puzzle that sealed the fate of ValuJet Flight 592 was how the oxygen generators ended up being accidentally shipped aboard the flight. During the first week of May 1996, most of the generators had been collected into the five cardboard boxes (In-Flight Fire 17). A mechanic took some of the boxes to the ValuJet section of SabreTech's shipping and receiving hold area after being asked to by either his lead mechanic or supervisor (In-Flight Fire 17). He then placed the boxes on the floor in front of shelves that held parts from other ValuJet aircraft and did not explicitly inform anyone about their contents (In-Flight Fire 17). At the time the boxes were placed in the hold area, at SabreTech, "no formal written procedure required an individual who took items to the shipping and receiving hold area to inform someone in that area what the items were or if the items were hazardous" (In-Flight Fire 18). None of the mechanics remembered seeing hazardous materials warning labels on any of the boxes containing the old oxygen generators (In-Flight Fire 18). Between May 7th and May 8th of 1996, SabreTech's director of logistics went to the shipping and receiving area and ordered the employees to clean up the area and remove all items from the floor in preparation for a facility audit and inspection by a potential customer (In-Flight Fire 18). During a previous audit and inspection by a potential customer, "the 'housekeeping' in the shipping and receiving area had been written up by the customer as unacceptable" (In-Flight Fire 18). As a result, something needed to be done with the boxes.

When the director of logistics called ValuJet to ask when they would come to Miami to audit the parts and remove what they needed, he was told that they would not be able to send someone until May 13th at the earliest, which was after when the new customer audit and inspection was set to take place (In-Flight Fire 18). A SabreTech store clerk began shipping procedures for the boxes of oxygen generators on May 8th and remarked to the director of logistics, "how about if I close up these boxes and prepare them for shipment to Atlanta," to which the director replied, "okay, sounds good to me" (In-Flight Fire 18-19). The store clerk asked the receiving clerk for a shipping ticket the next day and he wrote, "Oxy (short for oxygen) Canisters-Empty" (In-Flight Fire 19). The receiving clerk made the mistake that they were empty since none of the mechanics had remarked to him what they were and he had interpreted the descriptions of their green, "Repairable" tags, namely out dated, out of date, or expired, to mean that the generators were empty (In-Flight Fire 19). They were then packaged and driven out to Flight 592 on May 11th (In-Flight Fire 19).

Trans World Airlines Flight 800 Description and Technical Investigation

On July 17, 1996, a Trans World Airlines Boeing 747-131, registered N93119, was scheduled to operate an international passenger flight from John F. Kennedy International Airport, New York, New York to Charles de Gaulle International Airport, Paris, France (In-Flight Breakup 1). On the day of the accident, the 747 has departed Athens, Greece and arrived at JFK about 4:31 PM local time (In-Flight Breakup 1). The flight crew of that flight reported to NTSB investigators that they observed no abnormalities with the aircraft (In-Flight Breakup 1). A scheduled crew change occurred at JFK while the aircraft was being refueled (In-Flight

Breakup 1). To keep the crew and new passengers cool during the boarding process, the 747's auxiliary power unit and two of its three air conditioning packs were kept operational as it was a warm July night (In-Flight Breakup 1). On board the aircraft were 2 pilots, 2 flight engineers, 14 flight attendants, and 212 passengers (In-Flight Breakup 1). The flight's scheduled departure at 7 PM was delayed because of a disabled piece of ground service equipment and concerns about a passenger/baggage mismatch (In-Flight Breakup 1). After a delay of more than an hour, TWA Flight 800 finally received clearance to takeoff at 8:18 PM and became airborne a minute later (In-Flight Breakup 2).

After completing various instructions from Air Traffic Controllers, the 747 reached its initial assigned altitude of 13,000 feet about 17 minutes after takeoff (In-Flight Breakup 2). Three minutes later, the cockpit voice recorder picked up the captain remarking, "look at that crazy fuel flow indicator there on number four…see that?" (In-Flight Breakup 2). Less than a minute later Air Traffic Controllers advised the flight to climb another 2,000 feet (In-Flight Breakup 2). The captain then requested, "climb thrust" from the 747's four engine and the flight engineer responded, "power set" on the engines (In-Flight Breakup 2). As the aircraft started climbing, the cockpit voice recorder picked up three additional sounds before the end of the tape: "the sound of a mechanical movement in the cockpit, an unintelligible word uttered by a crew member, and lastly a sound like recording tape damage noise" (In-Flight Breakup 3). The NTSB conducted a sound spectrum study of the cockpit voice recording and it additionally revealed, "a very loud sound," picked up for a fraction of a second before immediately before the recording ended (In-Flight Breakup 3). Less than a minute after the cockpit voice and flight data recordings ended, the pilot of an Eastwind Airlines Boeing 737 radioed to Air Traffic Control that, "we just saw an explosion up ahead of us here…about 16,000 feet or something like that, it just went down into the water" (In-Flight Breakup 3). Numerous other pilots and countless other witnesses reporting hearing and/or seeing an explosion, accompanied by a large fireball, and lastly debris falling into the water (In-Flight Breakup 3). Some witnesses also reported seeing a fireball that resembled a flare moving upwards into the sky to the point that the large fireball appeared at which the it broke into two separate fireballs before descending into the ocean (In-Flight Breakup 3). Emergency services dispatched to the ocean quickly located floating debris, while most of the debris field had already sunk to the ocean floor (In-Flight Breakup 4). Tragically the onboard explosion and subsequent crash of the aircraft had killed all 230 people on board the 747 (In-Flight Breakup 4).

The National Transportation Safety Board immediately began a technical investigation into the cause of the TWA Flight 800 disaster. Concurrently the Federal Bureau of Investigation launched a criminal investigation into the cause of the crash. Because many witnesses had reported hearing an explosion and seeing a fireball over the ocean, this led many experts at the FBI to suspect that the crash was actual an act of terrorism or the result of a US Navy missile test gone horribly wrong (Michaelides-Mateou and Mateou 104). As a result, the FBI took a leading role with their criminal investigation, "applying their rules regarding the gathering of evidence and the release of information" (Michaelides-Mateou and Mateou 104). Regardless of what caused the crash, witness reports and the widespread distribution of wreckage quickly led the NTSB to conclude that, "TWA Flight 800 had experienced a catastrophic in-flight structural breakup" (In-Flight Breakup 256). The NTSB, along with other agencies involved in the recovery efforts, also quickly recovered the cockpit voice and flight data recorders and found both to be in good condition (In-Flight Breakup 58-59). The technical investigators concluded from the audio analysis of the CVR that, "a noise recorded on the (Flight 800) CVR in the last few tenths of a second before the CVR recording stopped was similar to the last noises heard on CVR recordings from other airplanes that had experienced structural breakups" (In-Flight Breakup 256). Because of all this preliminary evidence, both the criminal and technical investigators began exploring the possibilities for why the 747 had broken up in flight (In-Flight Breakup 256).

Thanks to the diligent efforts of various parties to the investigation, a ten-month search of the area where Flight 800 crashed ultimately yielded approximately 95 percent of the 747's wreckage (In-Flight Breakup 65). According to the NTSB's report, "throughout the wreckage recovery and documentation processes, fire and explosive experts from the Safety Board, DoD (Department of Defense), Federal Bureau of Investigation (FBI), Bureau of Alcohol, Tobacco, and Firearms (ATF), FAA (Federal Aviation Administration), and (other) parties to the investigation thoroughly examined all recovered pieces of the wreckage" (In-Flight Breakup 65). The report continued that the examination was to look, "for evidence of damage characteristic of a bomb, missile, or high-order explosi(on)" (In-Flight Breakup 65). After thorough examination, none of the recovered wreckage showed any signs of such damage (In-Flight Breakup 65). Accordingly, the NTSB and other experts concluded that through the examination of, "adjacent or nearby pieces of wreckage, no evidence of damage from a bomb, high-order explosive, or missile warhead entry or detonation (was observed)" (In-Flight Breakup 65).

While the NTSB and other investigators had determined that the inflight breakup of TWA Flight 800 was not caused by an intentional act, they still had not discovered why the 747 plunged out of the sky. However, the investigators had observed that all the wreckage from the accident airplane had came of three predominant debris zones in the ocean (In-Flight Breakup 65). Investigators labeled these three zones by colors, "red, yellow, and green, from farthest west to farthest east" (In-Flight Breakup 65). The debris of the red zone was of most interest to investigators for several reasons. This zone was the most dispersed, located furthest west, and none of the debris from this zone exhibited crushing damage like those found in the yellow and green zones (In-Flight Breakup 69). All these reasons pointed to the debris from the red zone being the first to leave the aircraft during the inflight breakup.

After determining that the inflight breakup of TWA Flight 800 had begun from the middle section of the Boeing 747 that ended up in the red zone of debris, investigators then began to figure out what caused this section to fail (In-Flight Breakup 256). The investigators looked into the possibility of a fuel/air explosion in the center wing fuel tank (In-Flight Breakup 259). First, the center wing fuel tank is located exactly in the area of the 747 where debris first departed from the airframe and was located in the red zone of debris (In-Flight Breakup 260). Further, some of this debris exhibited light soot damage that would signify an explosion in that area as opposed to the prolonged fire damage exhibited by most of the airframe recovered in the green zone (In-Flight Breakup 260).

Because of these discoveries, subsequent tests and examinations of the wreckage by both the NTSB's Metallurgy Structures and Sequencing Groups concluded that, "the initial event in the breakup sequence was an overpressure event within the CWT (center wing fuel tank)" (In-Flight Breakup 260). In addition, the groups concluded that, "because there was no evidence that a high-energy explosive device detonated in this (or any other) area of the airplane, this overpressure could only have been caused by a fuel/air explosion in the CWT" (In-Flight Breakup 261). To provide further evidence towards this conclusion the NTSB conducted several tests under precise conditions that Flight 800 would have been flying on that warm July evening (In-Flight Breakup 261). This led them to determine, "the fuel/air vapor in the ullage of TWA

Flight 800's CWT was flammable at the time of the accident" (In-Flight Breakup 261). While the NTSB exhaustively sought to find the exact source and location of ignition for the explosion of the center wing fuel tank, they were never able to conclusively determine either (In-Flight Breakup 294). However, the Board ultimately concluded that the energy for the explosion, "entered the CWT through the FQIS (fuel quantity indicating system) wiring" (In-Flight Breakup 294). They reached this conclusion for two reasons. First, the fuel quantity indicating system has the only wiring in the center wing fuel tank (In-Flight Breakup 279). Last, this was the exact, malfunctioning system that the captain had noticed just minutes before the explosion (In-Flight Breakup 2). The National Transportation Safety Board, "determines that the probable cause of the TWA flight 800 accident was an explosion of the center wing fuel tank (CWT), resulting from ignition of the flammable fuel/air mixture in the tank" (In-Flight Breakup 308). The report concluded, "the source of ignition energy for the explosion could not be determined with certainty, but, of the sources evaluated by the investigation, the most likely was a short circuit outside of the CWT that allowed excessive voltage to enter it through electrical wiring associated with the fuel quantity indication system" (In-Flight Breakup 308).

Air France Flight 296 Description and Technical Investigation

On June 26th, 1988, a series of special flights were to be conducted by Air France on behalf of the Mulhouse flying club (Final Report 26 June 1988 4). The flights consisted of a flight from Paris-Charles de Gaulle airport to Basle Mulhouse airport, two round trips from Basle-Mulhouse, and then a return flight from Basle-Mulhouse back to Paris (Final Report 26 June 1988 4). At the start of each of the two round trips from Basle-Mulhouse, the crew of the Airbus A320, registered F-GFKC, were to conduct low flyovers of the Mulhouse flying club's airshow organized at the Mulhouse-Habsheim aerodrome (Final Report 26 June 1988 4). The round trips were not able to land at Mulhouse-Habsheim aerodrome because the airport was not large enough to accommodate an Airbus A320. Various departments of Air France assisted in the preparations for conducting the flyover which included filing various paperwork to the proper authorities and giving the crew the necessary information to conduct the flight safely (Final Report 26 June 1988 4). These preparations were supposed to specifically prepare for potential obstacles around the Mulhouse-Habsheim aerodrome and the necessary information to conduct the planned low-flyover of the aerodrome's runway (Final Report 26 June 1988 4). While the preparations included maps, visual flight charts, visual landing charts, a scheduled flight plan, and various other information about Mulhouse-Habsheim airport, the crew were provided with, "no instructions either concerning runway axis or height of (the) overflight (flyover)" (Final Report 26 June 1988 4).

The crew of Flight 296 successfully piloted the A320 with 6 crewmembers and 130 passengers onboard from Paris to Basle and then quickly briefed for the planned flyover of the Mulhouse-Habsheim aerodrome (Final Report 26 June 1988 5). For this leg the Captain was designated as the pilot in command and based on the cockpit voice recordings, explained the flyby program to his copilot (Final Report 26 June 1988 5). He explained his intention to flyover the field twice, "first (conducting an) overflight at low speed, with landing gear and flaps extended, (also known as "dirty" configuration) at a height of 100 feet, (and then an) overflight at high speed in clean configuration" (Final Report 26 June 1988 5). After taking off, the crew quickly reached their cruising altitude of 1000 feet within a minute and visually identified the aerodrome two minutes later (Final Report 26 June 1988 5). The aircraft began descending for the flyby at a rate of 600 feet per minute and quickly reached the targeted altitude of 100 feet for the flyby; however, the aircraft quickly passed 100 feet and continued descending at the same rate of descent before abruptly slowing to a descent rate of 50 feet per minute (Final Report 26 June 1988 6). The A320 then leveled off at 30 to 35 feet in near level flight, significantly less than initially briefed by the crew (Final Report 26 June 1988 6). Throughout the entire descent the crew maintained the engines at idle, even as the aircraft decelerated and began to pitch up near the very end of the flight (Final Report 26 June 1988 6). During the last five seconds of the flight before impact the engine controls were pushed to maximum thrust to initiate an emergency go around but it was too late for the flight (Final Report 26 June 1988 6). Only four minutes after the A320 had initially taken off the rear fuselage of the aircraft touched the trees at the end of the runway at Mulhouse-Habsheim aerodrome (Final Report 26 June 1988 6). The back of the A320 was followed by the engines, main landing gear and eventually the tip of the right wing which broke off (Final Report 26 June 1988 6). As the aircraft sank into the forest, the broken right-wing tip leaked fuel which immediately started a fire which quickly penetrated the cabin (Final Report 26 June 1988 6). The aircraft's evacuation was immediately started on the left side of the A320 to avoid the raging fire (Final Report 26 June 1988 6). The quick evacuation resulted in 4 crew members and 93 passengers escaping without injury (Final Report 26 June 1988 Contents 2). Tragically, 3 passengers were killed in the ensuing fire and a further 2 crew members and 34 passengers were injured (Final Report 26 June 1988 Contents 2).

The BEA initiated a technical investigation into the crash and was able to conclude early on that there was no evidence of any mechanical or instrument failures on the aircraft (Final Report 26 June 1988 47). Further, they determined that the weather, infrastructure of the aerodrome, and other environmental factors played no role in the accident (Final Report 26 June 1988 47). After ruling these factors out, the BEA turned its focus to the last possible causes for the accident, the failures during the preparation for the flight at Air France and more importantly how pilot errors caused the flight to crash.

The BEA concluded that the planning for Flight 296 was rushed and not prepared properly. They ultimately discovered several reasons that likely contributed to the plans being incomplete and hurried for release to the crew. First, the flight plans were drawn up last minute on a Friday afternoon by the employee responsible for its preparation (Final Report 26 June 1988 48). He then quickly gave the document to the technical assistant to the Air France Airbus A320 division who would have barely had time to review it (Final Report 26 June 1988 48). The BEA concluded that, "reception of this document therefore seems to have been fortuitous" (Final Report 26 June 1988 48). Also, the Air France Airbus A320 likely did not address the flight planning sooner because of their workload related to getting the A320 into service since it was a brand-new type of aircraft for Air France (Final Report 26 June 1988 48). Last, the employee who prepared the flight plan likely assumed that he did not need to fill in every detail since Captain Asseline, "was perfectly capable of planning this flight himself given his (important) position in the company" (Final Report 26 June 1988 48). The BEA also concluded that Captain Asseline had a strong personality in Air France and was given, "a field of actions (responsibilities) much greater than appears in the airline's organization chart" (Final Report 26 June 1988 48). Due to this reason, as well as due diligence, the BEA concluded that although no indications of Air France note 50420, (an internal document regarding how to safely conduct airshow flybys at or above 100 feet), were given in the flight plans, the crew should have still referred to the document based on the general nature of the flight (Final Report 26 June 1988 48). Last, although the internal note at Air France specified that the minimum height for a flyby during a touristic or demonstration flight was 100 feet, this was in direct contradiction of the

French air safety regulations which imposed a minimum flyby height of at least 170 feet under similar flight conditions (Final Report 26 June 1988 49). The BEA noted that numerous flybys had been safely conducted by Air France under similar circumstances at roughly 100 feet in the years preceding the accident (Final Report 26 June 1988 49). Additionally, while it was noted that these flybys were usually conducted safely and without reprimands for the pilots, expect in one instance where the pilots were disciplined, the crew of Flight 296 were still bound by the stricter French air safety regulations (Final Report 26 June 1988 49).

Since the plans for Flight 296's flyby were drawn up on a Friday afternoon by an Air France employee in a rush to leave, it caused another distinct problem for the flight crew. The technical assistant to the Air France Airbus A320 division barely had enough time to review the entire file let alone enough to make verbal comments on the flight plan to Captain Asseline (Final Report 26 June 1988 49). Further the First Officer was not even contacted by the technical assistant since he was off duty two days before the flight (Final Report 26 June 1988 49). Again, since both pilots were specifically selected for the flight due to their managerial responsibilities at Air France, their flying experience at the time this did not seem to present any issue (Final Report 26 June 1988 49). Further the crew never considered getting more information regarding the topography and potential obstacles around the Habsheim aerodrome (Final Report 26 June 1988 49). This included neglecting to consider flying a reconnaissance flight above the aerodrome before Flight 296 and deciding to skip a safety briefing with the Habsheim airshow flight manager which would have given them detailed information about the terrain, runway used for the flyby, and the location of the crowd amongst other crucial details (Final Report 26 June 1988 49). The investigators also concluded that the two pilots of the doomed flight had only reviewed the flight plan on the same morning as the flyby (Final Report 26 June 1988 50).

Further since neither pilot of Flight 296 had previously performed a demonstration flight this meant that, "they made the flight preparation only from items differing from normal working documentation (for normal commercial flights)…describing an aerodrome and its surroundings which they did not know, and…they had free maneuver choice (of how to conduct the flyby)" (Final Report 26 June 1988 50). The BEA concluded that neither pilot tried to obtain more information that morning because they likely concluded that the flybys would present no major difficulties and that other Air France personnel would have been difficult to contact early on a Sunday morning (Final Report 26 June 1988 50).

The BEA also discovered that the pilots may have been more confident of performing the first flyby at a slow speed and reaching the limitations of maintain lift due to the added safety protections afforded by the Airbus A320's computer flight system (Final Report 26 June 1988 51). However, what the crew may not have properly considered was that they did not need to exceed the limits of safely operating the A320 at a slow speed to still degrade the flight characteristics of the aircraft (Final Report 26 June 1988 51). Therefore, they could put their A320 in a dangerous situation and beyond safe recovery even with the added onboard protections afforded by the new aircraft's computers (Final Report 26 June 1988 51). The investigators further concluded that, "the pilots would therefore probably not have considered such a maneuver at a speed so close to stall (speed) on (conventional) types of aircraft)" (Final Report 26 June 1988 51). Even so the BEA found, "for the flight of the accident, the crew did not hesitate to plan a low height flyover at a speed lower that (normal) approach (landing) speed without realizing that, because of the (added computer) protection, the aircraft's limits were reached without risk of exceeding them, but the performance of the aircraft was reduced in the way as on a conventional aircraft" (Final Report 26 June 1988 51). Essentially the crew's overreliance on the safety features of the A320 caused them to push the aircraft beyond its safe envelope of flight.

The BEA concluded that once the pilots had not properly prepared for the flyby and over relied on the safety features of the A320, they proceeded to make a series of other errors that resulted in the ultimate demise of the flight. First, the crew were late in identifying the Habsheim aerodrome after takeoff which caused them to rush their descent to get the aircraft low enough to conduct the flyby (Final Report 26 June 1988 53). The crew began descending quickly at a rate of 600 feet per minute to reach 100 feet, but instead of stopping at that altitude the aircraft kept descending (Final Report 26 June 1988 5). At 100 feet the First Officer warned the Captain of the descent rate saying, "Ok, you're at 100 feet there, watch, watch…" (Final Report 26 June 1988 54). As the aircraft approach 50 and quickly 40 feet, Captain Asseline dismissed his First Officer's and the automated warnings saying, "Yeah, yeah, don't worry" (Final Report 26 June 1988 54). The crew may have also dismissed the warnings because the barometric altimeter on the A320, the scientific device that tells pilots how high they are off the ground, is notoriously inaccurate when you get below 100 feet (Final Report 26 June 1988 55). Various other factors were cited by the BEA as potential reasons why Captain Asseline continued the descent past the briefed altitude of 100 feet (Final Report 26 June 1988 55). These included, the Captain's unfamiliarity with the topography around the airport, aggravated by the crew's lack of preparation, the crew's lack of experience flying over a grass strip aerodrome as opposed to large, conventional airports, the crew's potential false impressions regarding the height of the aircraft since the nose and cockpit section were much higher than the tail during the slow flyby, and lastly the color of the tree line was similar to that of the surrounding fields and was likely only identified by the crew as a hazard late in the flight (Final Report 26 June 1988 55).

The BEA also identified that Captain Asseline's over confidence likely contributed to the accident (Final Report 26 June 1988 56). In reference to his comment to the First Officer about not worrying during the descent as well as another comment he made to the first officer during the briefing about having done the maneuver, "20 times," the BEA stated that Captain Asseline was over confident in the A320 for several reasons (Final Report 26 June 1988 56). These included his extensive experience with A320 simulators and his development of the aircraft which led him to believe that, "he knew the A320 better than most of his colleagues," his experience doing similar flybys in the aircraft's dirty configuration in the A320 simulator albeit at a much higher altitude and hence more breathing room in case something went wrong (Final Report 26 June 1988 56). Last, the BEA concluded that the air show atmosphere and presence of female passengers close to the cockpit may have contributed to the crew's decision making (Final Report 26 June 1988 56). What ultimately sealed the fate of Flight 296 was the Captain Asseline's mistake to disconnect the autothrottle, a system used to automatically control the engine power on an airliner and bring the engines to idle power (Final Report 26 June 1988 56). While he believed that manually controlling the thrust, "was a safety measure intended to guarantee full application of thrust when required," the BEA concluded that not only was the decision not a "safety measure" it also put the flight in an extremely precarious position because it dangerously slowed the aircraft (Final Report 26 June 1988 56). In the last possible seconds as the A320 passed the control tower, Captain Asseline increased the engine power from idle to maximum thrust and raised the aircraft to full nose-up position, likely because he realized that the tree line was right in front of him (Final Report 26 June 1988 56). At this point the aircraft was flying so slow and low and that it had no energy reserves and although the engines were moved to full power they needed approximately five seconds to obtain enough power to successfully power the aircraft to clear the tree line (Final Report 26 June 1988 57). Tragically the engine did get to 91% thrust but by that point that tail of the aircraft had already impacted the tree line and created additional drag which caused the aircraft to pancake into the forest (Final Report 26 June 1988 57).

Air France Flight 4590 Description and Technical Investigation

On Tuesday, July 25, 2000, an Air France Aerospatiale/BAC 101 Concorde, registered F-BTSC, was scheduled to operate Flight 4590 from Paris Charles de Gaulle International Airport to New York John F. Kennedy International Airport (Accident on 25 July 2000 17). Onboard were nine crew members and one hundred passengers (Accident on 25 July 2000 17). After receiving clearance to depart Paris at 1:40 PM local time, the aircraft commenced its takeoff role two minutes later (Accident on 25 July 2000 17). Just seconds before the aircraft had reached V1, or the speed at which an aircraft leaves the ground, the right front tire on the left main landing exploded after running over a piece of debris on the runway (Accident on 25 July 2000 17). The failure of the tire threw huge piece of rubber against the underside of the left wing which caused one of the aircraft's fuel tanks, located just under the skin of the Concorde's wing, to rupture (Accident on 25 July 2000 17). A vicious fire quickly broke out and caused both engine on the left wing to begin losing power (Accident on 25 July 2000 17). Roughly 45 seconds later, the air traffic controller radioed to the crew that they had flames coming out of the left side of the aircraft (Accident on 25 July 2000 17). At nearly the same time, the number two engine on the left wing completely failed (Accident on 25 July 2000 17). The flight engineer onboard, also known as the second officer, called for the engine two to be shut down and the captain called for the engine fire procedure (Accident on 25 July 2000 17). One of the crew members then pulled engine 2's fire handle which quieted the fire alarm in the cockpit (Accident on 25 July 2000 17).

Immediately after this was accomplished the first officer directed the captain's attention to the decreasing speed of the Concorde which was beginning to drop dangerously slow (Accident on 25 July 2000 17). Just 15 seconds later the captain asked the first officer to retract the landing gear, after which the air traffic controller warned the crew that the Concorde had a large flame trailing the aircraft (Accident on 25 July 2000 17). This was followed ten seconds later by the fire alarm going off in the cockpit again (Accident on 25 July 2000 17). Meanwhile the first officer informed the captain that the landing gear on the Concorde had not retracted when he pulled the handle and immediately began calling out the speed of the aircraft to the pilot (Accident on 25 July 2000 18). Just three seconds later the ground proximity warning system, or GPWS, began going off in the cockpit informing the pilots that the aircraft was flying dangerously close to the ground (Accident on 25 July 2000 18). Although the pilots fought bravely to gain control of the aircraft, engine 1 on the left wing began failing simultaneously and within seconds the aircraft impacted a hotel at, "La Patte d'Oie" in Gonesse just miles from the runway where it had taken off (Accident on 25 July 2000 18). Tragically all one hundred and nine people on board Flight 4590 were killed in the impact (Accident on 25 July 2000 18). In addition, another four people in the hotel were killed and six more had also been injured by the crash (Accident on 25 July 2000 18).

The BEA immediately initiated a technical investigation to determine what had caused the crash of Flight 4590. Since debris from the Concorde's landing gear assemble was quickly located on the runway where the onboard fire had begun, it was clear that some type of catastrophic event had occurred to initiate the sequence of events on the runway (Accident on 25

July 2000 59). Aside from the wreckage of the landing gear assemble and rubber from the aircraft's tires, another strip of metal was located that was determined to have not come from the Concorde (Accident on 25 July 2000 61). In addition, a single part from the number 5 fuel tank was located, as were marks that signified some type of explosion had occurred (Accident on 25 July 2000 61-62). The technical investigation than shifted to answering four main questions, how the metal strip found on the runway got there and how it caused the tire to fail, how the tire failure caused the fire, why two of the engines had experienced surges, and lastly what led the pilots to ultimately lose control of the flight.

Since the one piece of debris found of the runway from where Air France Flight 4590 had departed did not belong to the Concorde that crashed, the BEA began the investigation by trying to determine where it came from. The agency began by reviewing records of aircraft that had departed the runway right in front of the Concorde as well as reviewing its specifications (Accident on 25 July 2000 102). The BEA concluded that the metal strip was likely a wear strip from a CF6-50 engine, the type used by Douglas DC-10 aircraft (Accident on 25 July 2000 102). The investigators also discovered that a DC-10 owned by Continental Airlines had taken off from the same runway as the doomed Concorde just two aircraft ahead and five minutes before; therefore, the BEA contacted the NTSB and scheduled a visit to the Continental Airline's base in Houston, Texas (Accident on 25 July 2000 103). When the investigators examined the same aircraft that had department almost right before the Concorde, they discovered that the lower left wear strip on the DC-10's right engine was missing (Accident on 25 July 2000 103). The investigators also determined that the wear strips on the left side of the right engine were not the original ones and appeared to have been more recently replaced (Accident on 25 July 2000 104). After reviewing maintenance records at Continental Airlines they discovered that the left wear strips on the right engine had been replaced twice in the past several months, first by the Israeli Aircraft Industries in Tel Aviv, Israel and second by a mechanic in Houston who observed one of the strips coming apart after the first repair (Accident on 25 July 2000 106). A closer examination by the investigators conclusively revealed that the position of the holes and length of the strip they had collected from the runway had come from the Continental Airlines DC-10 (Accident on 25 July 2000 108).

The BEA ultimately determined that the loss of the wear strip from the right engine of the Continental Airlines DC-10 was caused by a lack of rigorous maintenance procedures at the airline (Accident on 25 July 2000 171). The BEA placed part of the blame on the Israeli Aircraft Industry saying that the part should not have needed to be replaced within a month of the aircraft undergoing maintenance at its facilities; however, the second time the wear strip was replaced by Continental in Houston was also not done in accordance with the manufacturer's manual and specifications (Accident on 25 July 2000 171). When the BEA and NTSB inspected several workshops for Continental in Houston, they discovered inadequate adherence to maintenance procedures (Accident on 25 July 2000 171). Namely the engine was drilled with thirty-seven holes when the wear strip only required twelve, a titanium piece was used for the repair which was not normal, and lastly the lower right wear strip was too long which helped to cause the successive tearing which led the strip to fall off and end up on the runway in Paris (Accident on 25 July 2000 171).

The BEA closely analyzed the flight data recorder onboard the Concorde operating Flight 4590 and about forty second after the aircraft began taking off a slight yaw, uncommanded by the rudder, can be observed (Accident on 25 July 2000 161). This movement was followed less than a half second later by a short noise on the cockpit voice recorder (Accident on 25 July 2000

161). The investigators concluded that since the aircraft would have been about 1,700 meters from the start of its takeoff role when both items were recorded, it would have been exactly in the area where debris from the tire and the metallic wear strip from the DC-10 were recovered (Accident on 25 July 2000 161). The BEA determined that the most likely reason for the Concorde's tire to fail was that it had run over the wear strip dropped by the DC-10.

Once the BEA had determined that the tire failure on Flight 4590 was caused by the metallic wear strip from the DC-10, the investigation then shifted to determining how the tire failure had caused the fire onboard the aircraft. The investigators began by examining a 32 x 32 cm piece of the Concorde's lower wing which was discovered on the runway not far from the wear strip and tire debris (Accident on 25 July 2000 109). An intensive examination of the part by investigators determined that the part had not sustained any fire or major damage unlike most of the other debris located slightly further down the runway (Accident on 25 July 2000 109). Instead, this piece of debris had failed because of pressure from the inside of the fuel tank directed towards the outside causing it to rupture (Accident on 25 July 2000 109). After undergoing numerous computer models to try to understand how this pressure pushing outwards could have occurred, the BEA concluded that a piece of rubber weighing approximately 4.5 kg struck the underside of the Concorde's wing and had initiated the failure sequence (Accident on 25 July 2000 118). That initial shock of the impact against the skin that protected the fuel tank subsequently displaced a certain amount of fuel in the tank since it was filled to capacity (Accident on 25 July 2000 113). However, the displaced fuel also caused a displacement movement or wave within the liquid which caused neighboring panels to the one initially struck by the tire debris to experience extreme stress (Accident on 25 July 2000 113). The stress from the wave ultimately led to the piece of aircraft skin covering fuel tank 5 to be ejected from the aircraft onto the runway and a major fuel leak from the wing of the Concorde to begin (Accident on 25 July 2000 118).

Since the BEA had determined what caused the fuel tank to rupture, they then turned to the cause of the fire that immediately followed it. Although the investigators came up with two potential hypotheses to explain how fuel tank 5 caught fire, it was impossible for them to determine a definite conclusion due to the catastrophic damage to the Concorde after its impact with the hotel. The first potential explanation for the combustion is that the explosion from the tire failure had also damaged electrical cables near the main landing gear (Accident on 25 July 2000 120). This damage caused an electric arc by a short-circuit which produced enough energy to be compatible with igniting the vaporized kerosene flowing out of fuel tank 5 (Accident on 25 July 2000 120). The other potential hypothesis considered by the investigators is that the fire was caused by the leaking kerosene encountering the hot sections of the Concorde's engines (Accident on 25 July 2000 121). Once the fuel was ingested through several potential areas on the nacelle/engine assembly of the aircraft the fuel could have ignited on contact with the hot walls of the engine or on contact with the gas coming from the thrust nozzles at the rear of the aircraft (Accident on 25 July 2000 122). Either hypothesis adequately explains how Flight 4590 ended up on fire.

Another major question the BEA sought to answer in its technical investigation was why Flight 4590 had experienced several engine surges in engine 1 and 2 which led them to ultimately fail. A surge in an aircraft engine is best characterized as a sudden loss of thrust or power being produced by the engine. Shortly after the Concorde had impacted the wear strip and one of its tires had failed, both engines 1 and 2 experienced their first surge (Accident on 25 July 2000 132). After engine 1 was disassembled, the ingestion of small particles of foreign debris, most likely from rubber tire debris, were observed in the engine, but the ingestion of hot gasses by both engines could have also caused the initial surge (Accident on 25 July 2000 132). About eight seconds later when the aircraft sharply changed its altitude, both engines experienced a greater surge which was again likely linked to the ingestion of hot gasses into the engines (Accident on 25 July 2000 132). At that point since the fire alarm for engine 2 was going off and its parameters were showing the engine to be performing barely above idle, the crew pulled the fire handle and manually shut the engine down (Accident on 25 July 2000 133). About fifty seconds later, engine 1 experienced a final surge that caused the engine to decelerate rapidly (Accident on 25 July 2000 133). This final surge was probably caused by the engine ingested debris breaking off the aircraft such as pieces of aluminum, glass fiber, or honeycomb from the Concorde's structure (Accident on 25 July 2000 133). The damage caused by this ingestion was severe, permanently damaged the engine, and ultimately sealed the fate of Flight 4590 (Accident on 25 July 2000 133).

The final piece for the BEA to explain why Air France Flight 4590 had crashed was what led the crew to ultimately lose control of the Concorde. First, in the last twelve seconds of the flight, the Concorde pitched up steeply from 12 degrees to over 25 degrees as well as banking from 2 degrees to over 113 degrees to the left (Accident on 25 July 2000 165). Two reasons contributed to why the aircraft was beginning to leave controlled flight. The main reason was that because engines 3 and 4 on the right wing continued to operate normally throughout the duration of the flight (Accident on 25 July 2000 165). So, when engines 1 and 2 began experiencing surges and failing, the overcompensation of the engines on the right wing forced the aircraft into a tight left bank (Accident on 25 July 2000 165). In addition to the thrust asymmetry of the engines, the BEA also concluded that the fire was becoming so strong that it was starting to destroy vital control surfaces in the left wing (Accident on 25 July 2000 165). Since the aircraft was on a tight bank and starting to lose speed, the only way to potentially gain more speed would be to descend altitude and speed the aircraft up, but because Flight 4590 was never able to gain much altitude after takeoff, the Concorde could not drop any lower without impacting the ground (Accident on 25 July 2000 165). The BEA also concluded that even if all four engines on the Concorde had been operating normally, the damage to the aircraft's left-wing structure and flight controls by the fire would still have caused the flight crew to lose control (Accident on 25 July 2000 165). This led the BEA to conclude that as soon the flight left the runway, it was doomed.

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