PART B — OPERATIONS INVESTIGATION

CHAPTER II

FLIGHT OPERATIONS

1. Flight Planning and Dispatching

The operations investigation may be started in any particular area, however, sooner or later the investigation must turn to the activities which took place prior to the flight. The accident which occurs on the planned route of flight presents one set of investigative problems, while the accident occurring far from the intended track presents another. The well-planned flight ending in an accident calls for different thinking than a spur-of-the-moment flight which crashes shortly after takeoff.

1.1. Regulatory Requirements, FAR's 23, 25, 91, 121, and 135

At the start of the operations investigation it is well to review the *current* Federal Aviation Regulations to determine what actions should have been taken in preparation for flight.

Some of the regulations which you will need to review are the Airworthiness Standards, **Part 23**, for small airplanes, and **Part 25** for transport category airplanes; **Part 91**, General Operating and Flight Rules; **Part 121**, Certification and Operations, Air Carriers and Commercial Operators of Large Aircraft; and **Part 135**, Air Taxi Operators and Commercial Operators of Small Aircraft.

In the Airworthiness Regulations emphasis is focused on the section on operating limitations and information. This section prescribes the information which must be furnished by the manufacturer to the crew for use in planning the flight. For light aircraft over 6000 lbs. and all large aircraft the information will be furnished in an airplane flight manual.

Part 91 outlines the general rules pertaining to flight planning and inflight operations. **Parts 121** and **135** contain further requirements for operations conducted within the scope of these regulations. These regulations are changed from time to time, therefore, ascertain which regulations were in effect at the time of the accident and/or the certification.

1.2. Sources — Air Carrier and Commercial Operators

The sources of flight-planning information available to the investigator and the procedures used to obtain the required data vary greatly between the air carrier and the general aviation accident investigation. For this reason, these types of investigations will be examined separately. The investigation, no matter what type of accident, has the same objective — *a complete well-documented examination of all aspects involved.*

1.2.1. Flight Manuals

In many respects, the investigation of the air carrier or commercial operator accident is easier to conduct than a general aviation accident investigation. The carrier is required to keep copies of all information used in planning and dispatching the flight. In addition, the operator is required to maintain manuals for the use and guidance of flight and ground personnel in conducting their operations. Information is available from these manuals concerning duties and responsibilities of crew members, flight dispatch, operational control, weight and balance procedures, pilot qualifications, and dispatcher qualifications. These books can save many hours of effort to determine *how* and *what* should have been accomplished by *whom* prior to the flight. These manuals and the airplane flight manual, required by FAR's, should provide necessary data for verifying the preflight computations.

1.2.2. Dispatch and Flight Release

The dispatch release used by the scheduled air carrier or the flight release used by the supplemental air carrier can be a valuable source of information to the investigator. These forms will have the identification of the aircraft, trip number, departure point, intermediate stops, destination and alternate airport, type of operation (VFR-IFR), minimum fuel and weather information (weather reports, forecasts, etc.) for the destination, intermediate, and alternate airports.

1.2.3. Flight Plan (Fig. B II-1, 1a)

A flight plan must be filed for all VFR and IFR flights by scheduled and supplemental air carriers. One copy of the flight plan is retained in the files and one copy is carried aboard the aircraft to the destination. This form will furnish information on time en route between check points, time to climb, and other data on the progress of the flight. The copy on board the aircraft often will have notations penciled in by the flight crew.

1.2.4. Load Manifest

A load manifest will be prepared prior to each departure. This manifest will furnish information concerning takeoff weight of the aircraft, maximum allowable weight for the flight, and center of gravity information to assure that the aircraft is properly loaded. In the case of the supplemental carrier, the names of the passengers will be included in the load manifest.

1.2.5. Company Records

Copies of all the documents listed above will be retained in the files of the operator. The scheduled air carrier will retain these items for at least three months, while the supplemental carrier or commercial operator is required to retain the files for at least six months.

1.2.6. FAA, ACDO, GADO, ARTC, FSS, etc.

Additional information concerning the operations of a particular operator may be obtained from the FAA Air Carrier District Office or the General Aviation District Office concerned with the operation involved. Information concerning flight planning, briefing, flight plans, etc., may also be obtained from the Flight Service Station or the control tower which handled the flight. En route traffic control agencies will be able to furnish information regarding the progress of the flight along the planned route.

1.2.7. Flight Support Documents

For the flight planning to be correct and complete, it is necessary that the planner be furnished with adequate flight support documents and data. Determine whether current charts and checklists were available and that the material available was compatible with the operation being planned. A VOR/DME chart is of little use in planning a flight in an ADF-equipped airplane.

One item which will be checked most often is the instrument approach procedure chart. This item is a graphic representation of an approach procedure outlined on an FAA Form 8260-5. The investigator should obtain a copy of the current 8260-5 and insure that the data on the approach chart is accurate. Several sources print and distribute approach charts. Each of these depicts the information in a slightly different manner, but they should agree with the current 8260-5 Form. (**Fig. B II-1b, c, d**)

1.2.8 Airport Data

Consider the suitability of the airport facilities in the event an accident occurs on or near the airport. Charts of the physical layout are available from the airport manager or the FAA Airport Engineers Service. In addition to the general plan of the facility, consider the gradient of the runway, overruns, approach zones, lighting systems, navigational and approach facilities, crash and rescue capability, snow removal, drainage, etc. Poor airport design and maintenance have contributed to many aircraft accidents.

1.3. Sources — General Aviation

The general aviation pilot is required by the regulations to familiarize himself with all avail-

FEDERAL AVIATION AGENCY

FLIGHT PLAN

Form Approved.
Budget Bureau No. 04-R072.3

1. TYPE OF FLIGHT PLAN: ☐ FVFR ☐ VFR ☐ IFR ☐ DVFR	2. AIRCRAFT IDENTIFICATION	
3. AIRCRAFT TYPE/SPECIAL EQUIPMENT 1/	4. TRUE AIRSPEED — KNOTS	5. POINT OF DEPARTURE
6. DEPARTURE TIME — PROPOSED (Z) / ACTUAL (Z)	7. INITIAL CRUISING ALTITUDE	
8. ROUTE OF FLIGHT		
9. DESTINATION *(Name of airport and city)*	10. REMARKS	
11. ESTIMATED TIME EN ROUTE — HOURS / MINUTES	12. FUEL ON BOARD — HOURS / MINUTES	13. ALTERNATE AIRPORT(S)
14. PILOT'S NAME		
15. PILOT'S ADDRESS AND TELEPHONE NO. OR AIRCRAFT HOME BASE	16. NO. OF PERSONS ABOARD	17. COLOR OF AIRCRAFT
18. FLIGHT WATCH STATIONS		

CLOSE FLIGHT PLAN UPON ARRIVAL

1/ SPECIAL EQUIPMENT SUFFIX
A — DME & 4096 Code transponder
B — DME & 64 Code transponder
D — DME
L — DME & transponder—no code
T — 64 Code transponder
U — 4096 Code transponder
X — Transponder—no code

FAA Form 7233—1 (4-66) FORMERLY FAA 398

0052-027-8000

Figure B II-1

SCALE 1:1,000,000 — WORLD AERONAUTICAL CHARTS — Nautical Miles / Statute Miles

PILOT'S PREFLIGHT CHECK LIST

DATE

	WEATHER ADVISORIES		ALTERNATE WEATHER		NOTAMS
	EN ROUTE WEATHER		FORECASTS		AIRSPACE RESTRICTIONS
	DESTINATION WEATHER		WINDS ALOFT		MAPS

FLIGHT LOG

DEPARTURE POINT	VOR IDENT. / FREQ.	RADIAL TO / FROM	DISTANCE LEG / REMAINING	TIME PT-TO-PT / CUMULATIVE	TIME TAKEOFF	GROUND SPEED
CHECK POINT					ETA / ATA	
DESTINATION			TOTAL			

POSITION REPORT: FVFR report hourly, IFR as required by ATC

ACFT. IDENT.	POSITION	TIME	ALT.	IFR/VFR	EST. NEXT FIX	NAME OF SUCCEEDING FIX	PIREPS

REPORT CONDITIONS ALOFT—
CLOUD TOPS, BASES, LAYERS, VISIBILITY, TURBULENCE, HAZE, ICE, THUNDERSTORMS

CLOSE FLIGHT PLAN UPON ARRIVAL

SECTIONAL AERONAUTICAL CHARTS — SCALE 1:500,000 — Nautical Miles / Statute Miles

Figure B II-1a

Reports Identification Symbol: FS 8260-1

STANDARD INSTRUMENT APPROACH PROCEDURE – TRANSMITTAL SHEET

TYPE PROCEDURE: VOR | FAA REGION: Mid States

TERMINAL ROUTES				MISSED APPROACH
FROM	TO	VIA	MINIMUM ALTITUDES	MAP 2.3 miles after passing SVG VORTAC
Center NDB	Woody VOR	Direct	2700'	Climb to 2500' left to R-006 to New Baltimore Intersection and hold.
Woody VOR	SVG VORTAC	Direct	2400'	
New Baltimore Int.	SVG VORTAC	Direct	2400'	Supplementary Charting Information
				Final approach course crosses intersection of runway 36 and 27L.
				TV tower 2.5 NM NE of airport 1260'.

1A. PROCEDURE TURN EAST SIDE OF CRS 223 OUTBND 043 INBND 2400' FT. WITHIN 10 MI. OF SVG VORTAC

1B.

2. FAF SVG VORTAC . FINAL APPROACH COURSE 043 . DISTANCE FAF TO MAP 2.3 (Nonprecision) .

3. SVG VORTAC 1500 feet

4. MINIMUM GS INTERCEPTION ALTITUDE ____ . GS ALTITUDE AT OM ____ MM ____ IM ____

5. DISTANCE TO RUNWAY THRESHOLD AT: OM ____ MM ____ IM ____

6. MSA 000-090 2800; 090-360 2300

PROCEDURAL DATA/NOTES

CITY AND STATE	AIRPORT AND ELEVATION	FAC. IDENT.	PRO. NO. AND EFFECTIVE DATE	SUP. AMDT. DATED
Calverton, Ohio	Colesville 890'	SVG	VOR-1	#4 4/13/69

FAA Form 8260-5 (10-67) SUPERSEDES PREVIOUS EDITIONS

Figure B II-1b

DAY AND NIGHT MINIMUMS

COND.	A MDA	A VIS	A HAA	B MDA	B VIS	B HAA	C MDA	C VIS	C HAA	D MDA	D VIS	D HAA
C	1300	1	410	1340	1	450	1340	1½	450	1560	2	670

A	Standard	T 2 ENG OR LESS	Standard all rwys.	T OVER 2 ENG	Standard all rwys.

FLIGHT CHECKED BY Lyndon M. Holtz — DATE 4/1/00

ALL AFFECTED PROCEDURES REVIEWED [X] YES [ ] NO — PART 97.FAR [X] YES [ ] NO

REQUIRED EFFECTIVE DATE 6/27/00

COORDINATED WITH [X] AT [X] ALPA [ ] NBAA [X] ATA [X] AOPA [ ] APA — OTHER

COORDINATES OF FACILITIES Woody NDB 39o 02' 27.02" 85° 01'46.01"

RECOMMENDED BY W. T. Door, Procedures Specialist

APPROVED BY J. T. Doe — CHIEF, CLT FIDO

CHANGES

1. Add terminal route from Center NDB to Woody NDB.
2. Add terminal route route from Woody NDB to final approach course.

REASONS

1. Revised inbound routing from the NE.
2. Same

Figure B II-1c

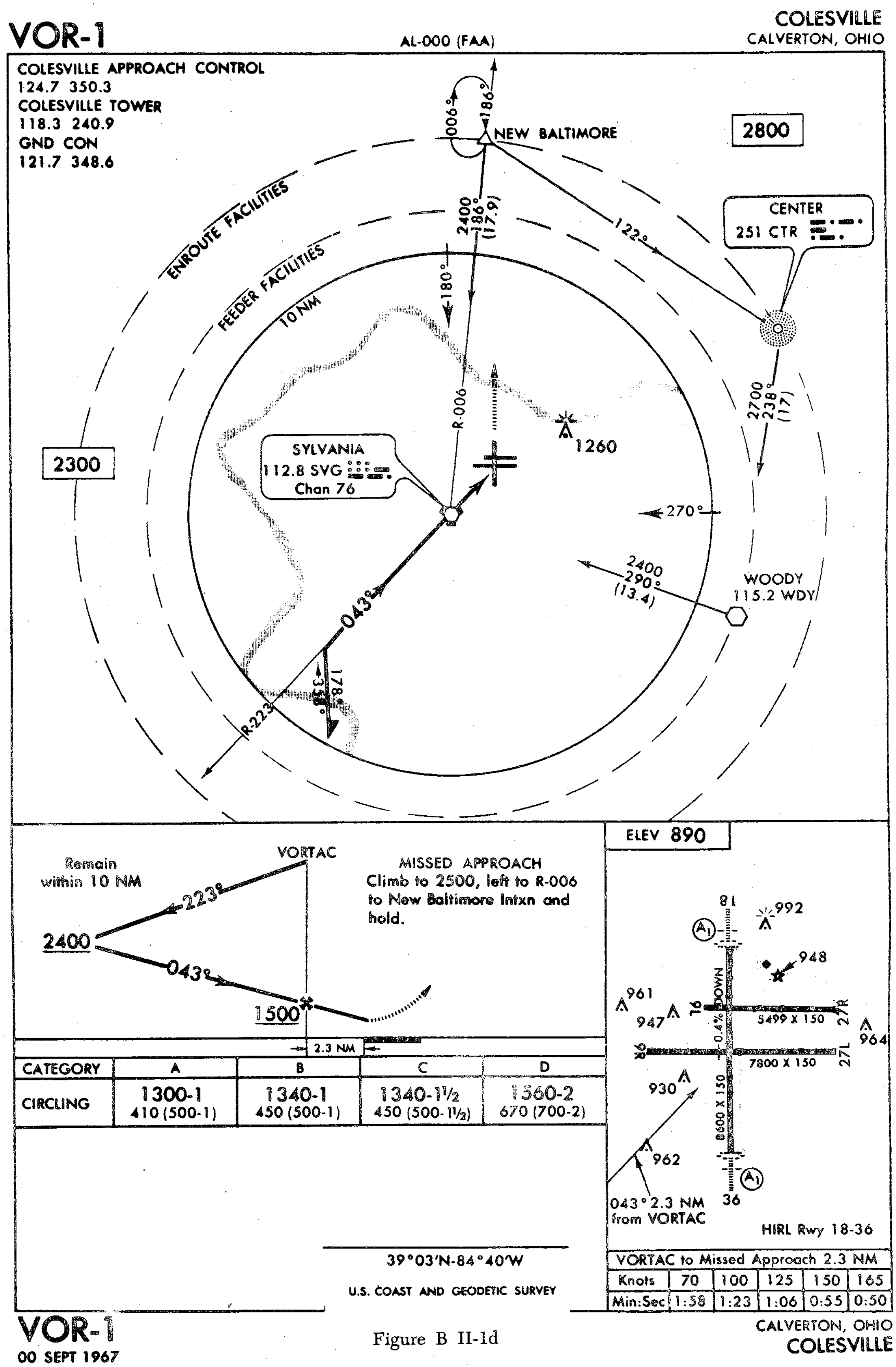


Figure B II-1d

able information concerning the flight he is about to undertake. For flights outside the local area, this information will include available weather reports and forecasts, fuel requirements, and alternate action to be followed if the planned flight cannot be completed. Compliance with this directive will result in adequate flight planning. It will require ingenuity in many investigations to determine how this requirement was carried out and what preflight planning was accomplished.

1.3.1. Flight Manual or Owner's Manual

The manufacturers of small aircraft (12,500 lbs. or under, maximum certificated takeoff weight) must provide certain information for the use of the operator. In the case of an aircraft of 6,000 lbs or less, MCTW, this information may be furnished in the form of an airplane flight manual, or a combination of manuals, markings, and placards. The form in which the manufacturer elects to furnish the information will be indicated in the FAA Aircraft Specification or Data Sheet. The information to be furnished will consist of operations limitations, operating procedures, performance information, and loading information. In addition to the airplane flight manual, which is an FAA-approved document, the manufacturer will probably furnish an owner's manual with the aircraft. The information contained in the owner's manual is not FAA approved. It will most likely reflect information based on maximum performance of the aircraft, at sea level on a standard day, not the performance which an average pilot in an average airplane can expect.

1.3.2. Flight Plan

All pilots are encouraged to file flight plans for all flights, however, a flight plan is required only for IFR and some special flights. In practice, you will find that the general aviation pilots file a flight plan for a very small percentage of their flights. The fact that a flight plan is not filed does not necessarily mean that the pilot did no planning. A search of the wreckage will often reveal some information as to the route of flight, time over fixes, etc. This information quite often will be on a plain sheet of paper rather than on some preprinted form, therefore, a close examination of all papers is necessary.

1.3.3. Airport Personnel

Many times the only available information concerning flight planning, destination, departure time, fuel on board, etc., will be obtained from personnel at the departure airport. The office staff, line personnel, and other pilots should be contacted. Even the smallest observation may be of great value in piecing together the purpose and route of the flight.

1.3.4. FAA, GADO, FSS, Tower, etc.

Personnel of the FAA may be able to give valuable assistance in the investigation. The General Aviation District Office personnel serving the area where the accident occurred or where the flight originated will be familiar with the operators in their area, and they may be able to obtain background information on the pilot through these sources. The Flight Service Stations will have a record of any contacts with the pilot and will conduct a communications search upon request. The FSS may be able to furnish information about the pilot's habits regarding flight planning, weather briefing, etc. If the flight originated at or near a controlled airport, the control tower may have been contacted by the pilot. Communications with most control towers will be available on recorder tapes. Contacts with most FSS stations are not tape recorded, therefore, early contact with the personnel on duty is a must if the greatest recall of the circumstances is to be achieved.

1.3.5. Flight Support Documents

The flight support documents available to the general aviation pilot will range from the most complete down to a road map obtained from the local gas station. Some airport operators furnish excellent facilities for flight planning. Other small airports may have no facilities at all. The search of the wreckage will reveal what documents were available in flight. These must be compared with the equipment in the aircraft to determine their suitability.

2. Weight and Balance

Weight and balance are important to the accident investigator in two ways. They affect the performance of the aircraft because improperly balanced or overloaded aircraft will require larger power outputs and fuel consumption to attain the desired results. In addition, they affect the stability and controllability of the aircraft. It is possible to load an aircraft in such a way that it is uncontrollable upon becoming airborne or after the loss of an engine. Such a loading is possible at a weight which is within the authorized limits for the aircraft.

2.1. Computation of Weight and Balance

It is the responsibility of the investigator to verify the weight and balance of the aircraft at the time of the accident. The computation of weight and balance is a mathematical process used to see if the aircraft was loaded to conform to the parameters established for the particular aircraft.

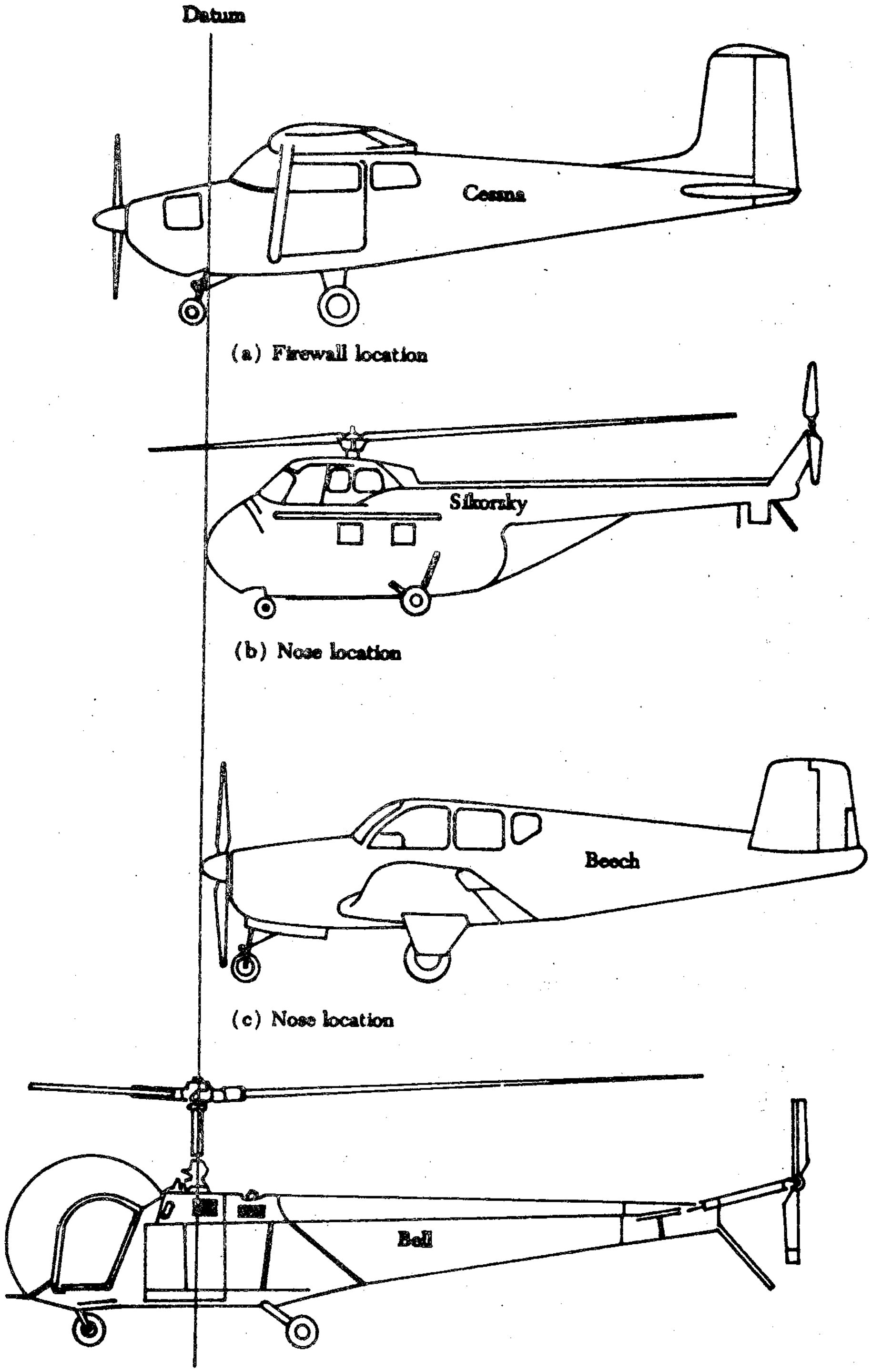
In computing weight and balance, a few terms are used which need defining. The **DATUM** is the reference point from which distance measurements are taken to various objects located in the aircraft. This point has no standard location but is established for the particular aircraft by the manufacturer. (**Fig. B II-2**) The datum location may be found in the Aircraft Specification or Data Sheet. The **ARM** (or moment arm) is the horizontal distance in inches from the datum to the center of gravity of any item in the aircraft. It is preceded by a plus (+) sign to indicate distance aft of the datum and a minus (−) sign for distance forward of the datum. The **MOMENT** is the product of a weight multiplied by its arm. The **CENTER OF GRAVITY (C.G.)** is the point about which the nose-heavy and tail-heavy moments are equal. The **CENTER OF GRAVITY RANGE** is the distance between the most forward allowable c.g. and the most rearward allowable c.g. for the particular aircraft. This distance may be expressed in inches from the datum or in percent of the mean aerodynamic chord. **MEAN AERODYNAMIC CHORD (MAC)** is the chord of a rectangular airfoil that would have the same pitching moments as the actual airfoil involved. Due to its constant dimensions, the MAC is much easier to work with than the actual airfoil. The MAC can be assigned station numbers for its leading and trailing edges. All calculations and measurements can be referenced from these points. The MAC location and dimensions may be found in the Aircraft Specifications, Aircraft Flight Manual, or the aircraft weight and balance report. **EMPTY WEIGHT** is the weight of the aircraft including all installed equipment, fixed ballast, hydraulic fluid, and undrainable fuel and oil. **MAXIMUM WEIGHT** is the maximum authorized loaded weight of the aircraft as listed in the Aircraft Specifications. **USEFUL LOAD** is the empty weight subtracted from the maximum weight.

Methods of computing the aircraft empty weight and center of gravity are shown in **Fig. B II-3, 3a.**

A typical problem which might be encountered would be an aircraft having a maximum allowable weight of 1775 lbs. and allowable c.g. range of +9.0″ to +18.1″. Investigation revealed that the aircraft had an empty weight of 950 lbs. and an empty c.g. of +12.3″. At the time of the accident the aircraft had on board, oil, 15 lbs. at −41″; a pilot, 170 lbs. at +6″; fuel, 50 lbs. at +23″. Computation of the weight and balance at the time of the accident would be as follows:

Item	Weight	Arm	Moment
Aircraft empty weight	950	+12.3″	+11,685
Oil	15	−41	− 615
Pilot	170	+ 6	+ 1,020
Fuel	50	+23	+ 1,150
	1,185		+13,240

$$\text{C.G.} = \frac{\text{Total moments}}{\text{Total weight}} \qquad \text{C.G.} = \frac{13{,}240}{1{,}185} = +11.17''$$



(a) Firewall location

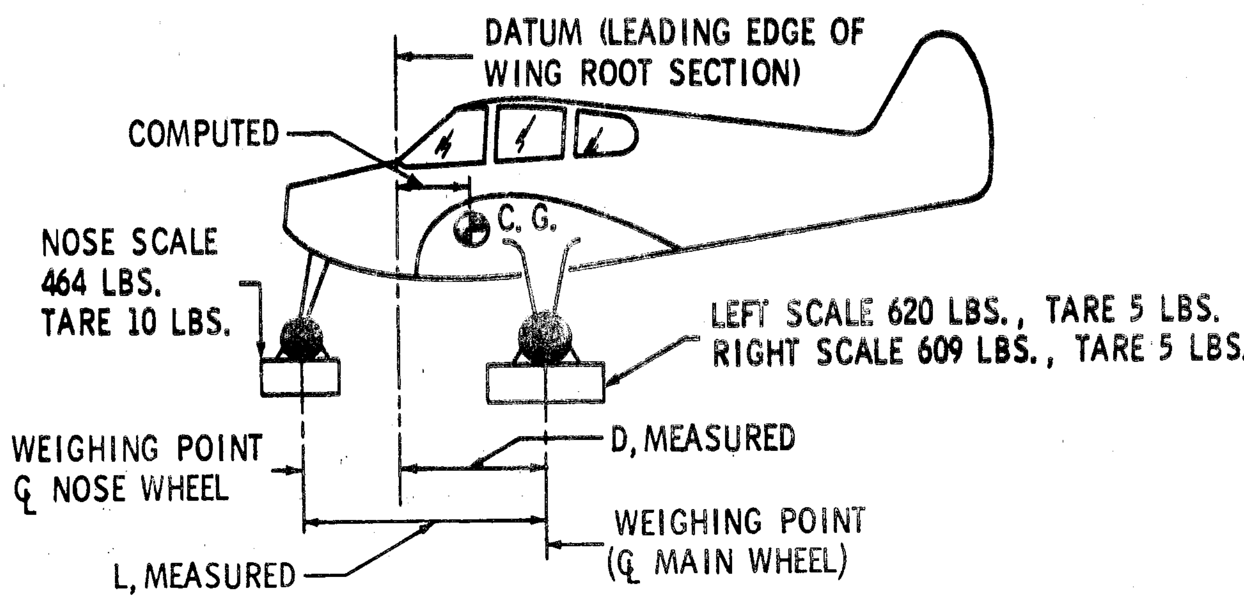
(b) Nose location

(c) Nose location

(d) Center line of rotation location

The datum may be at any location. This figure shows various datum locations, as used by some manufacturers.

Figure B II-2



TO FIND: EMPTY WEIGHT AND EMPTY WEIGHT CENTER OF GRAVITY

Datum is the leading edge of the wing (from aircraft specification).

(D) Actual measured horizontal distance from the main wheel weight point (C_L main wheel) to the datum.........34.0″

(L) Actual measured horizontal distance from the front wheel weighing point (C_L front wheel) to the main wheel weighing point ....67.8″

SOLVING: EMPTY WEIGHT

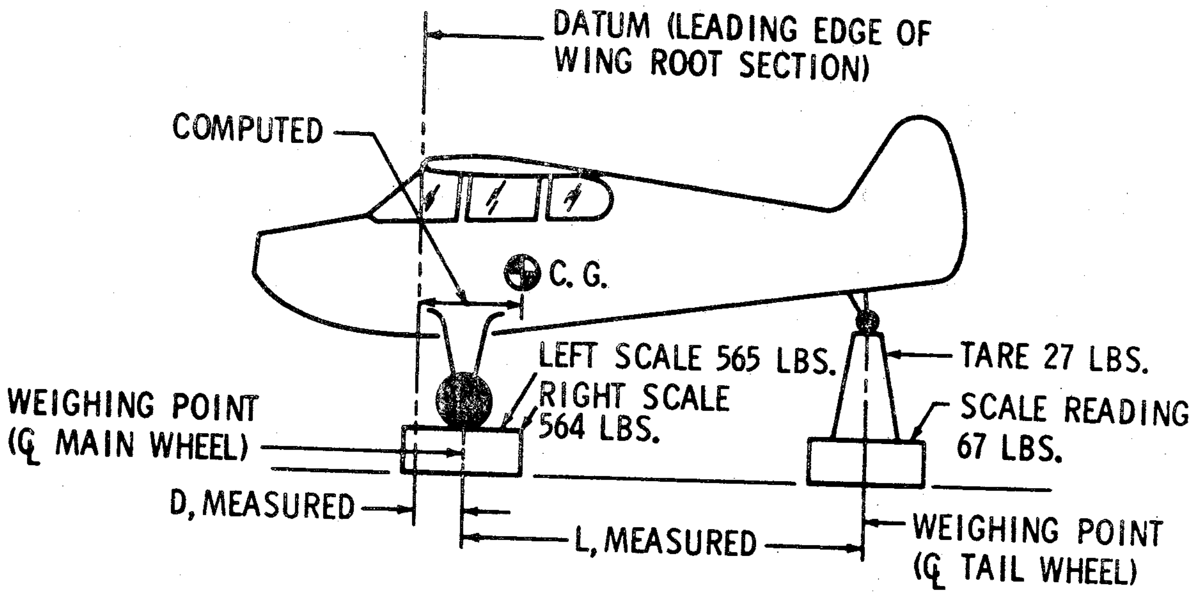
Weighing Point	Scale Reading #	Tare #	Net Weight
Right	609	5	604
Left	620	5	615
Front	464	10	454
Empty Weight (W)			1673

SOLVING: EMPTY WEIGHT CENTER OF GRAVITY

Formula: $C.G. = D - \frac{F \times L}{W} = 34'' - \frac{454 \times 67.8}{1673} = 34'' - 18.3'' = 15.7''$

—Empty weight and empty weight center of gravity — nosewheel type aircraft.

Figure B II-3



TO FIND: EMPTY WEIGHT AND EMPTY WEIGHT CENTER OF GRAVITY

Datum is the leading edge of the wing (from aircraft specification)

(D) Actual measured horizontal distance from the main wheel weight point C_L main wheel) to the datum .... 3″

(L) Actual measured horizontal distance from the rear wheel weighing point (C_L rear wheel) to the main wheel weighing point .... 222″

SOLVING: EMPTY WEIGHT

Weighing Point	Scale Reading #	Tare #	Net Weight #
Right	564	0	564
Left	565	0	565
Rear	67	27	40
Empty Weight (W)			1169

SOLVING: EMPTY WEIGHT CENTER OF GRAVITY

Formula: $$C.G. = D + \frac{R \times L}{W} = 3'' + \frac{40 \times 222}{1169} = 3'' + 7.6'' = 10.6''$$

—Empty weight and empty weight center of gravity —tailwheel type aircraft.

Figure B II-3a

AIRCRAFT SPECIFICATIONS NO. A-780

Manufacturer	Piper Aircraft Corporation Lock Haven, Pennsylvania

1 – Model PA-12; 3 PCLM (Normal Category), 2 PCLM (Utility Category); Approved March 24, 1947

Engine	Lycoming 0-235-C (See also Item 103 for optional engine.)		
Fuel	73 min. octane aviation gasoline		
Engine limits	For all operations, 2600 rpm (100 hp)		
Airspeed limits	Maneuvering	94 mph (82 knots) True Ind.	
	Cruising	110 mph (96 knots) True Ind.	
	Never exceed (Normal)	138 mph (120 knots) True Ind.	
	(Utility)	148 mph (129 knots) True Ind.	
C. G. range	(+9.0) to (+18.6)		
Empty weight C. G. range	(+9.5) to (+13.3). When empty weight C. G. falls within this range, computation of critical fore and aft C. G. positions is unnecessary. Range is not valid for nonstandard arrangements.		
Maximum weight	Normal – 1750 lbs. Utility – 1500 lbs.		
No. seats	3 (One at +6 and two at +34). Only one person permitted in rear seat when operating in utility category.		
Maximum baggage	41 lbs. (+56)		
Fuel capacity	38 gals. (+23) one 19 gal. tank in each wing.		
Oil capacity	6 quarts (–41)		
Control surface movements	Elevators	27° up	32° down
	Rudder	20° left	20° right
	Aileron	31° up	25° down
	Stabilizer	1°15′ up	5°30′ down
Serial Nos. eligible	12-1 and up		
Required equipment	Landplane – Items 1(a), 101, 102, 201(a),202(a) and 401(a).		

Specifications Pertinent to All Models

Datum	Leading edge of wing
Leveling means	Plumb bob from machine screw at door frame channels near upper rear corner of door to hole in plate near rear seat.
Certification basis	Type Certificate No. 780 (CAR 3)

Excerpts (portion) of FAA airplane specifications pertinent to weight and balance for a particular make and model airplane.

Figure B II-4

Computations for larger aircraft or aircraft with complicated loading schedules will be more detailed but will follow the same general procedure. The use of C.G. computers will simplify the operation and obtain the same results.

2.2. Sources of Weight and Balance Data for Specific Aircraft

When computing the weight and balance data it will be necessary to know the allowable limits for the aircraft involved as well as the empty weight information. This information may be available from one or more of the following sources.

2.2.1. Aircraft Specifications or Type Certificate Data Sheets

These documents published by the FAA include weight and balance data for all certificated aircraft in the normal or utility category. The Aircraft Specification contains considerably more information than the Data Sheet regarding optional equipment, however, both have information concerning the weight and balance limits for the particular model aircraft involved. (Fig. B II-4)

2.2.2. Aircraft Records

The current weight and balance data is required in the aircraft records and shall be carried aboard the aircraft during flight. These records should reflect any changes in weight and balance through modification or alteration of the aircraft.

2.2.3. FAA Records

The FAA Aircraft Registration Branch may have weight and balance information which was forwarded with other records for filing.

2.3. Supplemental Type Certificates

Modifications to civil aircraft are made under supplemental type certificates. Before a supplemental type certificate is issued, the applicant for the certificate must show that the altered aircraft meets the applicable airworthiness requirements. This does not necessarily mean that all aircraft modified under the STC, at a later date, will meet these requirements. Instructions and drawings may be misinterpreted. Weight and balance problems have been listed as causal factors in several accidents involving modified aircraft. These modifications have included installation of extra fuel tanks or seats, and changes to the horizontal stabilizer or elevator system. Review the weight and balance records as well as the actual modification to the aircraft to assure that the alteration was in accordance with the approved STC. Modifications to light aircraft which involve adding weight can be critical. Some of these airplanes, as originally certificated, cannot operate within the weight and balance limits when carrying a full load of passengers and full fuel tanks.

3. Crew History

A reconstruction of the physical, mental, and technical capabilities of the crew is a necessary part of the investigation. Statistically, it has been shown that crew factors are involved in the causal area of more than half of all aircraft accidents. These statistics should not be allowed to influence the completeness of the investigation to determine the proper probable cause. The investigation becomes part of the statistics; be sure the statistics are valid.

3.1. Crew Causal Factors

The ways in which the crew can become a causal factor range from the student pilot who ground loops in a crosswind to the experienced crew member who suffers a coronary attack. The NTSB categorizes over forty personnel causal factors involving crew members. This alone would necessitate a thorough investigation even if crew factor was known as the cause at the start of the investigation.

3.1.1. Certification and/or Qualification

Certification does not automatically qualify a crew member to cope with every possible situation which may be encountered, nor does the lack of certification automatically assure that the necessary qualification does not exist. The investigation should logically include both the certification status and qualifications of the crew. In order to obtain a certificate, the crew member must be able to perform certain tasks with an acceptable level of skill, thus, determination of what certificates the individual held will give a starting place for further investigation. From this point, determine what the individual did to maintain or increase his level of skill. The discovery that the crew member had qualifications far beyond his certificates could give a lead to an attitude which might explain the accident. In the same manner, the fact that the crew member allowed his skill to deteriorate since being certificated could clarify a simple situation which was allowed to develop into an accident.

3.1.2. Flight Checks

Actual flight checks may be flown with the FAA or company check pilots. Records of these checks will reveal the areas covered during the check flight. A correlation between the flight check conditions and the conditions at the time of the accident should be established. A weakness on the flight check may give a lead to the accident cause.

3.1.3. Physical Qualifications

The FAA maintains records of the periodic physical examinations which all crew members are required to take. Disqualifying medical conditions should not be found on the medical records. However, it is possible that information will be obtained regarding the requirement for glasses to correct some defect of vision. A failure to locate these glasses in the wreckage could furnish a lead to be pursued regarding the habits of the crew member involved. A check with the crew member's personal doctor may reveal conditions not reflected in the FAA records.

3.2. Sources

Information concerning the crew experience should be readily available in the case of the air carrier or commercial operator, but may be nearly impossible to obtain for some general aviation pilots.

3.2.1. Company Records

Air carriers and commercial operators are required to maintain records of the current and past experience of all crew members. These records will include information on flight checks, route checks, physical examinations, and training. An examination of the company records does not complete the investigation. Verification of the information furnished by the crew member at time of employment will be necessary, as will verification of offduty flight activities which might affect the proficiency or alertness of the crew member.

3.2.2. Pilot Records

The general aviation pilot will maintain the only record of his flight experience if one is available. There is no regulatory requirement that crew members, other than ATR pilots, maintain flight time records in addition to those required for verification of time to obtain additional ratings or to show currency. For this reason, the records available during the investigation will range from very complete to nonexistent.

3.2.3. Friends and Relatives

When flight logs are not available for the crew members, it is necessary to contact the crew member's family and friends for background information relating to his experience. Data as to how long the crew member was associated with aviation, types of aircraft flown, aviation employment, and location of flying activities are some of the items which may be obtained. It is often time consuming to verify the crew member's experience, but, a complete investigation and a reasonable analysis of the accident cause cannot be made without this information.

3.2.4. Medical Records

The FAA medical records will contain copies of medical examinations taken by the crew members. The medical examination form has a space for flight experience which may be helpful in establishing recent flight time. As with all other parts of the investigation, these forms should be compared with other flight time data.

3.2.5. FAA Records, ACDO, or GADO

The FAA Air Carrier District Office or the General Aviation District Office for the area covering the crew member's home base may be able to furnish data regarding the crew and their proficiency. Many times the crew members will be known to these offices through contacts requesting information, or through testing.

4. History of Flight

In order to evaluate the performance of the crew and aircraft, it is necessary to reconstruct the flight as it took place.

4.1. Coverage

The time span included in the history of flight has been the subject of many discussions. Logically, anything connected with the flight which might have a bearing on the probable cause needs to be considered. To take the history of flight as being from takeoff to accident is to neglect the planning which went into the flight and the crew members' preflight activities. To supply enough factual data for a reasonable analysis it may be necessary to consider the flight or flights which preceded the one ending in the accident.

4.1.1. Preflight

When the history of flight is considered in two portions – preflight and inflight – it is easier to determine to what extent the flight was planned and then how well the plan was followed. This section will not dwell on the flight planning investigation as that subject has been covered in section 1. This section will be devoted to additional preflight items which must be considered. The activities of the crew must be determined if their physical condition at the start of the flight is to be assessed. The amount of rest taken, time since the last meal, consumption of alcohol or medication could all have an effect on the accident cause.

4.1.2. Inflight

A determination of the events which took place between the takeoff and the accident is necessary to establish whether the flight proceeded as planned. The fact that the accident occurred far from the intended track may furnish a clue to adverse winds, faulty compass, or inadequate navigational charts. An accident on or near the intended flight path which occurs near the time estimated to be at that point, will help eliminate such factors as navigation error or inaccurate weather forecast of winds aloft.

4.2. Sources

Where history of flight information is obtained will vary with each investigation. Some basic starting points and the data which may be obtained are outlined in the following sections.

4.2.1. Airport Personnel and Flight Plan

Personnel at the departure airport may be able to furnish information regarding crew condition, flight planning activities, refueling, maintenance, departure time, and destination. If a flight plan is not filed, these people may be the only source for some of this information. Relatives of the crew may be of help with the purpose of the flight and the destination. The investigation is greatly simplified if a flight plan is filed. A comparison of the flight plan data and the planning factors available for consideration at the time of departure will give an insight into the extent of the flight planning.

4.2.2. En Route Radio Contacts — FAA, Unicom, or Company

A check with all communication facilities along the route of flight and in the area of the accident may reveal evidence of some problem which developed in flight. Normal, on-time position reports do not necessarily rule out the existence of problems, but the probability that the crew was aware of any serious situation is reduced. Comments by the crew regarding some item which they considered minor would establish a starting point for additional investigation.

4.2.3. En Route Stops

Contacts with personnel at en route stops can furnish valuable information about the crew's appearance or aircraft condition. Anyone who saw or talked with the crew should be contacted. Remember that even the smallest bit of information about a casual conversation may furnish a lead to the next step of the investigation.

4.2.4. Cockpit Examination

The examination of the cockpit may seem out of place in the operations investigation until it is considered that this is where the crew was working. The position of various switches or controls can give an indication of what they were attempting to do at the time of the accident. Radio frequencies will furnish information regarding navigational facilities being used and may indicate additional sources which had communications with the aircraft. The position of other controls may be indicative of inflight irregularities. The results of this examination must be integrated into the total investigation if the maximum benefits are to be realized.

4.2.5. Flight Recorder

The flight recorders presently installed in our civil aircraft record five parameters on a foil tape. The time, heading, altitude, airspeed and "g" loads are recorded throughout the flight. In the undamaged state, the flight recorder medium will furnish a history of the flight which forms the basis for further investigative efforts. Specialized equipment and techniques are necessary to convert the information on the foil to usable information for the investigator. Careful handling of the recorder during recovery and shipment will assure the maximum benefits. The NTSB Bureau of Aviation Safety has the necessary technical personnel and equipment for reading the foil.

4.2.6. Cockpit Recorder

The cockpit voice recorder is installed to record all incoming and outgoing communications as well as all conversations taking place in the cockpit or on the interphone system. The recorder has an automatic erase feature which provides for retention of the last thirty minutes of the recording. This feature prevents the gaining of information from the recorder concerning near misses, turbulence encounters, or any other situation which occurred more than one-half hour before landing. The recorder can furnish valuable assistance in determining emergency actions that were taken in the cockpit during a rapidly developing situation which did not allow time for normal communications with the ground. Correlation of the cockpit voice recorder tape with tapes from air traffic control facilities will provide a real time base for all conversation on the CVR tape. Transmitter or receiver failures may be revealed by comparing what was heard in the cockpit with conversations on ground facility tapes.

4.2.7. Witness Statements

Many times it is necessary to obtain information regarding the flight from witnesses. Backtracking along the assumed route of flight may produce witnesses who will be able to pinpoint the flight path and describe the actions of the aircraft prior to the accident. Many times witnesses will be located miles from the accident site.

4.3. Conduct of Flight

How the flight progressed can furnish valuable leads to the direction of the investigative effort. The investigator would not spend a great deal of time trying to verify the wind conditions at altitude if each of the en route position reports was recorded and the aircraft cruising speed was known.

4.3.1. In Accordance with Flight Plan

The aircraft which is proceeding along the planned route at the planned altitude and airspeed is not likely to be operating with an inoperative engine. By the same token, the aircraft on course making good the planned ETA's is not likely to have such an abnormal fuel consumption that fuel starvation will result, if the proper fuel load was on board at departure. Where and when the accident occurred in relation to the flight-planned position must be considered if the investigator is to proceed in a logical investigative sequence.

4.3.2. In Accordance with Planned Alternate Route

When the accident happens off the planned route of flight, determine if the aircraft was proceeding via a preplanned alternate route. The fact that an alternate route was being utilized could indicate a problem before the accident.

4.3.3. Flight Simulation for Witness Verification of Flight Path

It may be found that the witnesses do not fully agree in their descriptions of the aircraft flight path. When this occurs, it may be necessary to use simulated flights to obtain the greatest concurrence among the witnesses and the most reliable approximation of the flight path prior to the accident. In reenacting the flight, the same model aircraft as that involved in the accident should be used. The conditions should be similar (day - night, etc.) and several flights in random sequence should be flown to cover the range of estimates given by witnesses.

4.3.4. Other Methods of Establishing Flight Path

The determination of the flight path prior to impact may furnish a great deal of information concerning the control or controllability of the aircraft. Witnesses are a valuable aid in determining the flight path, however, they are not always available, or if available, they may not be completely accurate.

The investigator may be able to establish the flight path through the use of the flight recorder data and known wind information. Bank angles and radius of turn can be determined from the rate of turn, airspeed, and altitude information recorded on the flight recorder tape.

When the flight recorder data is not available, the angle of impact can be used as a starting point for reconstruction of the flight path. Examination of the area may reveal tree strikes or other ground contacts which will be of use. In the same manner, the lack of contact with an object in the apparent flight path can establish a turn or other evasive maneuver. The impact bank angle and the range of speeds which the airplane is capable of achieving can be used to construct a flight path envelope.

Radar information from the Air Route Traffic Control Center or other traffic control agencies can be very useful. A source of data which should not be overlooked is the SAGE system operated by the Aerospace Defense Command, U. S. Air Force. In using the SAGE information you should understand the position recording system employed. The SAGE position is recorded as the southwest corner of a block of airspace one minute of latitude by one minute of longitude. This may result in a somewhat wandering path when plotted.

4.3.5. Time of Impact

If reconstruction of the flight is to be of maximum value, the investigator must establish the time of impact with all possible accuracy. Only through knowing when the accident occurred will he be able to account for all of the flight time and distance covered. Wreckage examination for impact - stopped watches or clocks is a good starting point, but, these instruments may not have been accurate or may have been set for some other time zone. Time estimates from witnesses may be affected in the same manner. If the aircraft struck electric power lines the time of power outage will probably be accurately recorded. You should not overlook the possibility of indications on seismographs in the case of heavy aircraft and high impact forces. Many universities make and maintain seismic records. Time of impact is more easily and accurately determined when the flight data recorder or cockpit recorder tapes are available.

PART B — OPERATIONS INVESTIGATION

CHAPTER III

AIR TRAFFIC CONTROL AND NAVIGATIONAL AIDS

1. Airborne Equipment Availability

One of the items to be documented during the cockpit examination and subsequent investigation is the navigation and communication equipment installed in the aircraft.

1.1. Was Installed Equipment Compatible with Aids for Use on Planned Flight?

When the investigator has determined what equipment was available to the crew, it is necessary to compare the findings with the facilities along the route. All of the ADF equipment which could be put into an aircraft would be of no use if the only ground facility was VOR. The investigation necessarily will be more detailed with the more completely equipped aircraft. There have been cases of pilots attempting a VOR/DME approach in an aircraft equipped with VOR but no DME receiver.

1.2. Was Alternate Equipment Available for Backup?

In the event the investigation shows that the aircraft had the proper type of equipment, it is necessary to establish that the equipment was operational or that functioning backup equipment was available. Many accidents have occurred when the only piece of navigational equipment became inoperative at a critical time.

1.3. Equipment Required by Deviation from Planned Flight

The aircraft may have been adequately equipped for the planned flight but may have been required to deviate from this route to a route which did not have compatible facilities. An alternate airport having ILS is of little value to the pilot who does not have an ILS receiver.

1.4. Sources

A systematic investigation of the sources listed below will make the determination of installed equipment more complete. In addition to the kind of equipment, the investigation should establish the condition of the equipment prior to flight.

1.4.1. Aircraft Records

Information regarding installed equipment may be obtained from the aircraft records. This information may be in the aircraft log, on an equipment list, on the weight and balance data, or on an FAA Form 337. The investigator may be required to obtain copies of the FAA Forms 337 from FAA records for a complete file. Special note should be made of any equipment which was replaced after the original installation, to determine the capabilities of the new equipment as compared with the original.

1.4.2. Operator or Owner of Aircraft

A check with the operator or owner of the aircraft may reveal that some item reflected in the aircraft records was not on board at the time of the accident or that some piece of equipment was not operating properly. Information concerning the last inspection, repair, or overhaul should also be obtained.

1.4.3. Cockpit and Wreckage Eamination

All components of the various navigation and communication systems should be located. Many times cockpit control boxes will be removed while the set remains in the aircraft. The opposite condition can also exist. The physical connection of the units needs to be confirmed.

2. Ground Facilities

The ground navigation and communication facilities available range from low frequency homers to TACAN and DME. These may be federally operated and maintained (civil or military), State, or municipality operated, or privately owned and operated.

2.1. Review of Air Traffic Control Functions

The air traffic control system is a complex interlocking series of units including airport traffic control towers, departure control, air route traffic control centers (en route), and approach control, among others. These functions are enhanced through the use of radar and other electronic position information. When it appears that some function of the air traffic control system may be involved in the causal area, the best procedure is to obtain specialized assistance. Much time and effort is wasted by the investigator who is unfamiliar with what the system can and cannot do. Working through the FAA Coordinator and the Air Traffic representative he will help eliminate this problem. If it appears that an air traffic or navaid function is involved in the accident, the assistance of a specialist from the Bureau's Washington staff should be requested. He will conduct the investigation into these areas and prepare a factual report and analysis thereon.

The FAA's Air Traffic Service will prepare an accident package for all air carrier accidents, accidents resulting in serious injury or fatality while the flight is on an IFR flight plan, when air traffic functions may have contributed to the accident, when adverse weather was a factor and the crew was weather briefed by FAA, or when requested by the FAA accident coordinator. This accident package will include a record of all air traffic contacts with the flight. When the accident does not fall into one of these categories, the investigator may request information as needed. Remember, when in doubt, call for specialized help.

2.2. Availability of Ground Equipment for Planned Use

Just as with the airborne equipment, the investigator will ascertain that compatible ground equipment was available along the route of flight.

2.2.1. Installation, VOR, TACAN, DME, ILS

The investigator must assure that the equipment is in place as from time to time the facilities are moved, or the equipment is modified or replaced by other type installations.

2.2.2. Operational Status

Once it is established that the proper ground equipment was available the investigator will determine the operational status. It must be determined whether the station was off the air for maintenance, whether the maintenance was scheduled or unscheduled, and whether the maintenance or facility failure was properly NOTAM'd. The equipment monitor system for warning of equipment malfunction is checked to assure that there were no undetected outages.

3. Facilities Flight Inspection

An elaborate system for assuring the proper functioning of all navigational facilities comes under the Flight Inspection Division of FAA.

3.1. Review of Flight Inspection Functions

Specially equipped aircraft are used to determine proper alignment and operation of all navigational facilities. These checks are made both at low and high altitude for en route navigational aids. Approach aids and procedures are checked to assure that they meet all approach criteria. Copies of the flight inspection reports are maintained and should be reviewed by the investigator with the help of the flight inspection specialist. All facilities, civil, military, or privately owned, are flight checked. Approach plates published by the Coast and Geodetic Survey are checked for accuracy during the facility flight inspection. Approach plates published by other agencies are not always included in this check. The investigator will verify the information contained on the plate or plates being used at the time of the accident.

3.1.1. Normal Checks

There are three basic checks which could be called normal. The *site evaluation check* is made on a temporary installation to determine the suitability of the location for a permanent installation. *The commissioning flight check* is a comprehensive check to obtain complete information as to facility performance or operator proficiency prior to placing the facility in general use. The station performance during this check becomes the standard for the facility during subsequent checks. The *periodic check* is a regularly scheduled check to assure that the facility continues to operate in accordance with the required standards.

3.1.2. Post Accident Checks

Facility flight checks requested after an accident fall into the category of *special* flight checks. The special flight check is also performed when equipment malfunctions or deficiencies are reported, after major modification or major maintenance of the facility. When there is reason to suspect that a navigation or approach facility was involved in the causal area, the investigator should request a special flight check through the FAA accident coordinator. The post accident flight check carries the top priority of all checks.

3.1.3. Accuracy of Flight Check Equipment and Procedures

The present equipment in use for flight checking facilities insures accuracy and reliability. The low altitude capability, for example, allows for checking VOR and TACAN approach radials to less than two degrees. DME is checked to within at least 3% of the distance from the station or one-half mile. The ILS is flight checked down to an altitude of 100′, or lower, unless local conditions preclude such checks. This flight check capability, coupled with the ground monitor equipment, assures extreme reliability of navigational aid transmissions.

3.1.4. Limitations, Weather, Aircraft, etc.

The investigator coordinates a request for flight checks with the flight inspection personnel to assure that the request is reasonable. The present high altitude capability is limited by the availability of aircraft. The complete low altitude check of an approach facility is dependent upon visual positioning of the aircraft over the ground. In the event of low ceiling and poor visibility the flight check will be delayed, however, the ground check of the facility can be completed. A flight check report will be furnished when the check is completed. This report should be reviewed with the flight check crew to insure complete understanding of the information which the report contains. (Fig. B III-I)

FLIGHT INSPECTION REPORT - INSTRUMENT LANDING SYSTEM

Reports Identification Symbol FS 8071 - 19

1. STATION	2. LOCATION IDENT.	3. DATE/DATES OF INSPECTION

4. TYPE OF INSPECTION				5. COMMON SYSTEM
SITE EVALUATION	PERIODIC	SPECIAL		YES
COMMISSIONING	SURVEILLANCE	INCOMPLETE		NO

6. OWNER			
FAA	U. S. ARMY	PRIVATE *(Indicate actual owner)*	
	U. S. NAVY		
INTER-NATIONAL	U. S. A. F.	OTHER *(Indicate actual owner)*	
	U. S. C. G.		

7. FACILITY/COMPONENT INSPECTED					
LOCALIZER	OM	LOM	RUNWAY LIGHTS	DME	
GLIDE SLOPE	MM	LMM	ALS	RVR	

8. LOCALIZER		FRONT COURSE TRANS. 1	FRONT COURSE TRANS. 2	BACK COURSE TRANS. 1	BACK COURSE TRANS. 2
COMMISSIONED WIDTH ________ degrees					
MODULATION					
COURSE WIDTH					
CLEARANCE *(Normal)*	150 ∽				
	90 ∽				
MAXIMUM USEABLE DISTANCE					
IDENTIFICATION					
VOICE					
POLARIZATION EFFECT					
COURSE ALIGNMENT					
COURSE STRUCTURE	ZONE 1				
	ZONE 2				
	ZONE 3				
MONITOR ALARM LIMITS					
LAST INSP. DATE					
COURSE WIDTH	NARROW				
	WIDE				
CLEARANCE	150 ∽				
	90 ∽				
ALIGNMENT	150 ∽				
	90 ∽				
PERFORMANCE CATEGORY					

9. GLIDE SLOPE		TRANS. 1	TRANS. 2
COMMISSIONED ANGLE ________ degrees			
PATH WIDTH			
ANGLE			
MODULATION			
COURSE STRUCTURE	ZONE 1		
	ZONE 2		
	ZONE 3		
CLEARANCE AT 1.2° BELOW GSA			
MINIMUM CLEARANCE			
USEABLE DISTANCE			
MONITOR ALARM LIMITS			
LAST INSP. DATE			
ANGLE			
PATH WIDTH			
CLEARANCE AT 1.2° BELOW GSA			
MINIMUM CLEARANCE			
PERFORMANCE CATEGORY			

10. MARKERS AND COMPASS LOCATORS		SAT.	UNSAT.
MARKERS	OM		
	MM		
COMPASS LOCATORS	LOM		
	LMM		

11. RUNWAY VISUAL RANGE			
HIGH INTENSITY RUNWAY LIGHTS	SATISFACTORY	RVR AUTHORIZED	YES
	UNSATISFACTORY		NO

12. GENERAL	SAT.	UNSAT.
STANDBY POWER *(Date checked)*		
APPROACH LIGHTS *(Type)*		

DME	SAT.	UNSAT.
ACCURACY		
COVERAGE		

13. CERTIFIED FOR		
	AUTOMATIC APPROACH TO	FEET ABOVE RUNWAY NO.
	MANUAL APPROACH TO	FEET ABOVE RUNWAY NO.

14. DISCREPANCIES AND/OR REMARKS	CORRECTED YES	CORRECTED NO

FACILITY CLASSIFICATION	FLIGHT INSPECTOR'S SIGNATURE	REGION
UNRESTRICTED		
RESTRICTED		FIELD OFFICE
UNUSEABLE		

FAA Form 3468 (2-64)

Figure B III-1.

Part B — OPERATIONS INVESTIGATION

Chapter IV

WEATHER

Weather may be a major factor in the accident, or it may not be involved at all. The job of the investigator is to determine if weather was involved in the causal area and to what extent. In order to make this determination, it will be necessary to examine weather conditions as they were before and during the flight, as well as at the time and place of the accident. There will be many cases which require professional meteorological assistance.

1. Crew Briefing

The preflight briefing received by a crew should have influenced their preparations for and execution of the flight. It is one thing for a well-briefed, experienced crew to have a weather-involved accident and quite another for a student on a poorly planned cross-country flight to have a weather-involved accident.

1.1. Sources

When trying to determine if a crew had received a preflight weather briefing, several possible sources should be considered.

1.1.1. U.S. Weather Bureau

The U.S. Weather Bureau maintains facilities throughout the country to observe, collect, forecast, and disseminate weather information. Weather briefings may be obtained in person or by telephone from the briefer and/or forecaster on duty. Short-flight briefings may be obtained by Transcribed Weather Broadcasts (TWEB) or by the Pilot's Automatic Telephone Weather Answering Service (PATWAS). When a preflight briefing is obtained from Weather Bureau personnel, a written record is made and maintained by the station. If the TWEB or PATWAS had been utilized by the pilot, the investigator might obtain verification from someone who witnessed the call, or possibly from notes made by the pilot. Weather Bureau briefings do not have a "briefing-void" time, therefore, it must be determined that the briefing was obtained at a time appropriate to the time of departure.

1.1.2. Flight Service Stations

The FAA Flight Service Stations maintain facilities for briefing crews on aviation weather. A record of briefing is made, and may be available during the investigation. Unless otherwise notified, the briefing facility will dispose of such records in 15 days.

1.1.3. Private Weather Services

Private weather services are maintained throughout the country. These services are used normally by relatively large corporations, but briefings are available to anyone willing to pay for the service. These organizations will normally keep records of briefings, and they might have copies of data furnished to crews. Many companies receive these briefings by telephone, no matter where the flight originates.

1.1.4. Military

Many military aero clubs and other military personnel receive briefings from military weather stations. Under normal circumstances, the pilot will be provided with a Form DD 175-1, *Flight Weather Briefing,* a copy of which will be maintained by the briefing station.

1.2. Content

After locating the source of the briefing, it will be necessary for the investigator to determine the details which were provided, in order to assess completeness and adequacy of the briefing.

1.2.1. Completeness and Adequacy

It is considered that a complete and adequate briefing should contain the following:

a. Weather synopsis (positions and movement of pressure systems, fronts, precipitation areas, etc.)

b. Current weather (at point of departure, en route, including pilot reports, terminal, and alternate if weather is marginal)

c. Forecast weather (at point of departure, en route, terminal and alternate if required)

d. Alternate routes

e. Hazardous weather (tornadoes, tropical storms, thunderstorms, hail, turbulence, icing, dust storms, and sand storms)

f. Forecast wind aloft

g. A request for pilot reports

2. Forecasts

All of the forecasts pertinent to the flight should be obtained. This will allow an assessment of the accuracy of the forecasts and how they may have influenced the actions and decisions of the crew.

2.1. Aviation Area Forecasts

These forecasts serve the preflight service requirements of domestic flight operations and also serve as briefing aids for Weather Bureau and Flight Service Station personnel. They are issued each 6 hours and contain forecasts for a 12-hour period covering specified geographical areas. They contain a synopsis of the weather situation, information on clouds and weather, icing and turbulence, and have an additional 12-hour outlook appended.

2.2. Inflight Advisories

The Weather Bureau issues inflight advisories which are known as *SIGMETS* or *AIRMETS*. The *SIGMET* covers weather conditions of such severity as to be potentially hazardous to *all* flight operations, while the *AIRMET* concerns weather of such a degree as to be potentially hazardous to light aircraft, but not necessarily hazardous to transport category aircraft. If investigation reveals that a *SIGMET* had been issued covering the area and time period concerned with an accident, then the pilot should have been warned of one or more of the following which were in existence or were forecast to develop:

a. Tornadoes

b. Lines of thunderstorms (squall lines)

c. Embedded thunderstorms

d. Hail of 3/4 inch or greater diameter

e. Severe or extreme turbulence (see par. 3.2)

f. Severe icing (see par. 3.1.2)

g. Widespread dust storms/sand storms lowering visibility to less than two miles.

In the case of a valid *AIRMET*, one or more of the following conditions would be anticipated:

a. Moderate icing

b. Moderate turbulence over an extensive area

c. Sustained winds of 40 knots at or within 2,000 feet of the surface

d. Extensive areas of visibilities less than two miles and/or ceilings less than 1,000 feet, including mountain ridges and passes.

If either type of advisory was in effect, a careful analysis of the pilot's qualifications, experience, and aircraft equipment is required.

2.3. Terminal Forecasts

Terminal forecasts are intended to serve the preflight and inflight meteorological service requirements of domestic flight operations that relate to the terminal area. Designated Weather Bureau offices issue 12 and/or 24-hour terminal forecasts once each six hours for authorized locations. Each terminal forecast will contain the following items as appropriate:

a. Height of sky cover
b. Amount of sky cover
c. Visibility
d. Weather/obstruction to vision
e. Surface wind
f. Remarks

2.4 Other Forecasts

There are many other forecast products which may have to be documented. Some of these items might be:

a. Wind and temperature aloft forecasts
b. Significant weather prognostic charts
c. *Aviation Severe Weather Watch Bulletin*

3. Hazardous Weather

There are many types of hazardous weather conditions which must be considered, such as thunderstorms, lightning, icing, and turbulence.

3.1. Thunderstorms

Recent research has proven beyond any doubt that all thunderstorms are potentially dangerous. Their associated turbulence, hail, lightning, icing, and precipitation have been more than even experienced pilots could handle in many cases. A close examination of the wreckage is in order for the accident which may have been associated with thunderstorm activity. In addition to evidence of an inflight structural breakup because of turbulence, the investigator should look for hail damage. Hail can range from pinhead size to grapefruit size. It would take a powerful updraft to sustain grapefruit-size hail, and it is a fact that vertical velocities in thunderstorms have been measured as high as 208 feet per second (approximately 123 knots). The heavy rains which may be associated with thunderstorm activity can result in distractions which could lead to a loss of control by the marginally qualified flight crew. The most favored temperature regime for airframe icing is the 0° to −10°C range, so that if an aircraft were to penetrate the storm at an altitude corresponding to that range, a rapid and heavy accumulation of icing could be encountered. Carburetor icing must also be considered.

3.1.1. Lightning

Electrical discharge in the form of lightning from a thunderstorm has been responsible for damage to aircraft in flight (as well as on the ground). This damage has ranged from inaccurate instrument indications to minor (and some major) structural damage, or explosion, resulting in an accident. Generally, lightning causes only minor skin damage to all metal aircraft; however, there have been occasions when lightning ignited fuel or fuel vapor resulting in disintegration of the structure. Lightning strikes on aircraft with wooden structure usually result in more damage than a similar strike on all-metal aircraft. Investigation might reveal that lightning was occurring at the time of the accident. This information should be correlated with the examination of the wreckage. Lightning can also cause temporary distraction and/or blindness of the crew.

3.1.2. Icing

The Subcommittee on Aviation Meteorological Services under the U.S. Interdepartmental Committee for Meteorological Services at its meeting on November 4, 1968, established new standard terms for icing intensities to be used within the U.S. These new standard terms are as follows:

TRACE – Ice becomes perceptible. Rate of accumulation slightly greater than the rate of sublimation. It is not hazardous even though deicing/anti-icing equipment is not utilized, unless encountered for an extended period of time – over one hour.

LIGHT – *The rate of accumulation may create a problem if flight is prolonged in this environment (over one hour). Occasional use of deicing/anti-icing equipment removes/prevents acccumulation. It does not present a problem if the deicing/anti-icing equipment is used.*

MODERATE – *The rate of accumulation is such that even short encounters become potentially hazardous and use of deicing/anti-icing equipment or diversion is necessary.*

SEVERE – *The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate diversion is necessary.*

3.2. Turbulence

The main causes of turbulence are: vertically moving air in convective currents, air moving around or over mountains or other obstructions, and wind shear (change in wind direction and/or velocity in the vertical or horizontal). Turbulence not occurring in clouds is referred to as clear air turbulence. Although turbulence in the clear air can and does occur at any level, it is high level turbulence (normally above 15,000 feet m.s.l.) which is referred to by convention as CAT. At its meeting on September 25, 1967, the Subcommittee on Aviation Meteorological Services adopted for use in the U.S. the *Turbulence Reporting Criteria Table* on the following page.

3.2.1. Convective Turbulence

Heating from below causes convection currents, both ascending and descending. Various surfaces heat (and cool) at different rates causing currents of different intensities. Accordingly, an aircraft flying through such currents will experience rough air of varying intensity as it traverses the up and down currents of air. Land and sea breezes are also examples of convective activity. If sufficient moisture is present, cumuliform clouds will develop. If the convection is strong enough and sufficient moisture is available, the result will be the development of the cumulonimbus/thunderstorm.

3.2.2. Turbulence Caused by Obstruction to Wind Flow

Air moving over even reasonably smooth terrain will result in some low level turbulence. However, faster air movement and rougher terrain will result in increasing turbulence and to higher levels. High winds blowing over a mountain range can result in what is called the *mountain wave.* The air blowing up the windward slope is generally smooth. However, as the air spills over the lee slopes, strong downdrafts and turbulence can result. In addition to the turbulence, it must be kept in mind that the mountain wave downdrafts may exceed the climb capability of the aircraft. If the wind velocity near the level of the ridge is in excess of 25 knots and is approximately perpendicular to the ridge, mountain wave conditions are likely over and near the lee slopes. If the wind velocity at the level of the ridge exceeds 50 knots, a strong mountain wave is probable with strong up and down drafts and severe or extreme turbulence. The worst turbulence will be encountered in and below the rotor zone (rotary air movement) which is usually 8 to 10 miles downwind from the ridge. This zone is characterized by the presence of *roll clouds* if sufficient moisture is available. Altocumulus standing lenticular (lens shaped) clouds are also visible signs that a mountain wave exists, but their presence is likewise dependent upon moisture. Severe turbulence might extend as far as 150 miles downwind from the mountain range and moderate turbulence might extend as far as 300 miles downwind. The turbulence can extend from the surface into the stratosphere. It should be kept in mind that if the air is dry, the telltale clouds will not form, but all the activity and dangerous features of the mountain wave will exist.

A classic example of mountain wave turbulence in clear air occurred in January 1964. In the lee of the Sangre de Cristo Mountains in Colorado, a highly instrumented B-52H encountered extreme turbulence at 14,500 feet m.s.l. (6,500 feet above the ground). The turbulence lasted approximately 8 seconds. This was long enough to cause major structural dam-

TURBULENCE REPORTING CRITERIA TABLE

INTENSITY	AIRCRAFT REACTION	REACTION INSIDE AIRCRAFT	REPORTING TERM-DEFINITION
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). Report as **Light Turbulence**;* **or** Turbulence that causes slight, rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. Report as **Light Chop.**	Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking.	Occasional – Less than 1/3 of the time Intermittent – 1/3 to 2/3 Continuous – More than 2/3
Moderate	Turbulence that is similar to Light Turbulence but of greater intensity. Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed. Report as **Moderate Turbulence.*** or Turbulence that is similar to Light Chop but of greater intensity. It causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude. Report as **Moderate Chop.**	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.	NOTE 1. Pilots should report location (s), time (GMT), intensity, whether in or near clouds, altitude, type of aircraft, and, when applicable, duration of turbulence. 2. Duration may be based on time between two locations or over a single location. All locations should be readily identifiable.
Severe	Turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Report as **Severe Turbulence.***	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.	EXAMPLES: a. Over Omaha, 1232Z, Moderate Turbulence, in cloud, Flight Level 310, B707.
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage. Report as **Extreme Turbulence.***		b. From 50 miles south of Albuquerque to 30 miles north of Phoenix, 1210Z to 1250Z, occasional Moderate Chop, Flight Level 330, DC8.

*High level turbulence (normally above 15,000 feet ASL) not associated with cumuliform cloudiness, including thunderstorms, should be reported as CAT (clear air turbulence) preceded by the appropriate intensity, or light or moderate chop.

age to the aircraft. The rudder and almost the entire vertical fin were lost. During the encounter, accelerations of +3.5 to –.4g vertical and 1.1g horizontal were recorded at the c.g. Accelerations of +4.7 to –1.5g vertical and 2.5g lateral were recorded at the vertical fin support bulkhead.

3.2.3. Wind Shear Turbulence

As indicated previously, wind shear is a change in wind direction and/or velocity in the vertical or horizontal. These changes over a relatively short distance result in a shearing or tearing effect. The resultant boiling or churning eddies of air produce the turbulence.

One well known phenomenon wherein large wind changes take place in a relatively short distance is the *jet stream*. The jet stream is a meandering, high-level, narrow, strong stream of winds. Clear air turbulence associated with the jet stream occurs most often in and near the maximum wind speed centers which move along the jet stream. There is evidence that the maximum occurrence of severe turbulence in the vicinity of polar-front jet stream is on the cold air side near the polar tropopause and below the jet core level (below and to the left of the core looking downstream). The next most likely areas are above and to the left of the core and left of the core near and above the polar tropopause. The dimensions of the turbulent areas are variable and isolated but generally are less than 2,000 feet in depth, 20 miles in width, and 50 or more miles in length.

An extreme form of wind shear is that associated with strong temperature inversions near the ground. Such a condition could pose a real threat to an aircraft either on final approach or almost immediately after departure. For example, a pilot could have this problem when departing during early morning hours from an airport located in a valley. Considerable nocturnal cooling because of radiation would form a shallow layer of relatively cold air just above the surface. Assuming relatively calm conditions in the cold air and a moving layer of warm air aloft, there would be a narrow zone of wind shear along the boundary between the two. Not only would there be a turbulence encounter in this zone, but because of the difference in windspeed between the warm and cold air, a pilot would experience a substantial loss of altitude or airspeed (assuming in this case that the direction of the warm air was the same as that of the aircraft).

4. Actual Weather

After having determined the source and extent of a pilot's or a crew's preflight (and/or inflight) weather briefing, it will be necessary to attempt to establish what the weather conditions had been at the time and place of the accident. When this is accomplished, an evaluation can then be made concerning the accuracy of the forecasts and the investigator can make an assessment of the performance or the actions of the crew.

4.1. Professional Meteorological Assistance

In order to assure the most complete collection of factual meteorological data and an analysis thereof, NTSB investigators have the capability of requesting assistance from the Board's professional meteorological staff located in the Bureau of Aviation Safety. It is recognized that some weather-involved cases do not require professional assistance, but on the other hand, there are many more cases which simply cannot be resolved without such assistance. A request for a weather study from the Board's meteorologists will result in receipt of a detailed summary of factual meteorological data, the backup documents and an analysis of those facts. That analysis will include an assessment of the weather which prevailed in the vicinity of the accident site, as well as a determination of the adequacy of weather briefings and the accuracy of the then valid forecasts. As appropriate, the investigator may wish to have a special weather study related to such items as wind, or perhaps temperature and moisture over a particular route, rather than a complete package on *all* weather aspects.

Since assessments of the adequacy of briefings and the accuracy of forecasts are routine facets of Board investigations, it is obvious that the facilities and services of one or more other agencies are involved. For this reason, Board investigators must use discretion in requesting certain types of assistance (i.e., aftercasts, opinions, or analyses) from Weather Bureau personnel. Weather Bureau personnel are extremely cooperative in assisting the investigator in the collection of factual material, and requests should normally be restricted to such material.

4.2. Weather Documentation

In those cases not requiring professional meteorological assistance, the investigator will need certain documents to complete his factual file and to act as backup material for analytical purposes. The investigator has a wide choice of material he might request from the appropriate Weather Bureau office. Following is a partial listing of material from which can be selected the required documents:

a. Weather radar reports

b. Weather radar photographs

c. Hourly aviation weather teletype sequences

d. Surface weather observation forms

e. Pilot weather reports

f. Surface synoptic charts

g. Upper air charts

h. Pseudo-adiabatic charts

i. Winds aloft data

j. Ceilometer record

k. Transmissometer records and tables

l. Visibility reference charts

m. Triple register record

n. TelAutograph or Electrowriter record

o. Barograph trace

p. Weather satellite photographs

q. Area forecasts

r. Terminal forecasts

s. *SIGMETS* and *AIRMETS*

t. *Aviation Severe Weather Watch Bulletins*

u. Wind aloft forecasts.

4.3. Witness Statements

The on-scene witness can be one of the best sources of information on weather conditions at the precise time and place of an accident. Of course, the extent of the lay-witness information is directly proportional to the quality and detail of the interview. Local conditions not evident in reports from official sources may be uncovered. All weather information collected from witnesses should be furnished to the Board meteorologists if they are assisting on the case.

The interview of witnesses should explore the weather *trend,* as well as the conditions at the time of the accident. The sudden formation of fog, the development of shower activity, or a duststorm, present a different insight into the pilot's problem than does a gradual deterioration of the weather over a period of hours.

The investigator should also try to determine from witnesses if the pilot had an opportunity for alternate action prior to entering an adverse weather condition over the accident site. Many times the witness can reveal that the weather was relatively good behind the pilot or that he circled the airport prior to continuing into an area of poor weather.

5. Weather Conditions vs. Pilot or Aircraft Capability

The consideration of weather involvement in the causal area will require that the investigator compare pilot ability and the aircraft capability with the weather conditions which were verified during the investigation. Many accidents have occurred when a noninstrument qualified pilot became trapped under a lowering cloud deck. Other accidents have happened when a noninstrument qualified pilot attempted an over-the-top flight in an aircraft which was not capable of the performance necessary to remain on top of building clouds. There have been many cases in which noninstrument-qualified pilots arrived over the destination after an over-the-top-flight only to find that there were no breaks available for a VFR descent. Too many pilots simply overestimate their ability to cope with certain weather situations.

PART B — OPERATIONS INVESTIGATION

CHAPTER V

WITNESSES

1. Philosophy

The NTSB/FAA philosophy of questioning witnesses to aircraft accidents is to *interview* rather than *interrogate*. "Interview" connotes a cooperative informal meeting where the interviewer approaches the interviewee as an equal. The cooperation of the interviewee is sought; he is encouraged to tell his story freely without interruption or intimidation. An interview is usually conducted informally with a voluntary or cooperative answering of questions.

"Interrogation" connotes that questioning is done on a formal or authoritative level such as a lawyer/witness situation, a police officer/suspect session, or a parent/child relationship. Here the questioning may be devious, shrewd, or clever with the objective of tricking, trapping or antagonizing the witness to get the information at any cost.

It is the interview rather than the interrogation philosophy which is desirable in the questioning of witnesses by accident investigators. The witness is confronted with the need for air safety and accident prevention; most people are in favor of these goals and willingly narrate their observations.

1.1. Introduction

The category of *eyewitnesses* in this section will be interpreted as persons in the vicinity of the crash site at the time of the accident. Such persons as designers, manufacturers, aerodynamicists, physicians, maintenance personnel, mechanics, metallurgists, crewmembers, and other experts in specialized fields shall not, for purposes of this section, be considered as witnesses unless they observed the accident firsthand.

1.2. Purpose

The investigator interviews aircraft accident witnesses with either of two basic objectives in mind:

a. Establish a preliminary suspect area.

b. Complement other phases of the investigation.

The thoroughness with which these two objectives are carried out is contingent upon the thoroughness of the investigator. The experienced investigator realizes that bits of seemingly insignificant information may assume great importance when combined with investigation findings in other areas.

2. Locating Eyewitnesses

The locating of aircraft accident witnesses often requires an extensive search of the accident site area; the following potential sources are intended as a guide in supplementing the investigator's ingenuity in locating witnesses.

a. Residents in the vicinity of the accident site should be canvassed. Information may be obtained regarding time of accident, engine sound, duration of sound, fluctuation in dynamic level, unusual noises, flight path, local weather, attitude and altitude of aircraft, configuration, maneuvers, relative speed, heading, initial condition of wreckage, rescue operations, etc.

b. Local authorities often will have names of persons reporting low flying aircraft, crashes, or other unusual observations concerning aircraft.

c. Airport terminal personnel, e.g., ticket agents, airport limousine dispatchers, fixed base operators, aircraft dealers, insurance agents, and rental car agency employees may have valuable witness information.

d. A newspaper office is often contacted by the witness who believes he possesses significant information.

e. A plea via local news media may encourage the reticent or transient witness to contact investigation headquarters.

f. Witnesses have been found among crews or passengers of other aircraft flying in the same locale. These witnesses may be of assistance in recalling significant communications and visual observations.

g. Contact temporary area personnel such as mail carriers, delivery men, public utility employees, repairmen, etc., who may have been in the area at the time of the accident.

h. Expeditious arrival at the accident site facilitates the questioning of sightseers and the curious regarding what attracted them to the accident. These spectators may also know of other witnesses who have departed the site.

i. Rescue personnel can often provide significant aircraft occupant evacuation information or occupant location information prior to rescue operations.

j. One witness may lead to another. Ascertain whether or not the witness was alone at the time of the observation. The reticent or introverted witness may be reluctant to volunteer information and as a consequence may never be found without the aid of his more talkative companion.

2.1. Witness Location Significance

The exact spot from which a witness makes an observation may explain why his statement differs from that of other witnesses in the crash vicinity. A witness location chart, to be used in conjunction with the written statement, should be prepared for clarification purposes.

a. A witness downwind of the flight path may often hear engine or other sounds not audible to the upwind observer.

b. Sound is deflected and distorted by walls or buildings and may cause the witness to erroneously report flight path direction, sound origin, or dynamic level.

c. Noise level at the point of observation may account for a witness missing significant sounds noted by other observers.

d. The witness looking toward the sun sees only a silhouette, while the witness with the sun at his back may note attitude, maneuvers, or color.

e. A witness located in a group may be influenced by the power of suggestion. An outspoken member of the group might exclaim, "Those two aircraft missed a collision by inches!" when, in fact, the vertical separation was 1000′. The type of individual who hates to be critical of others reports that the planes passed in close proximity when in reality his initial impression was that there was adequate separation.

2.1.1. Sensory Illusions

Most investigators are aware of sensory illusions and their effect on pilot action. These same illusions and their influence on witnesses should be considered by the interviewer. The following examples of sensory illusions will serve to create an awareness of their existence and their potential influence upon witness observations.

a. The rotating versus the oscillating object. (The experiment with the rotating trapezoidal window is an excellent example of observer susceptibility to illusions.)

b. Consider the relative motion illusion, particularly with reference to velocity, when the observer in motion views an aircraft also in motion. It is incumbent upon the investigator to consider speed and direction in which the witness was moving, in relation to the direction of the observed aircraft. The apparent speed of an aircraft will be higher when the aircraft and observer are moving in opposite directions.

c. Visual illusions resulting from false information being fed to the brain may account for witness observations that the aviation accident investigator must evaluate carefully before accepting their credibility, e.g.:

(1) Flicker vertigo: In rare cases people suffer adverse effects such as nausea, vomiting, disorientation, or unconsciousness, resulting from the effect of a flickering light.

(2) Oculogyric illusions: Pilots recovering from a tight constant turn or spin view objects which appear to be rotating in the opposite direction of the turn or spin. The illusion created by a sudden tilting of the head resulting in the erratic movement of an observed object or light may account for unexplained cases where unnecessary evasive action resulted in loss of control.

(3) Autokinesis: Staring at an isolated light at night can produce a false sensation that the light is moving nondirectionally.

(4) False horizon: Flying left wing low with reference to an isolated light to the left can give a false mental horizon tilted to the right. (The reverse is also true.)

(5) Erroneous estimation of the height of lights in the vicinity of an airport dur- a night visual approach may account for some long or short landings.

d. Human factors studies of the behavior of the human body in a foreign element such as the atmosphere have been and are continuing to be conducted in an effort to prevent accidents.

Additional problem areas of which the interviewer should at least be aware are:

(1) Coriolis effect.

(2) Night vision limitations imposed by the physical structure of the eye.

(3) Refraction error caused by a wet windshield.

(4) Projection of a fictitious horizon relative to attitude of the nose of the aircraft.

(5) Illusion of being closer in on the approach to a runway having the lights on bright, versus lights on dim situation.

(6) Erroneous estimate of altitude on a visual approach when there is an up or down slope to the runway, or an up or down slope to the approach terrain.

(7) The tendency for a pilot conditioned to landing on a 300′ x 12,000′ runway to orient himself accordingly when approaching a 100′ x 4,000′ runway. (This situation was considered as a contributing factor during the landing approach accident of an Air Force B-58 at the 1965 Paris Air Show.)

e. The possibility of illusions influencing witness observations makes it advisable that witnesses be selected from various points of observation. This tends to provide a more comprehensive coverage of the occurrence. This is not to say, however, that an average of witness observations is to be assigned greater credibility than a competent witness whose observation deviates from the majority.

f. Consideration must also be afforded the local observer who in many cases is more apt to note occurrences significant or unique to local surroundings than is the transient to whom the same occurrence would hold little significance.

2.1.2. Negative Observations

For purposes of this section, consider negative observations as those events or situations which do not call for any degree of aviation technology, but are items that an average lay witness probably would observe. The investigator may, by inference, obtain much positive information from negative observations, e.g.:

a. Passengers or observers report the night evacuation of an aircraft as excessively slow and that numerous objects seemed to be obstructing the exodus. This could indicate that the impact lights failed to operate, or that no fire existed in the cabin immediately following the crash.

b. Seasoned travelers report none of the customary approach sounds such as flaps or the thump of the landing gear. Lack of such observations could direct the investigation toward a malfunction in the hydraulic system, or possibly an operational problem.

c. Passengers in window seats fail to note the proximity of aircraft awaiting takeoff. Lights which would normally be obvious during the approach are not reported. These negative observations could direct the investigation into the area of a below-minimums approach, erroneous forecasting, or perhaps an excessively high approach precluding the sighting of lights in the approach area.

3. Expediting the Interviewing of Witnesses

Prompt arrival at the accident site is probably the accident investigator's finest investigation aid. It affords the opportunity of examining the wreckage before excessive disturbance, and permits questioning of witnesses before they reflect on their observations. Probably the greatest advantage of prompt arrival, however, is in the area of interviewing witnesses.

Witnesses are human, prone to forget with the passing of time. They are influenced by association with other witnesses and other people. They read newspapers, listen to the radio, and watch television; news media have their effect on the witness. The witness, like the fisherman, may embellish his story when he finds listeners less attentive than when he originally told the story. The best solution for remedying these witness frailties or tendencies is to interview the witness promptly.

A memory experiment associated with time lapse was conducted by a group of psychologists and revealed the following facts of significance to the witness interviewer:

a. Interviews taken immediately following an occurrence contained maximum detail, and were generally more complete.

b. After a two-day delay, the information was more general, with fewer specifics, but the main or more vivid points remained.

c. After a seven-day delay, many of the more vivid events remained, but there was considerably more conjecture, analysis, and opinion injected by the witness. Positiveness as to events observed also declined with time.

Witnesses, when contacted promptly, are usually appreciative of the need for aircraft accident investigation and the promotion of air safety. Some witnesses may consider the interview an imposition and become indignant and impatient when asked to recount their observations. This situation is unfortunate, but preferable to the witness who complains about the complacency of accident investigators because he was never contacted and asked to submit a statement, or was contacted several days after the occurrence.

The intelligent witness is aware of voids or blanks in his statement (which the trained interviewer, incidentally, realizes exist in all observations) and endeavors to eliminate them through the application of logic or reasoning. The longer a witness has to reflect on his observations, the more likely he is to modify or supplement the facts in the interest of coherency. Maximum witness reliability can best be achieved via prompt interviewing.

The investigator is urged to visit the accident site, survey the situation, and decide upon certain questions which he feels witnesses could answer, e.g.:

a. "The aircraft wreckage lies in a 6-foot crater." Did witness hear a boom that could confirm supersonic flight?

b. "The aircraft is not fully instrument equipped. The wreckage is located near the top of a ridge which forms the boundary of a valley. The terrain is muddy and there are puddles of water."

Question witnesses regarding weather: Was the cloud cover obscuring the top of the ridge? How heavy was the rain? Was an aircraft heard circling? Was the pilot instrument qualified?

Occasionally subsequent evidence dictates that certain witnesses be requestioned. The requestioning of a witness does not necessarily indicate that the interviewer was remiss in the conduct of the initial interview. Instead, the investigator may employ this technique with the witness who appears to rationalize and analyze during the initial interview. The investigator would attempt to separate fact and analysis by observing whether or not the more vivid areas of observation were presented as they were initially, and whether areas of suspected conjecture and opinion were analyzed differently than when the witness was first interviewed. By this means, the investigator would attempt to separate fact and analysis, and verify witness reliability. Requestioning a witness may also be in order in confirming technical group findings revealed during the field phase of the investigation. Example: Passenger witnesses were requestioned in an overshoot accident regarding their observation of spoilers after negative wreckage findings by technical groups in the area of faulty brakes, faulty thrust lever linkage, and reverse thrust mechanism.

4. A Successful Interview

The information derived from the witness interview is often directly proportional to the skill of the investigator in establishing rapport. The Witness Group spokesman is responsible for the success or failure of the interview.

The interview should not simulate a surprise party. Make prior arrangements to interview the witness at a time and place convenient for him under conditions conducive to maximum cooperation and recall.

Optimum results are obtained by appointing a spokesman for the Witness Group who is responsible for: introducing the witness to members of the Group, the showing of credentials, the allaying of any qualms the witness might have relative to submitting a signed statement, the answering of any questions posed by the witness concerning the need for and the use of the signed statement, general control of the Witness Group, and establishment of rapport.

Rapport consists primarily of placing the witness at ease, and assuring him that he is not going to be grilled, or given the third degree. Discussion of a topic of mutual interest will usually accomplish this. Setting the stage and placing the witness at ease should include explaining the objective of accident investigation — **ACCIDENT PREVENTION.**

Initially, encourage the witness to tell his story in his own way without questions, comments, suggestions, or interruptions from the interviewer. Periods of silence in this phase, while the witness collects his thoughts, have been found to encourage the witness to expound more fully and to avoid omissions. The investigator's ability to be a good listener and to keep the interviewee doing the talking is essential in this phase.

Questions from Witness Group personnel subsequent to the narration of the witness should be channeled through the designated Group spokesman since he:

a. Has already established rapport.
b. Will screen redundant questions.
c. Can organize questions via subject matter and attempt to question by following the sequence of the occurrence.

Prior planning on the part of the interviewer is necessary to direct the interview in a systematic line of questioning. Predetermined questions concerning probable suspect areas should be asked of all witnesses.

This does not mean the use of a prepared list of questions, but rather the exploration of areas of greatest probability based on the aviation knowledge of the interviewer. Prior planning has the advantage of:

a. Reducing the number of bare "yes" or "no" responses common to the prepared questionnaire.

b. Containing the interview within areas relevant to the occurrence.

c. Reducing the tendency of the interviewer to ask leading questions.

d. Avoid the rigid stereotyped interview.

4.1. Aids to Interviewing

Successfully interviewing the aircraft accident witness is primarily an application of common sense. Show the witness the same consideration that would be appreciated if the situation were reversed. The experienced interviewer adopts a certain style or technique in interviewing witnesses that he has found effective through interviewing a number of witnesses in the past. The following suggested interviewing tips for the novice interviewer will also serve as a review or checklist for the experienced accident investigation witness interviewer:

a. During the initial narration of the witness it is advisable for the interviewer to take notes. The note taking should be unobtrusive, and only with the consent of the witness. Even with the consent of the witness, discretion should be used, and note taking should cease if it is distracting to the witness. Notes should not be so extensive that the witness becomes absorbed with what the interviewer is doing. Explain to the witness that the notes are used to suggest areas in his narration that may require further explanation.

b. Frequently the witness has difficulty putting into words what he observed. In cases such as this, signed explanatory sketches or diagrams are valuable supplements to the witness statement. They should not be construed, however, as substitutes for the narrative statement. When there is doubt in the mind of the investigator concerning the exact meaning of a statement he should check the answer of the witness. Perhaps the simplest method is to rephrase the answer and get the witness to confirm it.

c. Courtesy and consideration should be afforded the witness at all times. Be patient with the witness if he has difficulty in remembering details. Normal witness observations are expected to have periodic voids. If the witness is indefinite in a given area, allow him to record his statement that way. Do not insist that the witness give a straight "yes" or "no" answer.

d. Attempt to have the witness confine his comments to his observations. Avoid hearsay or areas not within his personal knowledge. If the witness reports that someone else described the accident to him, take the name of the individual and see the witness personally at a later date. Get the full meaning of each statement of the witness. Analyze each answer carefully for suggestions or leads to further questions.

e. After the witness has completed his narrative, the investigator usually will have some specific questions to ask relative to areas that appear in his notes. Keep questions simple; avoid aviation jargon or terminology that could be foreign to the witness.

f. Use the straightforward and frank approach in questioning the witness as opposed to the shrewd or clever technique employed by the defense attorney. The investigator is interested in obtaining information from the witness and not in tricking him or trapping him into an unguarded statement.

g. Avoid arguing with the witness concerning moral responsibility of the pilot, operator, or aviation in general. Witnesses have been known to regard the interview as a medium for voicing their opinions on airport location, low flying aircraft, landing and takeoff noise, and any other phase of aviation that annoys them. Attempt to keep the witness on the subject of his observations relative to the accident.

h. Do not assist the witness with terminology when he experiences difficulty in describing some technical phase of aviation. The statement should be in the words of the witness and in terms that he understands.

i. Percentages and fractions, when used by a witness in describing an event, should be translated into exact descriptions. There is a tendency to exaggerate in terms of percentages or fractions of the whole, e.g., a witness reports, "Seventy-five percent of the passengers panicked when flames emanated from the engine." The stewardesses reported that, "One or two people were a little nervous but the remainder stayed calm." A passenger tells about how he dislikes a given airline because "nine-tenths of the time they lose my baggage." It was learned that a briefcase that the passenger had left in the cabin was never located and that on another occasion his luggage had been placed aboard another plane which arrived within ten minutes of his scheduled flight.

j. The wording of the question is very important, for example:

   POOR: "Were all three landing gear in the down position?"

   BETTER: "Did you see the landing gear?"

   POOR: "Did you see the stabilizer fail and drop from the aircraft?"

   BETTER: "Did you see anything fall from the aircraft?"

   POOR: "Was the aircraft red, green, or yellow?"

   BETTER: "What color was the aircraft?"

The following example illustrates how answers are affected by rewording the question. "Should the United States do all in her power to promote world peace?" Of the people questioned, 97% answered yes. The question was reworded: "Should the United States become involved in plans to promote world peace?" In this instance only 60% answered yes. The connotation of the word "involved" made the difference.

k. Qualifying the witness is important in establishing observation credibility. Witness vocation and aviation experience should be established. When an aircraft mechanic describes the sound of an aircraft engine as surging or backfiring, his observation should be more reliable than a similar observation of a person totally unfamiliar with the operation of an aircraft engine.

l. Use the individual versus the collective witness interview. The collective witness interview allows witness #2 to hear the statement of witness #1. In hearing the statement, witness #2 could possibly take information that is mentioned by witness #1 and use this information to fill blanks in his observation. Many times the collective witness interview will result in one witness contradicting and correcting another. In the collective witness interview, one witness may be influenced by the statement of another. Feeling that a witness knows more about aviation will cause another to alter his original observation to conform with the statement of the first witness. Conformity of witness observations is not necessarily what the accident investigator desires.

m. Use of a tape recorder is a matter of individual interviewer preference. Consideration should, however, be given to certain associated circumstances and requisites:

   (1) A signed written statement is desirable.

   (2) Tape must be transcribed and forwarded to witness for signature.

   (3) Witness must edit transcription.

   (4) Some witnesses concentrate more on the microphone than on their observations.

   (5) Environment may not be conducive to recording.

   (6) Mechanics of operating the tape recorder may be a disadvantage, e.g., changing tape in the middle of an in-

terview; faulty recording due to inexperienced operator or mechanical malfunction.

(7) Witness should be provided with a copy of his statement.

n. The National Transportation Safety Board, Bureau of Aviation Safety, has confirmed that the investigation of catastrophic accidents can best be accomplished via the *Team Concept*. The Team Concept entails an Investigator-in-charge or Team Captain and a number of Group Chairmen, e.g., Operations, Structures, Systems, Powerplants, Human Factors, and Witnesses. The situation occasionally arises when more than one Group desires to interview certain witnesses. Should this situation arise, chairmen of Groups previously mentioned should avoid interview duplication by assigning specific Groups to interview certain witnesses. For example, Operations Group — interview air traffic service personnel; Human Factors Group — interview passengers; Witness Group — interview lay witnesses. Coordination among chairmen is essential in assuring that all witnesses are questioned concerning information significant to other Groups, as well as their own.

o. Courtesy during the interview is emphasized; courtesy is also important in concluding the witness interview. Thank the witness for his cooperation and time in providing the information and the signed statement; bear in mind that the statement was voluntary, and perhaps given during the time that the witness may have allotted for something else. The investigator should leave a phone number and address where he could be reached, should the witness recall additional information that he failed to include in his statement.

p. It is occasionally necessary that the interviewer assist certain well qualified, observant witnesses with the organization of their statements. A few minutes spent here will aid future readers in grasping the full significance of the information. Valuable witness interviews have been wasted because an investigator has failed to obtain a complete statement written in an understandable manner. Application of the following suggestions may help avoid this problem:

(1) Assist the witness with the mechanics of organizing the written statement. Suggest the use of an outline if the witness appears to have difficulty in organizing the report and collecting his thoughts.

(2) Encourage the witness to use drawings, sketches or photographs if they will help clarify the written statement. Drawings, sketches or photographs are merely supplements to the report and do not take the place of the written statement.

(3) Assist the witness in organization only. Do not aid the witness with aviation terminology; his statement should be written in his own words.

(4) Witnesses tend to minimize or omit observations which, to them, have little significance. The investigator's aviation background should guide him as to the significance of the information to be included in the statement of the witness. Frequently, relatively insignificant information becomes vital to the cause of the accident once the pieces of information have been put together by the experienced interviewer.

(5) A witness will occasionally omit information from his written statement that he included in his oral description of the accident. It is the responsibility of the interviewer to catch these omissions and insure that they are inserted in the written report. Permit the witness to add omissions at the end of the statement rather than rewrite the entire statement.

The Witness Group Chairman should read the completed statement aloud to the witness in the presence of the Witness Group. This precaution is necessary to insure that the written statement contains all details mentioned in the oral description and also to permit the witness to confirm that the written statement accurately reflects his observations.

q. Usually a witness is willing to sign any written statement that he has prepared relative to his observation of an aircraft accident. Occasionally a witness refuses to sign his written statement. When this situation arises, the investigators should ask the witness if all the information in the report is factual. If the witness confirms that the information of the report is factual, but that he prefers not to sign the report for personal reasons, the investigator should not press the matter further but accept the statement unsigned. The investigator should realize that at a later date, it would be possible to subpoena the witness and take his statement under oath.

Aircraft accident witnesses are frequently subpoenaed to be deposed or to testify at a Public Hearing. The situation could arise where a decision is made to subpoena a witness on the basis of his written statement. It is conceivable that the written statement, particularly in a large catastrophic type accident where there are many witnesses, could have been taken by another member of the Witness Group other than the NTSB Group Chairman. Should this situation arise, it is the policy of the National Transportation Safety Board that witnesses subpoenaed to be deposed or to testify at a Public Hearing be screened personally by an NTSB investigator. This precaution is necessary to insure that the NTSB has personal knowledge of a witness and has not judged his credibility solely on the basis of a written statement. This tends to prevent any possible embarrassment on the part of either party at a Public Hearing.

r. A professional approach to witness interviewing requires that the witness be provided with a copy of the statement. This is a common courtesy which should be afforded the witness. The copy may bring to mind additional observations the witness made relative to the accident when he has an opportunity to reread his statement at his leisure.

s. Reserve any questions which might tend to provoke a negative witness attitude for the final portion of the interview, e.g., if the witness lives on the approach path to a busy airport runway, delay asking such questions as: Did you move here after the airport was built? Does commercial jet noise bother you? Why don't you move?

4.1.1 Witness Types

There are as many variations in witness types as there are types of people. To better evaluate the observations of the witness, it is advisable that the interviewer have some knowledge of what factors affect, motivate, and influence some of these types.

a. INJURED WITNESS. When questioning the injured witness, attempt to keep the Witness Group small. Obtain the permission of the attending physician prior to interviewing the injured witness. The witness might be under sedation, in a state of shock, or in a condition where no coherent statement could be expected. The investigator should be cautioned, however, to listen to seemingly incoherent statements or ramblings of the injured witness; these ramblings may contain a clue as to the cause of the accident. The investigator should also be alert to any gestures that the injured witness might make in describing aircraft attitude or indicating emergency moves in the cockpit. Limit questions to the essentials; screen and plan them carefully. This could be the only opportunity to question the injured witness. Insure that the investigator is accompanied by another member of the Witness Group for verification of witness observations.

b. CHILD WITNESS. Children may be the most objective observers. Unlike the adult witness who analyzes what he sees and may alter his observation in favor of logic, the child will generally report what he sees, regardless of how improbable it may be. Discretion must be used particularly in questioning young children (4-7 years); they sometimes live in a world of fantasy that to them is as real as everyday adult life. The astute questioner should be able to separate fact and fantasy.

Children are particularly susceptible to leading questions. (A leading question is defined as a question which contains the answer.) Most children are quite impressed with the fact that an adult is asking them questions, and they are even more impressed when the adult listens to the answers. In order to retain the adult's attention, the child will attempt to please by giving the answer he thinks the interviewer wants. Here the leading question is particularly dangerous, since the interviewer has already given the child an indication of an acceptable answer.

c. ILLITERATE WITNESS. The interviewing of the illiterate witness may present a delicate situation. Many people who are illiterate prefer to keep it a secret. Should this situation exist, question the witness individually to avoid any possible embarrassment. If facilities are available, it is preferable to have the illiterate witness dictate his statement; however, the interviewer may write the statement for the witness and read it back to him for verification. The interviewer should be a witness along with another member of the Witness Group when the illiterate makes his mark.

d. "KNOW-NOTHING" WITNESS. The "Know-nothing" witness fears involvement, and even though he has witnessed the occurrence he prefers to remain in the background and not get involved. This type can sometimes be approached by stressing the need for aviation safety and by appealing to his humanitarian nature and public responsibility.

e. PREJUDICED WITNESS. The prejudiced witness may hate aviation, consider it to be dangerous, and feel that aircraft should be abolished. He believes aircraft fly too low, make too much noise, and are a general public nuisance. This individual may be encouraged to give a statement by sympathizing with him and listening to his complaints.

f. INTOXICATED WITNESS. The intoxicated witness should be listened to, but his written statement should not be taken. Individuals often say things under the influence of alcohol that they would not say if sober.

g. SUSPICIOUS WITNESS. The suspicious witness guards his privacy and resents any intrusion by the public. He is suspicious of government investigators, hates publicity, and in all probability would prefer not to give a written statement. This witness may be encouraged to give a statement by stressing the importance of aviation safety and by convincing him that his help is needed. Present investigator credentials, and try to resolve any fears or suspicions the witness might have relative to giving a statement.

h. TALKATIVE WITNESS. The talkative witness is usually the type of individual who is delighted to be the center of attention and will talk for hours concerning his observations. Impress upon this witness the need for a businesslike interview, the importance of aviation safety, and the fact that you have other witnesses to contact. The boasting witness also falls within this category. Impress upon him the need for facts and that any stretching of these facts might mislead government investigators as to the actual cause of the accident.

i. TIMID WITNESS. The timid witness is the type who requires moral support and encouragement. This witness is frequently insecure, discounts his own importance, and fails to see why any information that he has would be of interest to anyone else. This category often includes the foreignborn witness. Allow the witness to write his statement in his native language, permit him to dictate it to a translator, if he prefers. Allow him to write his statement in private, gain his confidence and be empathetic.

4.2. Factors Affecting Witnesses

Certain psychological factors tend to influence witness observations. It is advisable that the interviewer have some knowledge of potential motivating factors to better understand why witnesses report as they do.

a. Witness reporting reliability is partly dependent upon intelligence. However, reporting accuracy is not as apparent in observation as in the area of ability to recall, and in the organization of thoughts. The less intelligent witness tends to have difficulty in recalling specific detail simply because it failed to interest him. He will also have difficulty in organizing his thoughts and presenting his observations in a coherent manner. No witness should be overlooked on the basis of apparent lack of intelligence or as a result of age. No significant variation has been found in contrasting the accuracy of adult female and male observations.

b. Emotion and excitement tend to produce decided distortion and exaggeration, especially in the witness' verbal description of an occurrence. The witness who is awaiting the arrival of relatives at the airport is observing aircraft taking off and landing. Emotion will tend to influence the description of an airplane that crashes, if he believes that a loved one is aboard. Accuracy depends partly on the observer's mental state at the time, and partly on the complexity of the situation in which the events occur.

   Exaggeration tends to creep into the interview after a witness has repeated his observations several times, or has been given time to reflect on the events. He can be compared to the fisherman who in describing the fish that got away, adds a few inches to the length of the fish each time the story is told. Witnesses tend to fill in blanks or voids in their observation, after they have had time to apply logic and reason. They temper their statements in the hope that their observations will be accepted by the interviewer.

c. A common witness failing is "transposition." The witness reports all the facts, but places them out of sequence with the actual occurrence. The experienced investigator should pick this up and attempt to have these areas clarified when the witness prepares his written statement.

d. Omissions are common in witness statements simply because the witness does not consider certain information important. Omissions concerning details of an observation have been found to be most common in the free narrative type report, i.e., the witness is asked to prepare a statement of observation without the benefit of questions in specific areas to describe engine sound, altitude of the aircraft, attitude, weather at the time of observation, etc. Omissions are more common in the free narrative type statement than in the completion type.

   The "completion" or "interrogatory" type statement, as contrasted with the "free narrative," asks the witness to comment on specific areas of observation, such as weather, proximity of other aircraft, altitude of the aircraft, color, etc. The completion type witness questionnaire covers a broader area of observation than does the free narrative, but it also leads the witness to comment in areas where he had no previous impression. Additions are more common in the completion type questionnaire, since the investigator has given the witness a clue to what information he desires. A combination of the free narrative and interrogatory type statement is usually satisfactory for aircraft accident investigation.

e When a number of witnesses reflect general agreement in describing an occurrence, the circumstances may, in general, be considered correct. Exercise caution, however, since psychological experiments show that there is a strong tendency for the same detail errors to appear in testimony of different individuals.

f. Witnesses tend to be particularly astute and perceptive in areas of observation in which they are personally involved, e.g., witnesses on the ground, watching a co-owner of an aircraft taking their relatives up for a ride, will probably observe the aircraft more closely than individuals who have no personal interest in the safe operation of the aircraft.

g. A witness, like anyone else, tends to have his thoughts disrupted when a strange event interrupts the familiar. A lecturer, in reciting a prepared text, occasionally has difficulty getting back on the subject once he has been interrupted by a question from the audience. Witnesses, like the lecturer, need time for readjustment. Witness reports tend to be inaccurate during this period of readjustment. For example, a witness sees an aircraft approaching for a landing; the plane yaws to the right twice, the right wing drops, the wheels start to retract, there is a power application, the right wing strikes the terrain momentarily, recovery is made, and the plane bellylands in a flat attitude. A witness observing the approach expected the aircraft to continue the approach and make a normal landing. The witness had his train of thought interrupted by unfamiliar events. The witness reported that the plane made a wheels-up landing during an attempted go-around. During his period of readjustment, the witness missed many of the fine points preceding the wheels-up landing, such as the plane yawing, the dropping of the right wing, and the retraction of the wheels.

h. Witnesses who have sustained a frightening or traumatic experience often have difficulty recalling even the most vivid events. This may be a result of the natural tendency of the mind to dispel or push unpleasant thoughts back into the subconscious as a protection against uncomfortable and upsetting memories. Many times the pilot of an airplane which has crashed, will recall nothing more than "during the approach everything appeared to be normal."

i. In establishing witness credibility, the investigator should be cautious, and be aware of the interviewer tendency to interpret ambigous answers in accordance with the investigator's particular beliefs, opinions, or prejudices. For example: The temperance advocate, when interviewing a group of Skid Row occupants, attributed their misfortunes and current social status primarily to their excessive use of alcohol. A psychologist who was completely unbiased interviewed the same group; he attributed their situation to alcohol in less than 50% of the cases. Interpreting circumstantial evidence as pilot error should be guarded against, particularly by the investigator who, as a well-qualified, accident-free aviator, shows little sympathy toward pilot incompetence.

j. The interviewer should be aware of the witness tendency to underestimate long distances or periods of time, but to overestimate short distances or periods of time.

This section and the previous section, 4.1.1 Witness Types, have probably raised questions in the investigator's mind concerning the reliability of witness observations. Before accepting witness statements as 100% accurate, the interviewer should be aware of:

a. Hazards in accepting as reliable even the most obvious and sincere statement.

b. The more common sources of errors in witness observations.

c. The importance of securing from the interviewee a complete free narrative report of the occurrence, before attempting to question the witness in detail.

5. The Report

The witness phase of the aircraft accident investigation concludes with the preparation of a written report. The report is usually prepared by the Witness Group Chairman. It is prepared in two parts, a ***Factual*** and an ***Analysis.*** The *Factual* is intended as a public document; the *Analysis* is intended for within-agency use only. (Only the Factual will be discussed in this section.) When the NTSB does not use the Team Concept in the investigation of an aircraft accident, the Investigator-in-charge acts in the capacity of Group Chairman for all Groups, the Systems, Powerplants, Structures, Human Factors, Witnesses, etc. In this situation, witness statements merely become a part of the Investigator-in-charge report, and reference may be made to witness observations in reporting the accident investigation to the reader. The Team Concept investigation requires the submission of a report based solely on witness observations. This report is prepared by the Witness Group Chairman. Ingenuity plays an important part in the preparation of the Witness Group chairman's report. The Witness Group Chairman may supplement his written report with various clarifying documents, for example:

a. Witness location chart.

b. Relief map.

c. Pertinent photographs.

d. Probable flight path as described by witnesses.

e. Passenger seating chart.

f. Originals of witness statements.

The Witness Group Chairman's objective is to communicate the findings of the Witness Group to the reader. He attempts to:

a. Acquaint the reader with what the witness observed.

b. Determine the activity of the witness at the time the observation was made.

c. Record significant environmental factors at the time of the occurrence.

d. Qualify the witness.

How the investigator communicates these objectives is a matter of individual skill. The investigator's written summary of witness statements must, however, be factual. Witness observations should be reported via significant extracts from witness statements. The witness should be quoted, and no attempt should be made by the writer to paraphrase statements. When leading the reader toward the causal area in the factual report, refer the reader to key areas or significant statements made by witnesses in their written statements.

NTSB policy dictates that no analysis, conjecture, or opinion shall be included in any factual report. This requires that the Witness Group Chairman reserve any analysis of witness statements for the analysis section of his report. Conflicting witness testimony should be resolved with the aid of substantiating evidence, if conflicting testimony cannot be resolved with facts, so state, and analyze any possible reasons for conflict in the "Analysis."

6. Analysis

The gathering of the witness evidence comprises about 50% of the witness phase of the accident investigation. The success of the witness phase hinges on the remaining 50%, that is, the ability of the investigator as an analyst to apply his aviation knowledge to the seemingly unrelated observations of lay witnesses and to emerge with possible contributing and causal factors. For example, witnesses in observing the inflight breakup of a large jet aircraft reported the following: objects separated from the aircraft, white smoke, a flash followed by black smoke, an explosion a few seconds after the flash. The aircraft accident investigator should consider that sightings reported as white smoke may have been fuel vapor from ruptured fuel cells, and that the flash and the later reported explosion were possibly associated.

6.1. Purpose of Analysis

The purpose behind analyzing witness statements, as opposed to accepting them at face value, is to:

a. Translate layman observations into possible causal factors.

b. Evolve order and logic from apparent confusion.

c. Corroborate facts by coordinating witness information and other findings.

d. Evaluate witness credibility.

e. Evaluate the witness as a potential Public Hearing participant.

6.1.1. Techniques and Aids

Various techniques and aids are available in the analysis of witness statements.

a. The investigator must take into consideration witness preconceptions and prejudices to determine whether they had a bearing on the validity of the witness' statement.

b. Witness statements should be analyzed from the standpoint of personality. Is the witness a publicity seeker, crackpot, or an extrovert? Is he hostile toward giving an interview? Is he reticient toward submitting a statement?

c. The analysis of witness statements by aviation specialists, such as aeronautical engineers, aerodynamicists, powerplants specialists, systems specialists, et al, may provide information in specialized areas.

d. The analysis of witness statements, applying the sight/sound time differential, may confirm the sequence of a flash and an explosion.

e. The investigator should be certain that what the witness has told him is factual and not conjecture or opinion.

f. Witness statements must be analyzed in relation to what the witness was doing at the time of the observation. What first attracted the attention of the witness? Was the witness alone or did someone else direct his attention to the occurrence? What was the surrounding noise level at the point where the witness made his observation? To what degree was the witness concentrating? Was he eating, sleeping, or engaged in conversation?

g. The position of the witness or the point from which he made his observation could influence what he reports. For example, a witness looking into the sun sees only a silhouette, whereas a witness with the sun at his back might be able to discern the color of the aircraft. Any observation made through glass which is wet tends to distort the vision of the witness. Heat waves radiating from the surface of the earth tend to reduce the clearness of an observation. The possibility of the witness experiencing an illusion as rotation versus oscillation must be taken into consideration.

h. Psychological factors must also be taken into consideration when interviewing the witness. For example, is the witness emotionally involved? Is the witness prejudiced toward aviation? Could the witness have been influenced by other witnesses?

Never underestimate the value of any detail in investigating an aircraft accident. The investigation is particularly intriguing and challenging when approached through the human element – witnesses. A slipshod job in the witness phase may overlook a suspect area, delay the cause finding, or even mislead investigators to the extent that the probable cause determination is prolonged. The objective is to coordinate the witness information with investigation findings and enable the Investigator-in-charge to place each bit of evidence in its proper sequence.

PART B — OPERATIONS INVESTIGATION

CHAPTER VI

HUMAN FACTORS

In the accident investigation it is necessary to determine to what extent the human element entered into the cause of the accident. Investigation covers the areas of incapacitation, general physical and psychological condition of the crew members, as well as environmental factors which might have affected crew performance. These activities must be coordinated with the coroner or medical examiner to insure that autopsy and toxicological examinations are completed. Another important factor in the investigation is the procedure for evacuation or survival of personnel to determine whether any design factors may have contributed to injuries or fatalities.

1. Inflight Incapacitation

The possibility of an inflight incapacitation of a crew member must be considered, for many accidents and incidents have been linked to such an occurrence. Incapacitation can range from the discomfort of an upset stomach to complete collapse from acute food poisoning, or a coronary attack. Any physical problem which distracts the crew member from his duties may result in an accident. Coordination with the Operations Group in determining preflight activities of the crew may furnish valuable leads.

1.1. Physical Records

A review of the records of physical examinations of crew members should be completed to determine whether or not there was a preexisting condition which could have resulted in an incapacitation.

1.1.1. FAA Physical Examinations

The Federal Aviation Regulations require periodic physical examinations for certificated airmen. Records of these examinations are maintained at the FAA Records Center and may be obtained during the investigation.

1.1.2. Military Physical Examinations

All military crew members are required to undergo annual physical examinations. Records of these examinations are maintained by the Military even after the individual has separated from the Service. Copies of these records are sometimes most valuable in developing the medical background of flight crew members.

1.1.3. Private Physician Examinations

Investigation should determine whether or not any crew member was attended by a physician other than the one performing the required physical examinations. A crew member may be undergoing treatment for some condition which is not reflected on his physical examination record but which may have made him unfit for flight crew duties.

1.2. Autopsy

The post-mortem examination has proved to be one of the most valuable aids in establishing the existence of pre-accident incapacitation. Conditions which could have affected the crew's performance may not have been revealed during the routine physical examination but will be evident to the pathologist. The autopsy should be performed by an aviation pathologist if possible as he will be familiar with the type of information required. If an aviation pathologist is not available, be sure to discuss the purpose of the examination with the doctor making the post-mortem examination or the result may be an autopsy report which establishes the cause of death but does not recognize the possibility of an incapacitation prior to the crash. The Armed Forces Institute of Pathology has prepared "An Autopsy Guide for Aircraft Accident Fatalities." The investigator should be familiar with this document and make a reference copy available to the doctor performing the post-mortem. Extreme fragmentation, incineration, or putrefaction of aviation fatalities do not preclude an autopsy. The records reveal many cases where vital information was gained by completing the post-mortem examination under such circumstances.

1.3. Toxicology

An examination of blood, urine, or tissue of crew fatalities may reveal many facts useful in the investigation. The toxicological examination can establish whether or not a crew member was under the influence of alcohol. The presence of carbon monoxide in a significant amount in the body of a crew member could lead the investigator to a mechanical deficiency in the aircraft. The presence of drugs in his system could have resulted in changes in behavior pattern, or incapacitation, of a crew member. Exposure of the crew to insecticides or pesticides can be determined by the toxicologist. Specimens for toxicology should be packaged separately, frozen, and shipped in dry ice. If blood typing for identification purposes is required, a blood sample should be kept separate, refrigerated (not frozen) in a sterile container. The Armed Forces Institute of Pathology, The FAA Civil Aeromedical Institute, or State laboratories can perform these examinations for the investigation.

2. Crash Injuries

If the investigator properly evaluates the cause of the accident to make worthwhile recommendations as a result of investigation, it is necessary to determine the extent of crash injuries and their causes.

2.1. Physician's Records for Injured

The attending physician's records will furnish information about the specific injuries suffered by the occupants of the aircraft. The doctor also may be able to help identify the source of the injury.

2.2. Autopsies of Fatalities

The autopsy reports will establish the injury pattern for those aircraft occupants who were fatally injured. In the event a complete post-mortem examination is not performed, the pathologist may furnish a great deal of information from an external examination of the body.

2.2.1. Evaluation by AFIP

In those instances where multiple injuries result in fatalities, an evaluation of the autopsy findings by the AFIP may prove of great value. Their file of aircraft accident injuries will offer a correlation with other accidents and injury causes, thereby enabling the authorities to determine if change in the aircraft structure or interior is warranted.

2.2.2. Evaluation by Specialist

In a case where a preexisting disease or physical defect of a crew member is noted, a specialist should be contacted for an evaluation of the condition, and the relation it may have to the accident cause.

2.3. Injury Causes

One of the prime interests in determining the type of injuries is the identification of the injury source. Many relatively minor accidents have ended in fatalities because of poorly designed aircraft cockpits and cabins or inadequate escape procedures.

2.3.1. Seat Belt or Seat Failure

The seat belts should be examined for evidence of slippage at the buckle or failure of the attachment point. The seats should be checked for failures of the structure and hold-down fittings. All failures should be photographed. The cause of the failure should be determined.

2.3.2. Striking Fixed Object

In evaluating injuries, consider which fixed object the occupant may have struck while flailing around during the impact and post-impact gyrations. It is possible that relocation of some item would reduce or remove the injury hazard.

3. Post-Accident Survival

Accident records show that many survivable aircraft accidents have become catastrophies because of post-accident factors. The greatest potential hazards following the survivable impact are fire and/or drowning.

3.1. Fire and/or Explosion

When the accident occurs on land, the greatest post-impact hazards are fire and/or explosion. The prospect of adequate firefighting equipment being on hand immediately is rather remote. Smoke associated with fire constitutes a hazard because of the obstruction to vision and the toxic effects from inhalation. Many of the new plastics emit highly toxic fumes when heated.

3.2. Evacuation of Aircraft

The crucial survival factor is the ability of the occupants to rapidly evacuate the aircraft. How rapidly the evacuation can be completed depends on the number, type, and location of the emergency exits, the amount and adequacy of installed emergency equipment, knowledge, attitude, and training of the crew, and the conduct of the passengers. During the investigation, it is necessary for the investigator to examine these factors in detail in order to evaluate the adequacy of the present design requirements for emergency exits, equipment and training.

3.2.1. Route and Exit Used

The investigation will include an interview with the survivors to determine which exits were used and how the exits were reached. Quite often people do not use the nearest exit, but attempt to make their way to the door through which they boarded the aircraft. Ascertain any difficulties which were encountered in opening the exit or in using it after it was open.

3.2.2. Assistance Required

The amount of assistance which an occupant requires in leaving the aircraft could indicate a deficiency in the emergency exit design or operation, inadequate emergency briefing, or some obstruction. Complex operating requirements for the emergency exits are incompatible with the short time probably available for evacuation.

3.2.3. Length of Time Required

Thorough investigation will provide the only accurate evaluation of the amount of time which was required for all personnel to evacuate the aircraft. Compare the evidence furnished by each survivor to arrive at the true time. Statistics show that where post-accident fire occurs, not more than fifty seconds will be available for all the occupants to exit the aircraft. The number, size, type, and location of emergency exits are prescribed in the Federal Aviation Regulations, based upon the number of occupants. With high density seating and stretched versions of aircraft, demonstration evacuations are required to show that all occupants can abandon the aircraft in two minutes, using one-half the emergency exits. While these demonstrations are valuable, it must be realized that the conditions at an actual crash furnish the only valid measure of the emergency evacuation system. Aircraft accident investigation will furnish the necessary data for recommended changes to these systems.

3.3. Emergency Briefing

The Federal Aviation Regulations require briefing of the passengers before takeoff. The manner in which this briefing is given and the details covered will have a direct bearing on the passengers' use of the emergency equipment in the event it becomes necessary. Investigation should bring out how much of the briefing the passengers recall so that inadequacies may be corrected and techniques of briefing may be improved.

3.4. Performance of Emergency Equipment

The proper functioning of emergency equipment is mandatory if the maximum number of occupants are to survive. Special consideration must be given to these items during the investigation if the best possible equipment is to be developed.

3.4.1. Lights

The emergency lights must function properly if the passengers are to reach the emergency exits. Malfunctioning or inadequate lights have lead to confusion and loss of life. The survivors should be questioned as to the adequacy of the lights and any obstruction to light which they noted. A light which is adequate under most circumstances may become entirely inadequate if dense smoke fills the aircraft. In the event inoperative lights are reported, determine the cause of the failure and recommend corrective action.

3.4.2. Slides and Chutes

When the aircraft comes to rest with the exits at normal height above the ground, the slide furnishes a safe method of reaching ground level. Difficulties have been experienced in getting the chute or slide ready for use in the past due to inadequate training, poor design, or poorly worded operating instructions. It is stressed that the time available for evacuation does not allow for delays in getting the emergency exits open and ready for use. Any reports of difficulties should be closely examined and the causes corrected.

3.4.3. Exit Doors and Hatches

Difficulty in opening doors and emergency exits has existed in the past due to poor design and inadequate operating instructions. The means of opening emergency exits must be simple and obvious and must not require exceptional effort. The instructions must be clear and complete. Any deficiencies revealed in these areas require correction.

3.4.4. Ground Rescue Personnel and Equipment

The prompt response of well trained and well equipped rescue personnel can save lives. The investigative effort should include examination of the performance by rescue personnel and equipment. Deficiencies in training, equipment, or personnel should be reported. Procedures which worked exceptionally well should be widely publicized.

Part B — OPERATIONS INVESTIGATION

Chapter VII

OTHER FACTORS FOR CONSIDERATION

1. Wake Turbulence

Wake turbulence has caused several accidents involving light aircraft behind larger aircraft. These accidents generally have been associated with takeoff and landing, although there have been at least two structural failures resulting from small aircraft passing behind large aircraft away from the terminal area. The turbulence behind aircraft has been referred to as "prop wash" and "jet wash," however, tests have shown that the effects from thrust of the engine are not a factor for any appreciable distance behind the aircraft. The mass of air affected by the thrust is relatively small and dissipates at a high rate, usually within 500 to 1,000 feet, because of the high initial velocities imparted to the air.

The three basic ways that an aircraft may penetrate the trailing vortices are crosstrack, along track between vortices, and along track through the vortex center. The most severe conditions in each case will be when the penetration is at the vortex center level (Fig. B VII-1)

The penetration with the airplane crossing at right angles to the vortices tends to cause a pitching and vertical motion. The vertical loads developed in light aircraft crossing the wake of a large aircraft have been computed to be on the order of +3.2 G's to −1.2 G's with no control input by the pilot. An instinctive control reaction by the pilot could increase these loads to the extent that a structural failure could occur.

The airplane flying parallel to the vortices entering the middle of the vortex field would experience a downdraft. The decrease in rate of climb due to the vortices of a large aircraft exceeds the climb capability of the small aircraft. This settling is a hazard when encountered near the ground and it is also a hazard from the aspect that the pilot may stall the aircraft in an effort to check the settling.

The third type of encounter is perhaps the most dangerous. This occurs when the aircraft penetrates the center of the vortex core on a path parallel to the core. In this case the aircraft is subjected to a vertical airflow having a downward direction on one wing and an upward direction on the other. A light aircraft caught in one of the vortices of a large airplane would not have sufficient control capability to stop the roll if the encounter was within 1.6 minutes after the vortex was shed. It should be noted that the aircraft creating the vortex could be more than five miles away in this length of time. (Fig. B VII-2, 3, & 4)

1.1. Mechanics of Formation

The air velocities induced in the trailing vortices of an airplane are primarily a function of weight, span, forward speed of the airplane, and the density of the air. The intensity is directly proportional to the weight and inversely proportional to the wing span and speed of the aircraft. It can be seen that the greatest velocities will occur following takeoff and during landing approaches at maximum weight. Tangential velocities of 38 ft. per second have been measured and theoretical calculations indicate that higher velocities are possible. The induced flow is clockwise about the vortex from the left wing and counterclockwise about the vortex from the right wing as viewed from the rear of the aircraft. A large span wing with a small angle of attack will produce a relatively weak wake. As the angle of attack is increased the wake will increase in intensity, and the large induced velocities will cause a rapid deformation of the vortex sheet. In addition to being displaced downward, the vortex sheet begins to roll up from the edges. The rollup process causes the vorticity of the sheet to become concentrated into two vortex cores. The rolling up process is essentially completed within two to four span lengths behind the airplane.

1.2. Weather Conditions for Persistence of Vortices

A wind of more than about five knots, or convective action accompanied by atmospheric turbulence, particularly at the lower altitudes, tends to cause a more rapid decay or complete disruption of the vortices.

1.3. Location and Direction of Travel

In still air the vortices tend to settle and move downward. The vortices from a heavy aircraft move about 350 ft. per minute while those from a light aircraft move about 150 ft. per minute. As the vortices settle, they tend to maintain a constant lateral spacing until within two or three span lengths above the ground. At this distance their vertical motion is slowed, and they begin to spread laterally at a velocity equal to their initial vertical velocity. The vertical motion ceases at a height equal to approximately one-half the wing span when the airplane is near the ground. At higher altitudes the vortices stop descending 700 to 900 feet below the aircraft. Any wind which is present will affect the vertical and lateral movement of the vortices. A crosswind equal to the lateral velocity of the vortices will cause one vortex to remain stationary while the other will move downwind at its own lateral velocity plus the wind speed.

It should be noted that the vortex action begins at takeoff rotation and ceases at the landing touchdown. During flight the vortex cores will be below and downwind of the aircraft shedding them. (**Fig. B VII-1**)

2. Aquaplaning

Tire aquaplaning or hydroplaning is technically described as ***"a condition in which hydrodynamic lift force developed between the tire footprint and the fluid covered runway surface equals or exceeds the vertical reaction of the airplane mass acting on the tire, resulting in loss of directional stability or braking effectiveness.*** This means that the contact between the tire and the runway is lost as the tire rides on the film of water. The coefficient of friction which is as high as 0.8 on a dry runway will decrease to 0.3 at slow speeds and to 0.0 at high speeds during hydroplaning.

Much has been printed about the hazards of hydroplaning in regard to the length of the runway and stopping distance. Possibly of more importance is the loss of directional control which is associated with aquaplaning. When aquaplaning is encountered during a crosswind condition the situation is even more critical than a short runway, due to the fact that the use of reverse thrust will assist the crosswind in moving the aircraft off the side of the runway.

2.1. Surface Condition Necessary

The type of runway surface will determine the amount of fluid (water, slush, etc.) necessary for hydroplaning, the rougher the surface, the more fluid necessary to sustain hydroplaning.

There are three known types of hyroplaning. ***Dynamic*** hydroplaning occurs when there is standing water on the runway one-tenth of an inch or more in depth. The water acts to lift the tire off the runway. Tests have shown that the minimum speed for dynamic hydroplaning is approximately nine times the square root of the tire inflation pressure. This speed is for the onset of dynamic hydroplaning and it should be remembered that once hydroplaning has started it can continue to a much lower speed. Changing the weight on the tire has little effect on this speed as the size of the footprint changes with weight.

The second type of aquaplaning is ***viscous*** hydroplaning which occurs when the runway is damp, and results from the viscous properties of the fluid. A thin film of fluid a thousandth of an inch or so thick cannot be penetrated by the tire and it rolls on top of the film. This

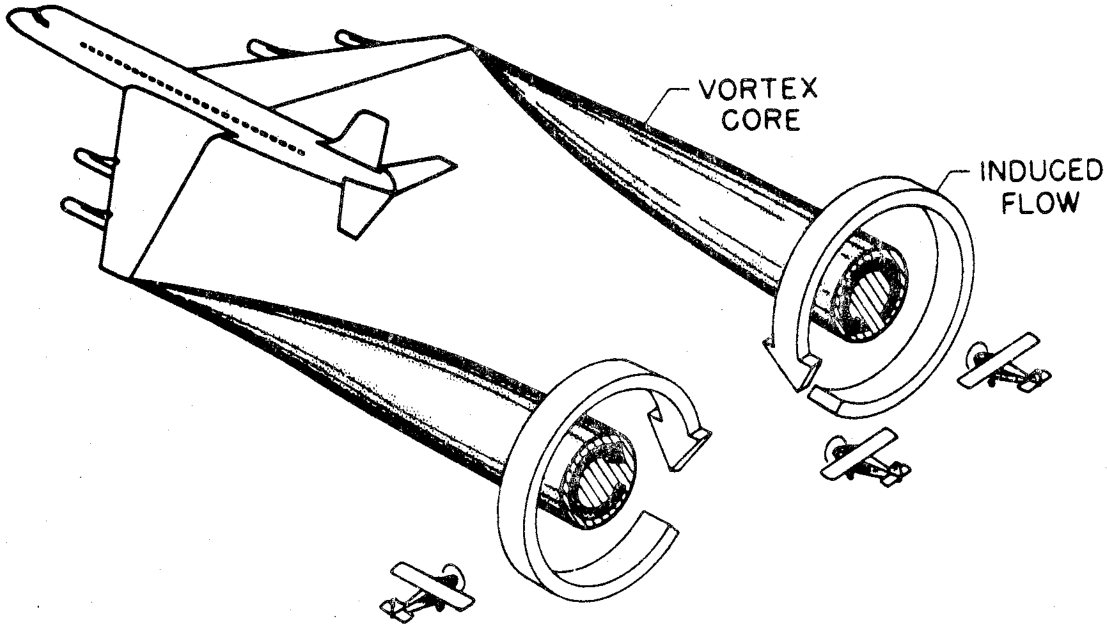
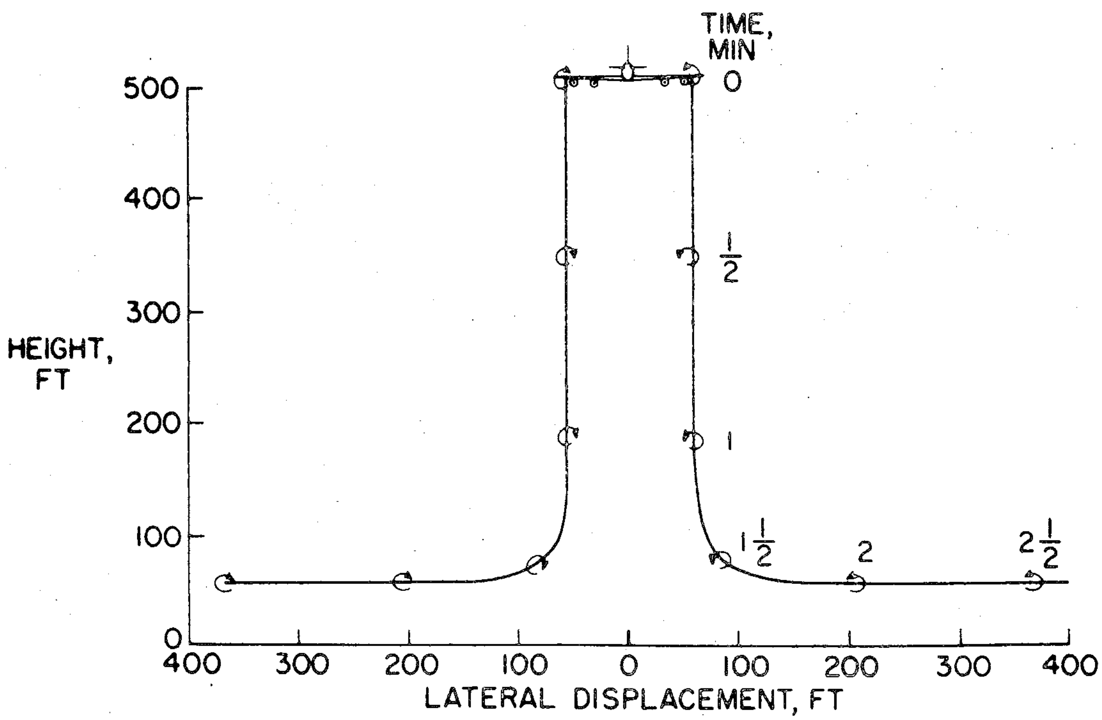
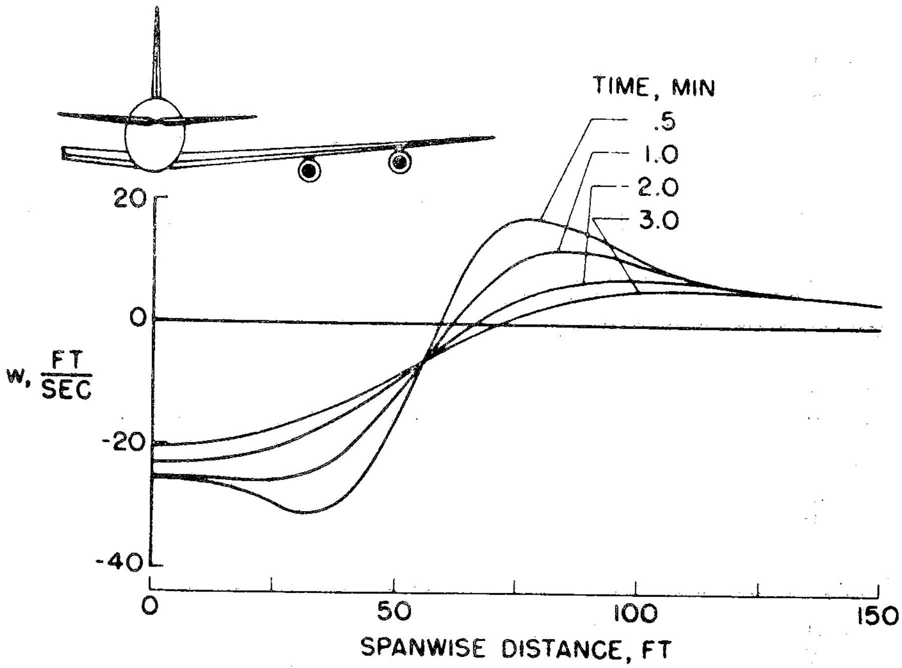


ILLUSTRATION OF TRAILING VORTEX WAKE AND TYPES OF ENCOUNTER

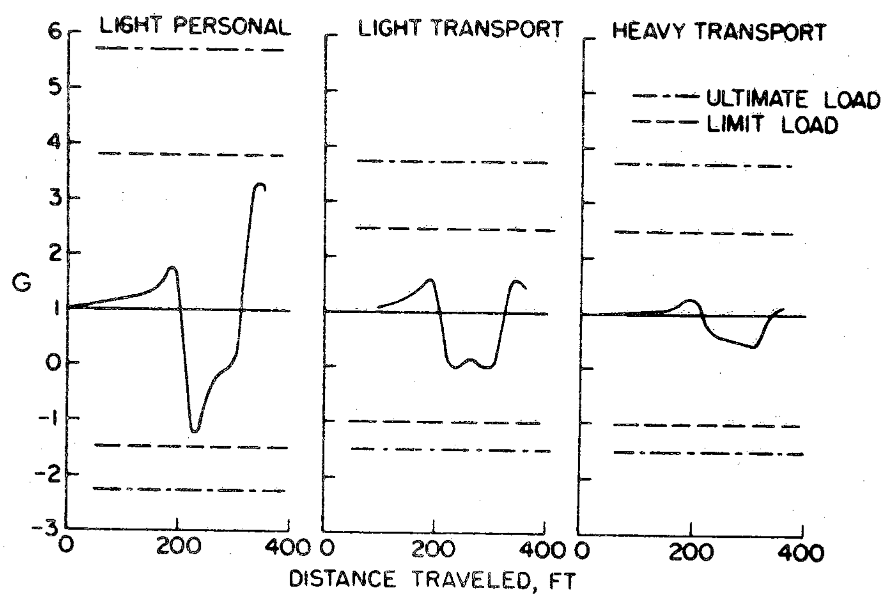


VERTICAL AND LATERAL DISPLACEMENT OF VORTEX PAIR DUE TO MUTUAL AND GROUND INTERACTIONS. CALCULATED FOR HEAVY TRANSPORT AT 160 KNOTS.

Figure B VII-1.

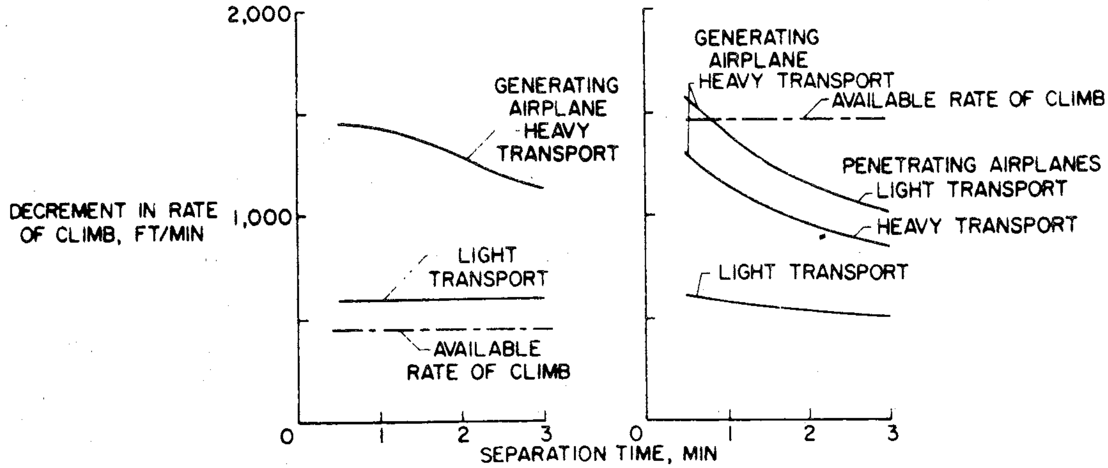


SPANWISE VARIATION OF VORTEX-INDUCED VERTICAL VELOCITY, ILLUSTRATING ATTENUATION WITH TIME IN CALM AIR. CALCULATED FOR HEAVY TRANSPORT AT 160 KNOTS.



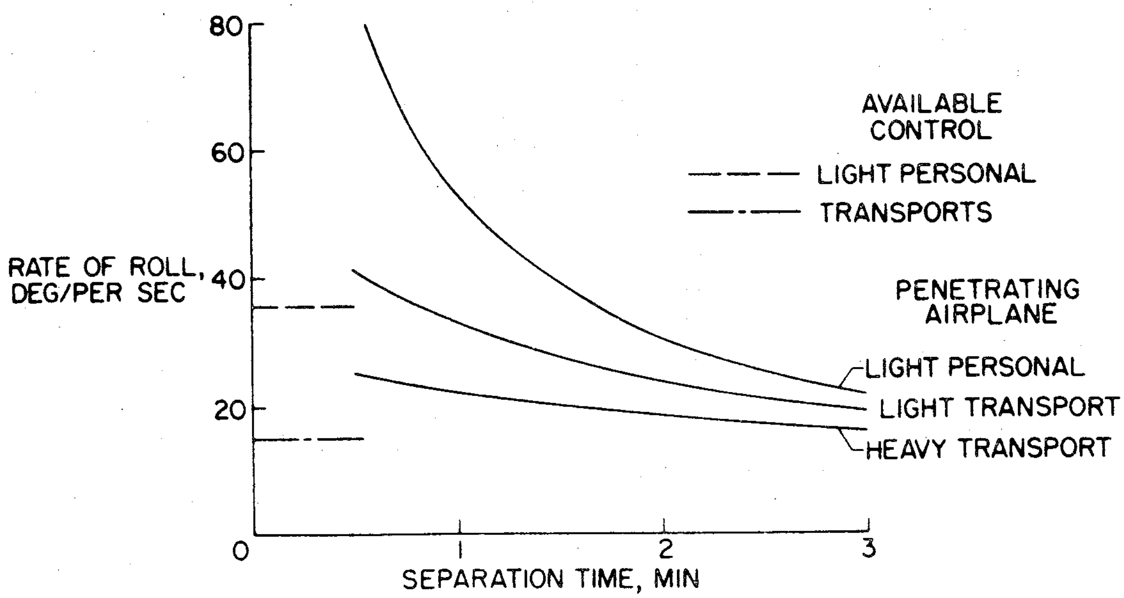
VERTICAL LOADS IMPOSED ON THREE AIRPLANES CROSSING THE VORTEX WAKE OF A HEAVY TRANSPORT. CALCULATE FOR TIME INTERVAL OF 1/2 MINUTE. DESIGN LIMIT AND ULTIMATE LOADS SHOWN FOR COMPARISON. BASED ON NO CONTROL INPUT BY THE PILOT.

Figure B VII-2.



a) PENETRATING AIRPLANES; LIGHT PERSONAL. (b) PENETRATING AIRPLANES; TRANSPORTS.

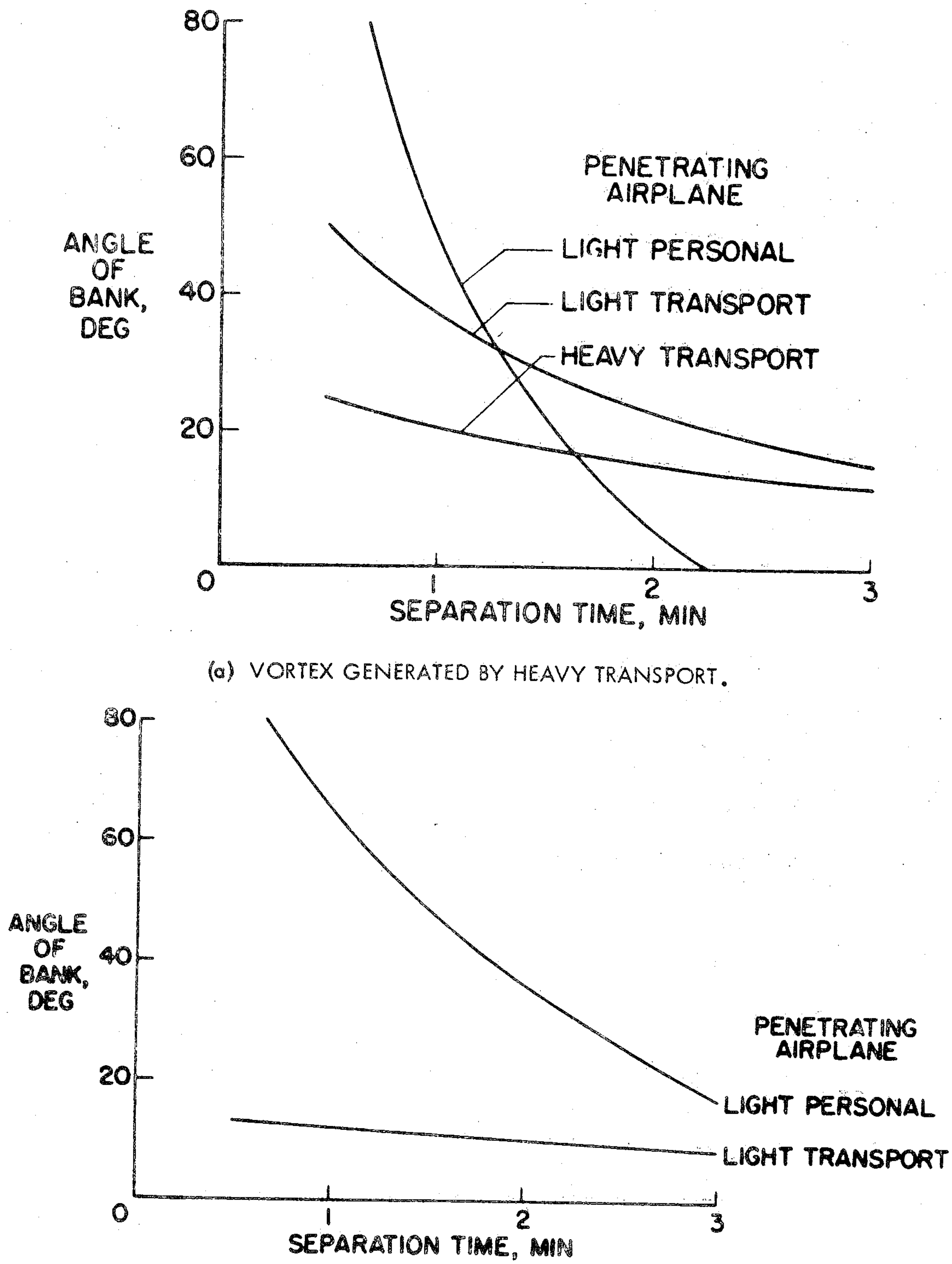
DECREMENT IN RATE OF CLIMB (SETTLING EFFECT) RESULTING FROM PENETRATION MIDWAY BETWEEN AND PARALLEL TO VORTEX. CALCULATIONS SHOWN FOR VARIOUS COMBINATIONS OF GENERATING AND PENETRATING AIRPLANES.



(a) VORTEX GENERATED BY HEAVY TRANSPORT.

CALCULATED MAXIMUM RATE OF ROLL DUE TO PENETRATION ALONG CORE OF VORTEX.

Figure B VII-3.



(a) VORTEX GENERATED BY HEAVY TRANSPORT.

(b) VORTEX GENERATED BY LIGHT TRANSPORT.

CALCULATED ANGLE OF BANK PRODUCED BY PENETRATION ALONG CORE OF VORTEX. FULL CORRECTIVE CONTROL AND TIME IN VORTEX OF 2 SECONDS ASSUMED. ASSUMED.

Figure B VII-4.

type of hydroplaning occurs at lower speeds than dynamic hydroplaning, however, viscous hydroplaning requires a smooth surface.

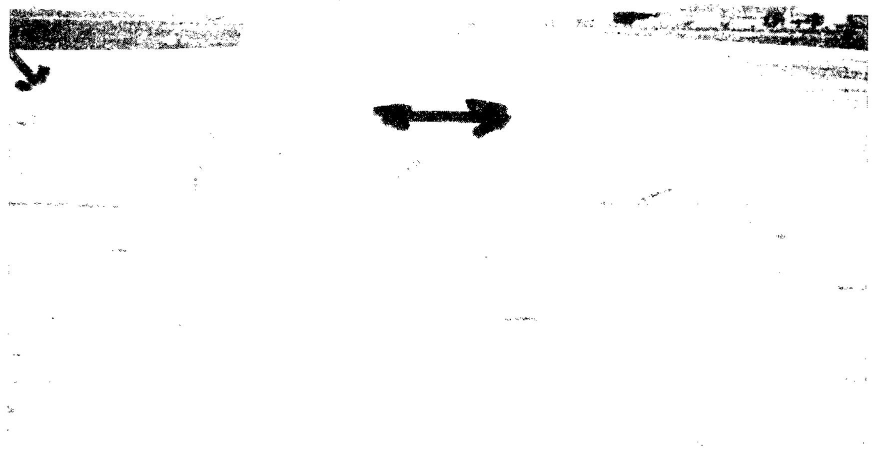
Reverted rubber hydroplaning is the third type. This type requires a prolonged skid, reverted rubber, and a wet runway surface. Reverted rubber is a condition in which the rubber takes on an uncured appearance. It is sticky and tacky due to the heat generated by friction between the tire footprint and the wet runway. This reverted rubber acts to seal the water between the tire and the runway. The water trapped in the tire footprint area is heated and converted into steam which supports the tire above the runway surface.

2.2. Tire Tread Effect

The depth and design of the tire tread greatly affects the potential for aquaplaning. The smooth tire does not furnish an escape path for the water between the tire and the runway surface, therefore, it is more prone to aquaplane. Tests made on a wet runway revealed that the test airplane landed at 185,000 pounds could be stopped in 4,250 ft. with new rib tread tire, while the same aircraft with worn rib tread tire required 6,200 ft. to stop. The dimple tread tire acts in the same manner as a smooth tire under aquaplaning conditions.

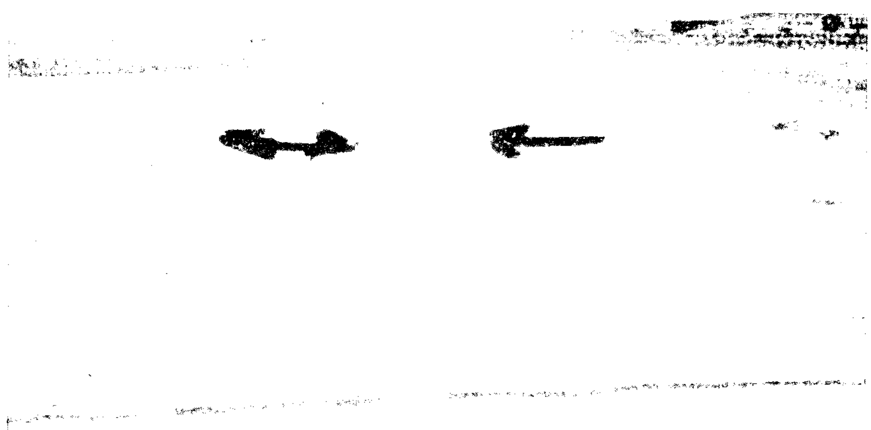
2.3. Runway Marks Left by Aquaplaning Tires

The aquaplaning tire leaves very distinctive whitish marks on the runway. These tracks are the result of the scrubbing action provided by the suction forces under the tire during aquaplaning. (**Fig. B VII-5, B VII-6.**)



Aquaplaning Marks

Figure B VII-5.



Aquaplaning Marks

Figure B VII-6.