5. Appendixes

Appendix A
Investigation and Hearing

Investigation

The National Transportation Safety Board was initially notified of this accident about 2050 eastern daylight time on July 17, 1996. A full go-team was assembled in Washington, D.C., and arrived on scene early the next morning; investigators from the Safety Board's regional office in Parsippany, New Jersey, went immediately to the scene of the accident. The go-team was accompanied by the Safety Board Vice Chairman and representatives from the Safety Board's Office of Government and Public Affairs.

The following investigative groups were formed during the course of this investigation: Systems, Structures, Maintenance Records, Airplane Interior Documentation, Witness, Metallurgy Structures/Sequencing, Medical Forensic, Fire and Explosion, Powerplants, Air Traffic Control, Operations, Aircraft Performance, Airport Security, Reconstruction, Hazardous Materials—Security, and Flight Test. Specialists were also assigned to stand by in the Safety Board laboratories for the cockpit voice recorder and flight data recorder.

Parties to the investigation were the Federal Aviation Administration (FAA); the Boeing Commercial Airplane Group; Trans World Airlines, Inc. (TWA); the International Association of Mechanists, Aerospace Workers, and Flight Attendants (IAM); the Air Line Pilots Association (ALPA); the National Air Traffic Controllers Association; Pratt & Whitney; Honeywell; and the Crane Company, Hydro-Aire, Inc. (For information about agencies and companies that assisted during the search and recovery operation, see appendix C.)

Additionally, representatives from France's Bureau Enquetes Accidents, the United Kingdom's Air Accidents Investigation Branch, and Australia's Bureau of Air Safety Investigations participated in the investigation as observers, in accordance with the provisions of Annex 13 to the Convention on International Civil Aviation. In addition, representatives from Canada's Transportation Safety Board and International Civil Aviation Organization, Singapore's Civil Aviation Authority, and Russia's Interstate Aviation Committee observed portions of the investigation.

Public Hearing

A public hearing was conducted for this accident from December 8 through 12, 1997, in Baltimore, Maryland. Chairman Jim Hall presided over the hearing. Parties to the public hearing were the FAA; Boeing; TWA; IAM; ALPA; Honeywell; and the Crane Company, Hydro-Aire.

Appendix B
Cockpit Voice Recorder Transcript

The following is a transcript of the Fairchild A-100 cockpit voice recorder (CVR) installed on the accident airplane. Only radio transmissions to and from the accident airplane were transcribed. The CVR transcript reflects the 31 minutes and 30 seconds before power was lost to the CVR. All times are eastern daylight time, based on a 24-hour clock.

Transcript of a Fairchild Model A-100 Cockpit Voice Recorder S/N UNK which was removed from a Trans World Airlines, Inc., Boeing Commerical Aircraft Co. B747-100 N93119, which was involved in an inflight accident on July 17, 1996 approximately 10 miles south of East Moriches, New York.

LEGEND	
RDO	Radio transmission from accident aircraft
CAM	Cockpit Area Microphone sound or source
INT	Aircraft flight/ground intercom sound or source
-1	Voice identified as Captain (left seat)
-2	Voice identified as First Officer (right seat)
-3	Voice identified as Second Officer
-4	Voice identified as Instructor Flight Engineer
-5	Voice identified as gate agent personnel
-6	Voice identified as male aircraft ground personnel
-?	Voice unidentified
TWR	JFK Local Controller (tower)
GND	JFK Ground Controller
DEP	New York Radar Departure Controller
FIC	TWA Flight Information Controller
GH	Kennedy Gate Hold Controller
CTR	Boston ARTCC Controller (center)
LOAD	TWA passenger/freight load Controller
ATIS	Kennedy automated terminal information service
UNK	Unknown source
*	Unintelligible word
@	Nonpertinent word
#	Expletive deleted

%	**Break in continuity**
()	**Questionable text**
(( ))	**Editorial insertion**
-	**Pause**

Note: All times are expressed in Eastern Daylight Savings time. Only radio transmissions to and from the accident aircraft were transcribed.

CVR Quality Rating Scale

The levels of recording quality are characterized by the following traits of the cockpit voice recorder information:

Excellent Quality Virtually all of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate only one or two words that were not intelligible. Any loss in the transcript is usually attributed to simultaneous cockpit/radio transmissions that obscure each other.

Good Quality Most of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate several words or phrases that were not intelligible. Any loss in the transcript can be attributed to minor technical deficiencies or momentary dropouts in the recording system or to a large number of simultaneous cockpit/radio transmissions that obscure each other.

Fair Quality The majority of the crew conversations were intelligible. The transcript that was developed may indicate passages where conversations were unintelligible or fragmented. This type of recording is usually caused by cockpit noise that obscures portions of the voice signals or by a minor electrical or mechanical failure of the CVR system that distorts or obscures the audio information.

Poor Quality Extraordinary means had to be used to make some of the crew conversations intelligible. The transcript that was developed may indicate fragmented phrases and conversations and may indicate extensive passages where conversations were missing or unintelligible. This type of recording is usually caused by a combination of a high cockpit noise level with a low voice signal (poor signal-to-noise ratio) or by a mechanical or electrical failure of the CVR system that severely distorts or obscures the audio information.

Unusable Crew conversations may be discerned, but neither ordinary nor extraordinary means made it possible to develop a meaningful transcript of the conversations. This type of recording is usually caused by an almost total mechanical or electrical failure of the CVR system.

	INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
	TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
1959: 40		Start of recording.		
1959: 41 CAM-?		got it.		
1959: 42 CAM-?		an agent comin'.		
1959: 43 CAM-?		yeah right.		
1959: 44 CAM- 5		passenger's bag pulled, the passenger was on board the whole time.		
1959: 49 CAM- 5		all right.		
1959: 50 CAM-1		is the bags back on?		
1959: 52 CAM- 5		huh?		
1959: 53 CAM-?		yes.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
1959: 53 CAM- 1	yeah he was on the whole time.		
1959: 54 CAM- 1	okay.		
1959: 56 CAM- 4	are we reconciled?		
1959: 56 CAM-?	let's go.		
1959: 58 CAM-?	push.		
1959: 59 CAM	((sound similar to cockpit door closing)).		
2000: 01 CAM- 1	we won't bother telling them that.		
2000: 03 CAM-?	nope.		
2000: 04 CAM- 1	you don't mind, huh?		
2000: 11 CAM- 3	we'd have a mutiny back there.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2000: 14 CAM- 4	now the lavatories are full.		
2000: 15 CAM- 1	okay, well she said she'd call me as soon as they ah --.		
2000: 16 CAM- 3	probably have to get the ATIS now, huh?		
2000: 18 CAM- 2	don't don't ah let them do their job Ralph they'll tell you when they're seated.		
2000: 22 ATIS	-- visibility greater than one zero ceiling better than five thousand temperature two eight due point two one altimeter three zero zero seven approach in use VOR DME runway two two left departure runway runway two two right and southwest departures runway three one left from intersection of kilo kilo all pilot are require to read back all runway hold short instructions in interest of noise abatement please use the assigned runway advise you have tango Kennedy airport information tango two three five one Zulu weather wind two two zero eight visibility --.		
2000: 36 CAM- 3	all door lights are out.		
2000: 37 CAM- 1	thank you.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2000: 53 CAM- 2	tango.		
		2001: 02 INT- 6	cockpit ground.
		2001: 05 INT- 1	hello ground
		2001: 06 INT- 6	all right every thing is shut down here you should have all doo lights out and when you have clearance you can release the brakes.
		2001: 13 INT- 1	yeah we'll get the clearance we're waitin' on all the people to sit down I'll be back with ya in just a second.
2001: 18 CAM	((sound of cabin chime)).		
		2000: 40 INT- 6	okay we're standing by.
2001: 23 CAM- 3	hello darling.		
2001: 24 CAM- 3	everybody seated thanks.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2001: 25 CAM- 1	amazing.		
2001: 26 CAM- 3	everybody's seated.		
2001: 27 CAM- 1	do we have push back clearance to move?		
2001: 28 CAM- 3	we're we're we cleared to push from FIC or -.		
2001: 30 CAM- 1	no not yet.		
2001: 31 CAM- 2	you have to call them.		
		2001: 32 RDO- 3	FIC TWA eight hundred gate twenty seven.
		2001: 37 FIC	TWA eight hundred?
		2001: 38 RDO- 3	yeah we're ready to push.

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2001: 39 CAM	((sound of electric seat adjustment)).		
		2001: 42 FIC	TWA eight hundred you're cleared to push gate twenty seven.
2001: 46 CAM- 2	cleared to push.		
2001: 47 CAM- 1	cleared to push.		
		2001: 48 RDO- 3	cleared to to push eight hundred.
		2001: 50 INT- 1	okay ground we are cleared to push yeah well wait a minute hang on a minute.
2001: 53 CAM- 1	did they say everybody was seated yeah they did.		
2001: 54 CAM- 3	yes.		
		2001: 58 INT- 1	okay, we're cleared to push sorry.

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2001: 57 INT- 6	brakes released please.
2001: 58 CAM	((sound similar to parking brake being released)).		
		2001: 59 INT- 1	beacon on brakes released.
		2002: 00 INT- 6	thank you.
2002: 02 CAM- 2	you got something else to do Ralph.		
2002: 05 CAM- 1	number one ADP-.		
2002: 06 CAM- 2	there you go.		
2002: 07 CAM- 1	and the electric.		
2002: 08 CAM- 2	it's a command.		
2002: 09 CAM- 1	electric's on.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2002: 10 CAM- 2	right.		
2002: 10 CAM- 2	that's a command.		
2002: 11 CAM- 1	command.		
2049: 27 CAM- 1	number one ADP on and the electric.		
2002: 16 CAM- 2	before you release the brakes.		
2002: 22 CAM-?	*.		
2002: 27 CAM- 2	block's at oh two I assume.		
2002: 29 CAM- 3	I'm showin' oh two out. is that what you want?		
2002: 32 CAM- 2	that's fine.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2002: 33 CAM- 1	yeah.		
2002: 34 CAM- 2	that's fine.		
2002: 35 CAM- 1	okay.		
2002: 38 CAM- 2	that's a minute over kill.		
2002: 40 CAM- 1	yeah well that was because they weren't seated they probably had people standing up and they were *.		
2002: 46 CAM- 2	* down.		
2002: 48 CAM- 2	exactly.		
2002: 50 CAM- 1	you can bet on it.		
2002: 54 CAM- 1	I still think I'm sittin' too high in this thing.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2003: 10 FIC	eight hundred.
2003: 11 CAM- 1	somebody calling us .		
		2003: 12 RDO- 3	go ahead.
		2003: 13 FIC	tell your mechanic to pull you back push you back far enough so we can get an arrival into your gate.
		2003: 18 RDO- 3	okay.
		2003: 21 INT- 1	and ah ground FIC wants you to push us back far enough so they can bring somebody in our gate.
		2003: 27 INT- 6	okay we'll do that.
		2003: 30 INT- 1	thank you.
2003: 32 CAM-?	* where's this thing.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2004: 07 CAM- 1	ah there's that ah new airplane.		
2004: 10 CAM- 2	one twenty nine yes sir.		
		2004: 43 INT- 6	okay this looks far enough.
		2004: 45 INT- 1	okay if you say so.
		2004: 47 INT- 6	brakes parked please.
2004: 48 CAM	((sound of parking brake being set)).		
		2004: 50 INT- 1	brakes parked.
		2004: 51 INT- 6	thank you cleared to turn your engines.
		2004: 54 INT- 1	okay we'll turn one two and four today.
		2004: 56 INT- 6	((sound of two mike clicks)).

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2004: 59 CAM- 1	turn one please.		
2005: 12 CAM- 2	((sound of cough)).		
2005: 19 CAM- 1	contact.		
2005: 22 CAM- 2	you got N- 1?		
2005: 26 CAM- 1	I do now.		
2005: 27 CAM- 2	you do now.		
2005: 29 CAM- 3	four fifty.		
2005: 30 CAM- 1	it bobbled but not much.		
2005: 42 CAM- 1	and turn two please.		

	INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
	TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2005: 44 CAM- 4	***.			
2006: 00 CAM- 1	N- one.			
2006: 01 CAM- 3	turning.			
2006: 04 CAM- 1	two.			
2006: 07 CAM- 3	four hundred.			
2006: 24 CAM- 1	turn four.			
2006: 25 INT- 1	turning four.			
2006: 27 INT- 6	* four.			
2006: 45 CAM- 1	contact.			
2006: 51 CAM- 3	four hundred.			

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2006: 56 INT- 1	disconnect ground equipment stand by for hand signals thank you.
		2006: 58 INT- 6	okay.
2007: 13 CAM- 1	okay and after start checklist when you have a moment.		
2007: 14 CAM	((sound of momentary power interruption to the CVR)).		
2007: 15 CAM	((sound of altitude alert tone)).		
2007: 20 CAM- 3	stand by.		
2007: 29 CAM- 1	after start.		
2007: 30 CAM- 3	after start checklist. flight recorder?		
2007: 33 CAM- 1	on.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2007: 34 CAM- 3	start switches?		
2007: 35 CAM- 1	off.		
2007: 36 CAM- 3	beacon lights?		
2007: 37 CAM- 1	are on.		
2007: 38 CAM- 3	brake pressure?		
2007: 41 CAM- 1	checked.		
2007: 42 CAM- 3	start levers?		
2007: 44 CAM- 1	idle detent.		
2007: 45 CAM- 3	engine anti- ice?		
2007: 46 CAM- 1	off.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2007: 50 CAM- 1	you need to get taxi clearance.		
		2007: 52 RDO- 2	Kennedy gate hold TWA's eight hundred heavy we're life guard ah we're ready to taxi out delta alpha with tango.
		2008: 01 GH	TWA eight hundred all right contact ground one two one point niner for the taxi inform them that you are lifeguard.
2008: 04 CAM- 3	after start checklist complete.		
		2008: 07 RDO- 2	roger.
		2008: 13 RDO- 2	Kennedy ground TWA's eight hundred heavy lifeguard comin' out delta alpha with tango.
		2008: 19 GND	ah TWA eight hundred heavy ah you're a life guard today?
		2008: 24 RDO- 2	yes sir.

INTRA- COCKPIT COMMUNICATION

TIME and SOURCE	CONTENT
2008: 52 CAM- 1	right on alpha and hold short of echo.
2008: 53 CAM- 1	clear right?
2008: 54 CAM- 2	clear right.

AIR- GROUND COMMUNICATION

TIME and SOURCE	CONTENT
2008: 25 GND	you know every day you come out and we don't know that you're a lifeguard and then you tell us you are and ah if you could tell company to ah you know ah put that in their flight plan ah it would help us out alot.
2008: 38 RDO- 2	TWA's eight hundred understand I don't think they knew it either until the last minute.
2008: 41 GND	all right TWA eight hundred taxi right on alpha and hold short of echo.
2008: 47 RDO- 2	TWA's eight hundred right alpha hold short of echo.
2008: 49 RDO- 3	and a load TWA eight hundred.

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2008: 55 CAM	((sound of parking break being released)).		
2008: 57 CAM- 2	clear left.		
		2009: 05 RDO- 3	and load TWA eight hundred.
		2009: 07 LOAD	eight hundred stand by.
2009: 19 CAM- 2	watch number one it's too high.		
2009: 26 CAM- 1	forty five percent.		
2009: 28 CAM- 1	you got a guy over there.		
2009: 30 CAM- 2	yup.		
2009: 34 CAM- 1	right on alpha huh?		
		2009: 36 LOAD	eight hundred ready to copy?

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2009: 37 RDO- 3	ready to copy.
		2009: 38 LOAD	on board twenty nine up front one eight three in the rear takeoff fuel is one seven six decimal six your gross takeoff weight is five nine zero seven seven one trim six decimal one and no reported GSI's. copy?
2009: 41 CAM- 1	clear.		
2009: 42 CAM- 2	yeah.		
2009: 43 CAM- 2	keep it comin'.		
2009: 51 CAM- 1	does he look clear?		
2009: 52 CAM- 2	yup it's no problem.		
		2009: 56 RDO- 3	okay twenty nine in the front one eighty three in the back one seven six decimal six on the fuel five nine zero decimal seven seven one on the takeoff weight six point one on the trim and no GSIs TWA eight hundred out.

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2010: 01 CAM- 1	one two three --.		
2010: 09 CAM- 1	ya think he's gunna try and get us out being a lifeguard?		
		2010: 10 LOAD	okay read back. * both times?
		2010: 12 RDO- 3	yeah we're out at ah zero zero zero two and ah expecting off here probably about ah thirty five.
2010: 15 CAM- 2	I think he just *.		
2010: 19 CAM- 2	that's your undershoot problem huh.		
2010: 21 CAM- 1 ?	* it is		
		2010: 24 LOAD	copy zero two and three five have a good flight eight hundred.
		2010: 25 RDO- 3	see ya.

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2010: 26 CAM- 1	how's that look?		
2010: 27 CAM- 2	better.		
2010: 50 CAM- 3	six point one on the trim.		
2010: 53 CAM- 2	okay set up here.		
2011: 58 CAM- 1	well we lost a little bit of weight huh? payload.		
		2012: 04 GND	TWA eight hundred make a left turn on um taxi way echo behind Carnival and hold short of runway three one right and you can monitor tower now on one two three point niner.
		2012: 17 RDO- 2	TWA's eight hundred heavy left echo hold short of three one right over to the tower, bye.
2012: 24 CAM- 1	left on echo behind carnival hold short of three one right.		
2012: 35 CAM- 2	((sound of cough)).		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2012: 38 CAM	((sound of parking brake release)).		
2012: 41 CAM- 2	can I have the weight slip if you are done with it, Ollie?		
2013: 22 CAM- 2	notice that's going to be an undershoot too.		
2013: 24 CAM- 1	what's that?		
2013: 25 CAM- 2	good.		
2013: 27 CAM- 1	well then someone's given me the wrong poop cause I was tryin' to turn like on the L ten eleven they said I was over- turning.		
2013: 33 CAM- 2	ah.		
2013: 38 CAM- 1	how much past center then?		
2013: 40 CAM- 2	nose wheel is back by the emergency exit door. right?		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2013: 41 TWR	and lifeguard TWA eight hundred heavy Kennedy tower good evening you with me?
2013: 42 CAM- 1	right, right.		
2013: 45 CAM-?	(sound of cough).		
2013: 46 CAM- 2	so you really can't start the turn until the nose wheel is past there the center taxi line and whatever it takes as far as -.		
2013: 54 CAM- 1	the angle but *.		
2013: 56 CAM- 2	as far as comin' out with the main gear you just want to play with it a little bit a few times to find out.		
2014: 04 CAM- 1	okay.		
2014: 07 CAM- 2	but that first turn would have been a very dirty *.		
2014: 10 CAM- 1	*.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2014: 11 CAM- 2	there's no way you could - .		
		2014: 12 TWR	TWA eight hundred heavy lifeguard Kennedy tower.
		2014: 13 RDO- 2	TWA's eight hundred heavy lifeguard go ahead.
		2014: 16 TWR	I'm gunna put you behind British Airways so the company heavy seven six knows to follow you so make a right on the runway a left at Zulu alpha and follow British.
		2014: 23 RDO- 2	TWA eight hundred heavy okay right on ah thirty one ah correction thirteen left and follow British.
2014: 29 CAM- 1	start the number three motor.		
2014: 31 CAM- 2	let's.		
2014: 33 CAM- 2	start taxi.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2014: 36 CAM- 1	okay.		
2014: 37 CAM- 2	are you ready?		
2014: 37 CAM- 3	okay.		
2014: 43 CAM- 2	just let me have one engine.		
2014: 39 CAM- 3	there you go.		
2014: 40 CAM-?	if you need it.		
2014: 41 CAM- 3	all right we got enough pressure.		
2014: 42 CAM- 2	okay here we go I'll get the engine for ya.		
2014: 53 CAM- 2	watch your feet just steer it.		
2014: 56 CAM- 2	just leave 'em alone for a little bit.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2014: 58 CAM- 1	you want number three back?		
2014: 59 CAM- 2	yup.		
2015: 01 CAM- 2	don't touch the engines.		
2015: 02 CAM- 1	okay.		
2015: 04 CAM- 2	start lever.		
2015: 08 CAM- 3	four hundred.		
2015: 23 CAM- 2	okay you can have 'em now.		
2015: 29 CAM- 2	here you got no problems.		
2015: 33 CAM- 1	delayed engine -.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2015: 34 CAM- 2	wide runway you don't need to worry about it.		
2015: 36 CAM- 1	yeah delayed engine start.		
2015: 39 CAM- 3	delayed engine start checklist. start switches?		
2015: 42 CAM- 1	off.		
2015: 43 CAM- 3	start levers?		
2015: 45 CAM- 1	idle detent.		
2015: 47 CAM- 3	engine anti- ice?		
2015: 47 CAM- 1	off.		
2015: 51 CAM- 3	delayed engine start checklist is complete.		
2015: 53 CAM- 1	taxi checklist.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2015: 55 CAM- 3	taxi checklist. Flaps and runway?		
2015: 58 CAM- 1	flaps are ten and green for runway two two right Kennedy.		
2016: 04 CAM- 3	ten eight green two two right Kennedy. take off data EPR and airspeed bugs?		
2016: 08 CAM- 1	five hundred and ninety thousand seven seventy one takeoff EPR's set at point three three bugs set and cross checked at one fifty three.		
2016: 16 CAM- 2	set and cross checked.		
2016: 17 CAM- 3	stabilizer trim?		
2016: 18 CAM- 1	is set at six point one.		
2016: 21 CAM- 3	probe heat?		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2016: 22 CAM- 1	on.		
2016: 23 CAM- 3	flight controls		
2016: 25 CAM- 1	checked.		
2016: 26 CAM- 3	auto- brakes?		
2016: 28 CAM- 1	armed.		
2016: 29 CAM- 2	now you can start it.		
2016: 31 CAM- 3	yaw dampers?		
2016: 32 CAM- 1	on.		
2016: 34 CAM- 2	wrong answer checked.		
2016: 35 CAM- 1	checked.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2016: 37 CAM- 2	right here don't roll out start rollin' out you're beside the line.01		
2016: 43 CAM- 3	seat belt shoulder harnesses?		
2016: 44 CAM- 1	checked.		
2016: 51 CAM- 1	okay gentlemen standard TWA crew coordination you call out eighty Vee one Vee R please.		
2016: 58 CAM- 2	that's the first officers -.		
2017: 00 CAM- 1	we're going to fly headings, huh.		
2017: 02 CAM- 2	I say that's standard first officer duties.		
2017: 06 CAM- 1	well.		
2017: 07 CAM- 3	taxi checklist is complete.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2017: 08 CAM- 1	two hundred five degree on the heading five thousand.		
2017: 10 CAM- 2	that's it.		
2017: 18		TWR	TWA eight hundred heavy caution wake turbulence from a seven fifty seven runway two two right taxi into position and hold.
		2017: 24 RDO- 2	TWA's eight hundred heavy lifeguard position and hold two two right.
2017: 28 CAM- 1	position and hold two two right.		
2017: 31 CAM- 1	will you alert the cabin please.		
2017: 40 CAM- 3	flight attendants please be seated for takeoff.		
2017: 55 CAM- 4	****.		
2018: 03 CAM- 2	now that's better.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2018: 04 CAM- 3	now it's coming on *.		
2018: 06 CAM- 1	I'll just extend it out to that line.		
2018: 07 CAM- 3	* sure *.		
2018: 09 CAM- 2	yeah that's one of the ways you test yourself too is whether when you get rolled out is the whole airplane longitudinally lined up.		
2018: 15 CAM- 1	yeah.		
		2018: 21 TWR	TWA eight hundred heavy lifeguard wind's two four zero at eigh runway two two right cleared for takeoff.
		2018: 27 RDO- 2	TWA's eight hundred heavy lifeguard cleared for takeoff two two right.
2018: 31 CAM- 1	before takeoff checklist.		
2018: 33 CAM- 3	before takeoff checklist. icing considerations?		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2018: 34 CAM- 1	checked.		
2018: 35 CAM- 3	cabin alert?		
2018: 36 CAM- 1	checked.		
2018: 36 CAM- 3	transponder?		
2018: 37 CAM- 1	that's checked.		
2018: 39 CAM- 3	ignition?		
2018: 40 CAM	((sound of click)).		
2018: 41 CAM- 1	flight start.		
2018: 42 CAM- 3	body gear steering?		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2018: 43 CAM- 1	disarmed.		
2018: 44 CAM- 2	clocks.		
2018: 46 CAM- 3	before takeoff checklist is complete.		
2018: 48 CAM- 1	thank you.		
2018: 49 CAM- 4	get right up in there.		
2018: 51 CAM	((sound of increasing engine noise)).		
2018: 59 CAM- 1	trim throttles.		
2019: 14 CAM- 2	eighty knots.		
2019: 23 CAM- 2	Vee one.		
2019: 35 CAM- 2	Vee R.		

INTRA- COCKPIT COMMUNICATION

TIME and SOURCE	CONTENT
2019: 41 CAM	((sound of two clicks)).
2019: 43 CAM- 1	gear up.
2019: 44 CAM- 2	gear up.

AIR- GROUND COMMUNICATION

TIME and SOURCE	CONTENT
2020: 00 TWR	TWA eight hundred heavy contact New York departure one three five point niner good evening.
2020: 05 RDO- 2	TWA's eight hundred heavy good night.
2020: 14 RDO- 2	Kennedy departure TWA's eight hundred heavy lifeguard leaving nine hundred climbing five thousand.
2020: 19 DEP	lifeguard TWA eight hundred heavy New York departure radar contact climb and maintain one one thousand.
2020: 24 RDO- 2	TWA's eight hundred heavy climb and maintain one one thousand.

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2020: 29 CAM- 1	climb to one one thousand and maintain.		
		2020: 44 DEP	TWA eight hundred heavy turn left heading one five zero.
2020: 47 CAM- 1	left to one five zero.		
		2020: 48 RDO- 2	TWA's eight hundred heavy turn left heading one five zero.
2020: 51 CAM- 1	flaps five.		
2020: 53 CAM- 2	flaps five.		
2021: 11 CAM- 1	flaps one.		
2021: 12 CAM- 2	flaps one.		
2021: 26 CAM- 1	flaps up.		
2021: 29 CAM- 2	say what?		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2021: 29 CAM- 1	flaps up.		
2021: 30 CAM- 2	flaps up.		
2021: 48 CAM- 1	climb thrust.		
		2022: 01 DEP	TWA lifeguard TWA eight hundred heavy turn left heading zero seven zero.
		2022: 07 RDO- 2	TWA's lifeguard eight hundred heavy turn left heading zero seven zero.
2022: 11 CAM- 1	left zero seven zero.		
		2022: 29 DEP	TWA eight hundred heavy or lifeguard TWA eight hundred heavy turn left heading zero five zero vector climbin' around traffic.
		2022: 35 RDO- 2	TWA's eight hundred heavy turn left heading zero five zero.

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2022: 41 CAM- 1	left zero five zero climb vector.		
		2022: 44 DEP	TWA eight hundred heavy the traffic in the turn will be three o'clock and five miles northeast bound four thousand nor- is a company seven two five five in trail will be a Saab-Fairchild when you're out of five I'll have on course.
		2022: 54 RDO- 2	TWA's eight hundred heavy understand.
2022: 58 CAM- 1	he's at three o'clock?		
2023: 00 CAM- 2	yeah.		
2023: 02 CAM- 2	that's the problem.		
		2023: 19 DEP	TWA eight hundred heavy direct Betty resume own navigation.
		2023: 22 RDO- 2	TWA's eight hundred heavy direct Betty own navigation.
2023: 26 CAM- 1	direct Betty and our own nav.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2019: 52 CAM- 1	that's alive.		
		2023: 37 DEP	TWA lifeguard TWA eight hundred heavy contact Boston one three two point three.
2023: 38 CAM- 2	huh.		
2023: 39 CAM- 1	direct Betty. correct?		
		2023: 42 RDO- 2	TWA's eight hundred heavy ah say again the frequency.
		2023: 44 DEP	one three two point three.
		2023: 46 RDO- 2	TWA's eight hundred heavy good day.
2024: 00 CAM- 1	*.		
2024: 01 CAM	((sound of noise of recording tape)).		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2024: 30 CAM- 1	seems like a home sick angel here (*/ awesome).		
2024: 36 CAM- 2	it's bleeding off airspeed that's why.		
2024: 38 CAM- 1	yeah *.		
		2024: 41.7 RDO- 2	New York center TWA's lifeguard eight hundred heavy eight thousand two hundred climbing one one thousand.
		2024: 48 CTR	TWA eight hundred Boston center roger climb and maintain one three thousand.
		2024: 53.4 RDO- 2	TWA's eight hundred heavy climb and maintain one three thousand.
2024: 57 CAM- 1	climb and maintain one three thousand.		
		2025: 31 CTR	TWA eight hundred what's your rate of climb?
		2025: 34.5 RDO- 2	TWA's eight hundred heavy ah about two thousand feet a minute here until accelerating out of ten thousand.

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2025: 41 CTR	roger sir climb and maintain flight level one niner zero and expedite through fifteen.
		2025: 47.1 RDO- 2	TWA's eight hundred heavy climb and maintain one niner zero and expedite through one five thousand.
2025: 53 CAM- 1	climb to one nine zero expedite through one five thousand.		
2025: 57 CAM- 3	pressurization checks.		
2025: 59 CAM- 3	(takeoff) thrust go on cross feed?		
2026: 02 CAM-?	ah.		
2026: 04 CAM- 1	yeah.		
2026: 07 CAM- 3	I'll leave that on for just a little bit.		
2026: 12 CAM- 3	is that right?		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2026: 13 CAM- 4	yes.		
		2026: 24 CTR	TWA eight hundred amend the altitude maintain ah one three thousand thirteen thousand only for now.
2026: 29 CAM- 1	thirteen thousand.		
		2026: 30.3 RDO- 2	TWA's eight hundred heavy okay stop climb at one three thousand.
2026: 35 CAM- 1	stop climb at one three thousand.		
2026: 51 CAM- 1	*.		
2026: 59 CAM- 2	twelve for thirteen.		
2027: 35 CAM	((sound of click)).		
2027: 47 CAM	((sound of altitude alert tone)).		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2028: 13 CTR	TWA eight hundred you have traffic at one o'clock and ah seven miles south bound a thousand foot above you he's ah Beech nineteen hundred.
		2028: 20.6 RDO- 2	TWA's ah eight hundred heavy ah no contact.
		2028: 22.5 RDO- 3	FIC TWA eight hundred.
		2028: 25 FIC	TWA eight hundred.
		2028: 25.7 RDO- 3	Eight hundred with an off report ah plane number one seven one one nine we're out at zero zero zero two, and we're off at zero zero one nine, fuel one seven nine decimal zero, estimating Charles De' Gaul at zero six two eight.
		2028: 42 FIC	TWA eight eight hundred got it all.
		2028: 44.8 RDO- 3	Thank you.
2029: 15 CAM- 1	look at that crazy fuel flow indicator there on number four.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2029: 23 CAM- 1	see that.		
2029: 35 CAM- 1	some where in here I better trim this thing (in/up).		
2029: 39 CAM- 2	huh?		
2029: 39 CAM- 1	some place in here I better find out where this thing's trimmed.		
		2030: 15 CTR	TWA eight hundred climb and maintain one five thousand.
2030: 18 CAM- 1	climb thrust.		
		2030: 19.2 RDO- 2	TWA's eight hundred heavy climb and maintain one five thousand leaving one three thousand.
2030: 24 CAM- 1	Ollie.		
2030: 24 CAM- 3	huh.		

INTRA- COCKPIT COMMUNICATION		AIR- GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2030: 25 CAM- 1	climb thrust.		
2030: 28 CAM- 1	climb to one five thousand.		
2030: 35 CAM- 3	power's set.		
2030: 42 CAM	((sound similar to a mechanical movement in cockpit))		
2031: 03 CAM	*.		
2031: 05 CAM	((sounds similar to recording tape damage noise)).		
2031: 12	end of recording.		

Appendix C
Search and Recovery Information

Search and Recovery

Agencies and companies with personnel and equipment that responded promptly to the accident and reported to the crash site and/or staging areas and/or provided long-term assistance during the search and recovery operation included most of the parties to the investigation and the following: Federal Bureau of Investigation (FBI);[662] Bureau of Alcohol, Tobacco, and Firearms; U.S. Coast Guard (USCG) (including its Underwater Search and Survey Divisions); U.S. Navy (and its contractor, Oceaneering Advanced Technologies, Inc., and subcontractor, Science Applications International Corporation); New York Air National Guard; New York State Army National Guard, 106th Air Rescue Wing; National Oceanic and Atmospheric Administration (NOAA); New York State Emergency Management Office; New York State Division of State Police; New York City Police and Fire Departments; Suffolk County Police and Sheriff's Departments, Medical Examiner, and Fire, Rescue, and Emergency Services; Nassau County Police Department; Southhampton Police Department; East Moriches Fire Department; and American Underwater Search and Survey Ltd.

During the first several hours after the accident, many private citizens and military and police personnel went to the crash site in boats to search for possible survivors.[663] The first responders reported that many pieces of wreckage (some quite large, including the right wing tip) were found floating in or near areas of fuel-fed fires, making recovery difficult. Although many first responders reported that they observed numerous pieces of wreckage sink beneath the water's surface, several pieces of wreckage were recovered from the water's surface during the 24-hour period after the accident.[664]

Because the Moriches Inlet was the closest inlet to the accident site (about 8 miles), throughout the night of July 17, boats traveled from the accident site to the USCG station at East Moriches, New York, with human remains and airplane debris. This station became the hub for staging and coordinating the search and recovery efforts almost immediately after the accident occurred. On July 18, 1996, the Safety Board, with other involved agencies, established a biohazard containment procedure for the search and recovery operation. The Suffolk County Medical Examiner established a temporary

[662] Because of the possibility that the TWA flight 800 accident was the result of a terrorist or criminal act, the FBI was involved in the investigation from July 17, 1996, until November 18, 1997, at which time, it determined that a terrorist or criminal act most likely did not cause the accident and withdrew from active involvement in the investigation.

[663] For additional information regarding the survival aspects of this accident, see section 1.15.

[664] The first responders' attempts to recover wreckage were limited by the presence of fuel-fed fires, the equipment available, and the size of some pieces of wreckage. For example, the crew of the USCG vessel *Juniper*, a 225-foot cutter/buoy tender, tried to recover the right wing tip, but the crane on board the boat was too short.

morgue at the East Moriches location.[665] A staging area for the ship-shore-hangar transfer of recovered airplane wreckage and debris was established at the USCG station at Shinnecock Inlet, New York (about 18 miles northeast of the debris fields).[666] Figures 21 and 22 in section 1.12 show the accident airplane's approximate flightpath, the Moriches and Shinnecock Inlets, and the three major identified debris fields.

On July 18, 1996, the Safety Board requested the U.S. Navy's assistance in the underwater search and recovery of the victims, the flight data recorder (FDR) and cockpit voice recorder (CVR), and the airplane wreckage.[667] Also on July 18, teams of scuba divers from state and local police departments began operations to recover victims and debris. SUPSALV coordinated with the NOAA vessel *Rude* (which arrived on scene on the night of the accident)[668] to use its side-scan sonar (SSS) to locate victims and wreckage on the ocean floor and to help target scuba divers' efforts until additional U.S. Navy personnel and equipment arrived. SUPSALV also contracted for the services of the commercial vessel *Pirouette*, which arrived on scene on the evening of July 19, 1996. On July 20, 1996, the *Pirouette* (supplied with U.S. Navy-owned equipment, including an SSS system, a towed-pinger locator, and a mini-remote operated vehicle [ROV]) joined the *Rude* in its efforts to locate victims and the FDR and CVR (which, as previously indicated, were recovered on July 24) and to map the underwater debris fields.

On July 21, the U.S. Navy's Explosive Ordnance Disposal and mobile diving units of the Atlantic Fleet arrived, providing additional scuba divers, surface support personnel, and the equipment and logistical support necessary for establishing a fully operational shore-based command, communication, and control center and dive station at the East Moriches location. The shore-based scuba diving operation used small watercraft to transport scuba divers from the U.S. Navy and local police departments between the shore-based dive station and the dive locations. Because this process was recognized as cumbersome and time-consuming (in part because of the distances involved), ocean-based diving stations were established when the necessary support equipment arrived at the site about a week after the accident.

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[665] A more permanent morgue operation was subsequently established at the Suffolk County Medical Examiner's Office in Hauppauge, New York.

[666] The Shinnecock Inlet location was chosen for transfer of recovered airplane wreckage and debris instead of the Moriches Inlet because the Shinnecock Inlet is wider and, thus, has significantly calmer water, facilitating the passage of boats loaded with wreckage.

[667] The Safety Board has had a memorandum of understanding with the U.S. Navy regarding wreckage recovery for many years and has requested the U.S. Navy's assistance during several investigations, including the United Airlines flight 811 accident on February 24, 1989, involving the in-flight separation of a cargo door on a Boeing 747-122 near Honolulu, Hawaii. Additionally, the U.S. Navy was involved in the search and recovery efforts for the Air India Airlines 747 that crashed in the Atlantic Ocean off the coast of Ireland in June 1985; the space shuttle Challenger in 1986; the South African Airways flight 295 747-200B airplane that crashed 130 miles northeast of Mauritius in November 1987; and the Birgenair 757 that crashed off the coast of the Dominican Republic in February 1996. U.S. Navy Supervisor of Salvage and Diving's (SUPSALV) testimony during the Board's December 1997 TWA flight 800 public hearing indicated that, on average, the U.S. Navy recovers about one military airplane from the ocean every 3 weeks.

[668] The *Rude* is an oceangoing research vessel that responded from Newport, Rhode Island, on the night of the accident to assist in the search for possible survivors and the early recovery efforts. The *Rude* continued to assist in search and recovery efforts until it departed the area on August 1, 1996.

By the end of July, two U.S. Navy salvage ships (the U.S.S. *Grasp* and U.S.S. *Grapple*) had reported to the accident site and were providing ocean-based stations for surface-supplied scuba diving and ROV operations. The U.S.S. *Grasp* was moored over the major area of airplane debris in the green zone, and the U.S.S. *Grapple* was moored over the major area of airplane debris in the yellow zone.[669] These ships were equipped with high-capacity cranes for lifting large pieces of debris from the water. Two U.S. Navy support vessels, the U.S.S. *Oak Hill* and U.S.S. *Trenton*, provided logistical support (berthing, dining, and medical) for scuba divers operating from the U.S.S. *Grapple* and U.S.S. *Grasp*, as well as a landing/docking area for the helicopters and amphibious watercraft engaged in the transportation of debris, personnel, and supplies. (Figure 47 shows a time line of salvage operation events, excerpted from the U.S. Navy's report.)[670]

Throughout most of the search and recovery operation, ROV, SSS, and laser line-scanning (LLS) equipment were used to search existing debris fields. This equipment was also used to explore areas outside existing debris fields that might contain victims and wreckage and to videotape the wreckage and ocean floor. Scuba divers and ROVs were used to systematically recover victims and wreckage.

Recovery Procedures

Small pieces of wreckage and debris were placed in bags and carried to the ocean surface by divers or placed in salvage baskets and lifted to the ocean surface by an amphibious tugboat or a salvage ship. (The ROVs performed some limited recovery tasks. The larger ROV could grip larger objects and perform some rigging tasks with its two sophisticated manipulator arms; however, the mini-ROVs could only retrieve small objects with their simple manipulators.) Larger items were rigged with lifting straps by divers and lifted by the tugboat (or, in the case of two very large pieces, the ship). Although some particularly small and/or potentially important pieces of wreckage were transported to shore by helicopter, most of the wreckage was transported to shore on the amphibious tugboats. Some very large pieces (including an 80-foot-long section of the right wing) had to be cut into smaller sections before they could fit on the amphibious tugs for the move to shore and in the trucks for the move to a storage/reconstruction facility. (The Safety Board leased a hangar at the former Grumman Aircraft facility in Calverton, New York, to be used for wreckage storage, examination, and reconstruction; this facility became the command center and headquarters for the investigation.)

[669] All other scuba diving (red zone and other areas of debris) was accomplished by mobile scuba diving teams operating from small boats.

[670] U.S. Navy. 1998. *U.S. Navy Salvage Report TWA Flight 800.* Report S0300-BZ-RPT-010, 0910-LP-015-6130.

FLIGHT 800 SALVAGE OPERATIONS TIME LINE OF EVENTS

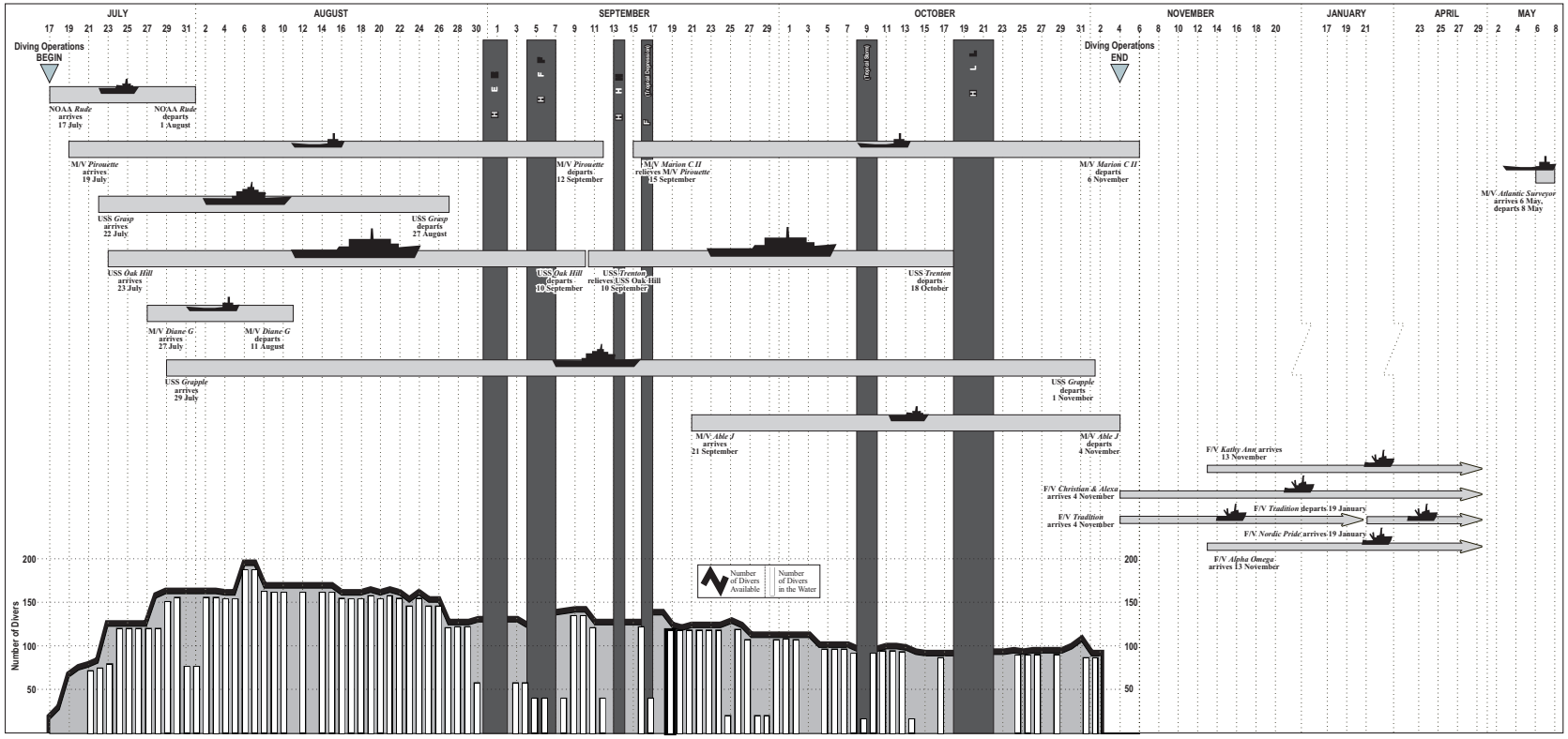

Figure 47. A time line of salvage operation events.

When the amphibious tugboats arrived at Shinnecock Inlet with wreckage, New York State Army National Guard and/or local police personnel used a mobile crane to transfer wreckage from the tugboats to 18-wheeled open bed trucks, which then transported the wreckage to the hangar at Calverton.[671] Safety Board and FBI personnel were present to observe all wreckage transfers to preserve the evidentiary value of the wreckage. Also, to ensure that wreckage recovery locations were accurately tracked, the amphibious tugboats and trucks/trailers were searched for any dropped debris after each trip.

U.S. Navy Salvage Report Information

The U.S. Navy's report, which documented the TWA flight 800 search and recovery efforts, indicated that the search and recovery operation occurred in the following three phases: (1) a period of intense activity, from July 17 to the end of August 1996; (2) a period of sustained effort, from September 1 to November 2, 1996; and (3) trawling operations, from November 4, 1996, to April 28, 1997.

According to the U.S. Navy report, the period of intense activity primarily involved recovering victims and those pieces of the airplane seen as critical to the investigation. These efforts included a thorough mapping of the debris on the ocean floor and required the almost continual use of ROVs, SSS, LLS equipment, and scuba divers. During the month of August, an average of 153 divers were available; on 26 days in August, all available divers were used. By the end of August, 211 victims had been recovered and identified. According to the U.S. Navy report, "two events marked the end of the period of intense activity and the beginning of the period of sustained effort. The first was the [August 27] departure…of the *Grasp* and the 25 divers that she carried. The second was the occurrence of heavy weather, much of it the result of Atlantic hurricanes, that made diving operations impossible on more than half of the days in September."[672]

The period of sustained effort involved the continued use of ROVs, SSS, LLS equipment, and scuba divers to recover the remaining victims and as much of the airplane as possible. In part because of inclement weather, the pace of the recovery operations moderated during this period. High swells and currents from Hurricane Edouard and other storms that affected the area during these months caused significant shifting of the wreckage and sand, requiring debris fields to be remapped. According to the U.S. Navy report, the period of sustained effort was "characterized by the steady and thorough exploitation of the debris fields. [SSS] was used to expand existing debris fields, make more detailed searches of existing debris fields, and explore areas that might contain debris. Divers and ROVs were used to systematically remove all of the debris from one

[671] The New York State Army National Guard provided 12 tractors and 10 trailers to transport wreckage to the hangar at Calverton.

[672] With the onset of autumn, severe weather became an increasingly significant operational factor in the search and recovery efforts. Five major storm systems affected the search and recovery operations in varying degrees: Hurricane Edouard (August 19 to September 3), Hurricane Fran (August 23 to September 8), Hurricane Hortense (September 3 to 16), Hurricane Josephine (October 4 to 8), and Hurricane Lili (October 14 to 27).

debris field before moving on to the next." The last search and recovery-related SSS and scuba diving operations occurred on October 13 and November 2, respectively. By November 2, about 95 percent of the airplane wreckage had been recovered.

At the Safety Board's request, the U.S. Navy proposed many options for the third phase of the recovery operation.[673] After reviewing the options, the Board chose trawling for the third phase because it provided an optimal combination of expected effectiveness, cost, environmental impact, and suitability for winter operations. Trawling operations involved the use of five commercial trawlers, under contract to the U.S. Navy, to scrape up layers of silt to recover pieces of wreckage that had become embedded in the ocean floor. Trawl lines several miles long were carefully laid out to cover the entire area being trawled, criss-crossing the debris fields, and the Board monitored and prioritized the trawling areas carefully. The scallop trawlers then moved along the trawl lines at 2 to 3 knots, towing 15-foot-wide nets on each side of the ship. After the trawler completed each pass along a trawl line, the nets were brought aboard and emptied; all natural materials were discarded; and all man-made objects were retained, documented, and transported to shore on small boats. Successive trawler sweeps were made to cover the gap between the two nets, and each area was reswept until no new material was recovered (some lines in the red zone were swept more than 10 times). When material recovered by the trawlers reached shore, it was examined by Safety Board personnel, who separated the airplane debris from other objects.

The trawling operation was complicated by the presence of a submerged trans-Atlantic telephone cable inside the northern boundary of the trawling area. To avoid snagging or otherwise damaging the telephone cable, the commercial scallop trawlers did not trawl within 200 yards of the cable; however, the area within 200 yards of the cable was thoroughly inspected and documented by an AT&T ROV and was declared clear of airplane debris.

Trawling operations ended on April 28, 1997, because successive trawling sweeps turned up no additional debris. Between April 30 and May 18, 1997, a U.S. Navy ROV was used to make a final inspection of the wreckage recovery area. The ROV made 85 dives after the trawling operations ceased, locating only one small piece of additional wreckage; therefore (with the concurrence of the Safety Board and the FBI), trawling and other search and recovery efforts were formally terminated on May 18, 1997. The trawling operation recovered pieces of the airplane that amounted to about 1 to 2 percent of its structure.

[673] Proposed options for the third phase of the recovery operation included trawling, the development of a rake attachment for ROVs, the use of a suction dredge, lift excavation, and the continued employment of scuba divers.