ACCIDENT INVESTIGATION BUREAU

(AIB)

GUIDANCE MATERIAL FOR ENGINEERING DEPARTMENT

FEBRUARY 2007

FOREWORD

This manual is an internal documentation of the Accident Investigation Bureau (AIB), (herein after called **"the Bureau"**). The manual is produced to provide the information and Guidance needed to perform the statutory functions of investigating accidents/serious incidents as required by the Civil Aviation Act 2006 and the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations.

This material has been prepared for the use and guidance of accident investigators in the performance of their duties. However, it is emphasized that all matters pertaining to an investigator's duties and responsibilities cannot be covered in this material.

As a result of the dynamic nature of the industry, changes in legislation as well as evolution of new technology, there may be need for amendments. Therefore, comments and recommendations for revisions/amendments to this publication for its improvement are welcomed.

The commissioner/CEO of the Bureau is accountable for approving the contents and amendments of this material.

Commissioner/CEO, Accident Investigation Bureau

PROCEDURE FOR AMENDMENTS

The Commissioner/CEO of the Bureau shall be the only person who can authorize amendments to this Guidance Material. Investigators can initiate amendments to the manual by forwarding such proposal to the Heads of Departments who will then forward same to the Commissioner for consideration.

Amendments are by page replacement or addition or by re-issue of the complete material. The table below shall be completed to effect any amendment to this manual.

Revision Number	Date of Revision	Affected Pages	Remarks/Purpose

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ENGINEERING GUIDANCE MATERIAL

The following groups are recommended most especially during major investigation

1. Power Plant Group
2. Structures Group
3. Systems Group
4. Maintenance Group

1. POWER PLANT GROUP

The Power plants Group is responsible for documenting the engines, propellers, engine-related components, and auxiliary power units. Depending on the efforts or participation of the Structures and Systems Groups, the Power plants Group might also document the engine nacelles and/or thrust reversers.

Initial investigative efforts should be focused on documenting evidence associated with the normal operation of the engine(s). A determination of normal engine operation at impact is most helpful for the investigation and can save needless documentation, tests, and analysis later on. Operating engines, especially at high power, may leave evidence such as propeller blade cuts in the ground or trees; efforts to document this evidence should be made before disturbing the accident site. If evidence suggests that the power plant may be a causal factor, look for evidence of pre-impact fire, uncontained failures, or separation of engine or engine-relate components.

As the investigation progresses, the integrity of the engine, mounts, engine and propeller controls, and fuel and oil supply systems should be documented through visual examination or borescoping before disturbing the wreckage. Any potentially relevant and recoverable recorder/computers with nonvolatile memory of engine/system parameters and in-flight faults should be recovered for examination and potential data retrieval, regardless of their apparent condition. If conclusive evidence of normal engine operation before impact cannot be documented onsite, additional testing, disassembly, or laboratory examination may be required.

Document engine-related components relative to aircraft structure and to initial impact point. Include final position of each engine relative to the normal position of

the engine. Document engine part distribution and path, if parts were liberated before ground impact, Identify and tag all engine and engine component model and serial numbers as shown on data plates or by other identifying marks. Also document in-flight and ground fire damage.

The following is a working list of documentation items for the Power plants Group.

A. Turbine Engine (Inlet, compressor, combustor, turbine, systems, accessories and components)

1. Inlet

a. Debris, mud distribution, foreign object damage, or ice ingestion damage; scrapes and scratches and their location inside the inlet. (Objects ejected from a rotating engine sometimes leave helical tracks as they fly forward.)

b. Bird or animal remains; if found, may be sent to an appropriate laboratory for further analysis

2 Compressor

a. Degree, uniformity, and direction of rotor blade airfoil bending, leading/trailing edge blade breakage, and any rub marks on the leading and/or tailing edges of the blades; suspicious blade, disk, or shaft fractures.

b. Blade integrity or damage and, if visible, uniformity of mud coating on stators, blades, and cases (using borescope through bleed ports or inspection plates).

c. Inlet guide vane (IGV) damage. If engine utilizes variable IGVs, check inlet case and/or stator vane actuators for impact markings to determine stator position at impact.

d. Anti-ice valve positions and appropriate anti-ice plumbing.

e. Nose cone damage, displacement and condition of PT2 or TT2 probes. (PT2 and TT2 probes should be unobstructed and have anti or deice systems intact.)

f. Oil leakage in the vicinity of the front bearing.

g. Degree of compressor rotation or binding

3. Combustor

a. Integrity of combustor mounting structure

b. Combustor burn-throughs, blow outs, and large cracks. Combustors can sustain many small cracks without performance degradation. Note if distress is immediately downstream of a fuel nozzle.

c. Condition of fuel nozzle. Note any obstructions on the nozzle that may distort or disrupt spray pattern. Even minute "streaking" of spray pattern can lead to severe burner and turbine distress downstream of the nozzle.

d. Condition of igniter.

4 Turbine

a. Physical condition of all visible stages of blades and stators, including degree and direction of rotor blade bending, leading and trailing edge blade damage, rub or scrape marked, and any debris.

b. Evidence of overheats in first-stage nozzle guide vanes. Note any molten metal impinged on vanes.

c. Damage to pressure and temperature exhaust probes, cones, and struts.

d. Evidence of leakage in area of rear turbine bearing

e. Degree of turbine rotation.

f. Twisting or bending or shaft (if visible).

5. Systems, Accessories, and Components

a. Oil

(1) Condition of engine/ oil, magnetic plugs in gearbox, and oil scavenges lines.
(2) Obtain oil sample from lubricating tank. Compare to previous oil samples from same engines.

b. Fuel

(1) Main fuel and fuel control filters
(2) Fuel control linkage positions, integrity, and continuity and freedom of linkage movement. Presence of fuel in control.
(3) Obtain fuel sample

c. Bleed and Breather Air

(1) Major damage or disruptions to bleed ducts and breather tubes
(2) Aircraft/engine bleed systems for evidence of ingestion of dirt, vegetation, or debris (might provide indication of engine speed, EPR, and thrust by relating individual engine bleed operating schedules (i.e., starter, surge, air conditioning) to bleed locations where ingested material was found.

d. Accessories

(1) Accessory gearbox and tower shaft integrity (attempt to rotate N_2 rotor by means of the starter drive pad or other accessory drive pad).
(2) Check starter for evidence of in-flight engagement and possible disintegration.
(3) Check generator or alternator for evidence of high electrical loads.

e. Components

(1) Damage or displacement of various attached components and wiring.
(2) Surge bleed valve position.

B. Reciprocating Engines (Power section, Induction and Exhaust system, Accessory section)

1. Power Section

   a. Impact damage and evidence of pre-impact damage to each cylinder.

   b. Freedom of crankshaft rotation. If feasible, remove damaged cylinders or other obstructions to crankshaft rotation

   c. Condition of valves and piston heads, especially for indications of detonation or pre-ignition (as necessary, by bores cope)

   d. Remove rocker box and pushrod covers and, if possible, rotate engine to observe valve motion. Examine rocker arms, pushrods, springs, and valve keepers for breakage and wear.

   e. Check compression. If necessary, remove a representative number of cylinders to determine internal condition/power train continuity within the engine.

   f. Leak-check, removed cylinders by placing upside down and filling with kerosene. (No leakage should be present.) Intake/exhaust valves should not be damaged.

   g. Uniformity of pistons; if necessary, clean and weigh pistons. Check piston rings for movement. (Rings should not be loose, rounded, or frozen.) Note condition of cylinder, walls for piston ring marks, scrapes, etc.

   h. Amount of wear on crankshaft counter weight dampers, if abnormal.

2. Induction and Exhaust Systems

   a. Induction system blockage.

   b. Impellers/blowers (for turbo or supercharged engines). Evidence of internal blower fire, decoupling, and/or

rotational scoring. Clutches and linkages of blower controls. Oil leakage at impeller seals and inside the intake pipes. (Oil deposits indicate seal leakage and may result in heavy gray or white smoke.)

c. Carburetor, position of carburetor heat door (if installed). Examine carburetor for fuel in the bowl, float level, and general condition of jets.

d. Condition of inlet air scoops, carburetor air screens.

e. Security, rigging, and position of carburetor linkages (OF, AUTO-LEAN, AUTO-RICH)

f. Bends and folds in exhaust pipes.

3. Accessory Section

a. Fuel pump, freedom of rotation, and evidence of rotational scoring on gear housing pockets. Integrity of drives splines and coupling shafts.

b. For fuel injected engines, examine the master control, vapor vents, boost, and venture suction.

c. For twin row fuel injection engines, examine condition of flow dividers and synchronization of injection pumps.

d. Evidence of fuel leaks, condition of injector lines, and condition of control diaphragms and diaphragm actuating devices.

e. Operation and security of fuel discharge valves.

f. Integrity and continuity of tank-to-engine fuel lines.

g. "As found" positions of the main engine, fuel, cross-feed, and firewall shutoff valves.

h. Obtain fuel samples from aircraft fuel tanks, pumps, and lines, and from fuel source tanks or trucks, ad required. If necessary, obtain fuel samples from other aircraft, which were refueled from the same sources.

i. Examine oil filters for contamination and proper installation.

j. Oil pressure relief valve position.

k. Oil type and quantity. Obtain oil sample if possible.

l. Integrity and condition of oil lines. (If collapsed or kinked, determine if this is pre-impact condition.)

m. Magnetic sump plugs.

n. Condition of oil pump, ability of gear drive to rotate, and evidence of rotational scoring.

o. Oil tank and cooler condition, proper installation, and condition of vents.

p. Spark plugs, ignition harness/wires, magnetos, coiled, rotor caps, distributor electrodes.

C. Propellers

1. Blade condition, blade angles

2. Associated hydraulic/electrical/mechanical controls for each propeller.

3. Presence and spacing of any propeller slash marks.

4. Propeller governors

D. Auxiliary Power unit (APU)

E. Nacelles (coordinate with Structures Group)

1. In-flight and ground fire damage, include sooting or scorching on adjacent surfaces

2. Punctures or penetrations caused by liberated engine parts

3. Integrity and security of cowl latches.

4. Mud and debris forced into inlet cowl, or between engine accessories, and cowl panels.

5. Position of flap and cooling door actuator shafts.

6. Major scrapes and penetrations by external foreign objects (e.g. trees).

F. Thrust Reverser (coordinate with Structures and Systems Groups)

1. Post-impact position (i.e., stowed, or amount deployed) as indicated by reverser lock latches and reverser actuator positions.

2. Operating mechanisms to determine if the final position of the reverser was due to crew actions or impact forces.

3. Impact and/or fire damage to the entire assembly including the linkages

2. STRUCTURES GROUP

The Structures group Leader will usually be the point-of-contact for on-site activities. As such, he will oversee and coordinate on-site activities and assure security of the wreckage during the on-site investigation. The initial on-scene responsibilities of the Structures group leader should include restricting access to the wreckage; this may include roping or marking off the area and utilizing security guards as necessary. Arrangements should be made to restrict access to the wreckage to only those who have proper authorization. Access to the wreckage will be typically be and retrieving the cockpit voice and flight data recorders. Special care may be required to maintain the integrity of the recorders.

Basically, the Structures Group will be responsible for accounting for the total aircraft structure, documenting the aircraft damage/wreckage, and determining the pre-accident integrity of the aircraft.

The responsibility of the Structures Group will often overlap those of other groups, especially the Systems, performance, and Survival Factors groups. In absence of a specific agreement with another group, the Structures Group will be responsible for documenting the overall wreckage immediately preceding impact. Coordination with other groups will be necessary during preparation of field notes and throughout the investigation.

The Structures group leader will normally be in charge of the wreckage throughout the on-site investigation activities. He should be consulted before any wreckage is moved and should ensure that minimal damage occurs if and when it is to be moved. It may also be his/her responsibility to authorize the release of the wreckage at the end of the field phase of the investigation. Arrangements to revisit the wreckage should always be discussed in the event that additional, future documentation is necessary. Wreckage release will be to the owner or their authorized representative. The Structure group leader should emphasize the importance of taking proper safety precautions throughout the investigation. This will include the use of protective gear (gloves, masks, boots); the discharge of pressurized components (tires, struts, oxygen bottles); and the elimination or minimization of ignition sources (smoking, cutting equipment). Moreover, before any whether any hazardous materials are on board the aircraft or whether the area is unsafe for any reason. If so, the proper officials should be notified and the area decontaminated before any investigative work is conducted at the site.

A. Visual Survey of Crash Site and Surroundings

1. Conduct "walk around" inspection (arrange for aerial view if necessary)
2. Note general wreckage distribution
3. Check for and document extremities of the aircraft, condition of leading edges, and evidence of pre-impact aircraft configuration.
4. Determine pre-accident integrity of the aircraft
5. Document impact attitude (heading, flight path, etc) and crush lines
6. Document pre-impact strikes on surrounding obstacles.
7. Document fire patterns and damage
8. Formulate general plan of investigation

B. Wreckage Distribution

1. Determine method of obtaining data
   a Global Positioning System (GPS) unit
   b. Surveyor
   c. Laser transit
   d. Tape measure, compass, etc

2 Determine appropriate plotting method
   a. Airport or local map
   b. Centerline
   c. Grid
   d. Polar

3. Establish Location
   a. Latitude/Longitude
   b. Elevation
   c. Terrain characteristics

4. Obtain maps, charts, and aerial photographs

5. Identify group member(s) to help in identification of parts

6. Information required

   a. Note initial impact marks and heading

b. Note major ground scars (direction, length, depth, etc.) and obstacles struck
c. Location of significant pieces (control surfaces, cockpit, engines, "four corners of aircraft etc)
d. Limits of ground fire
e. Necessary terrain features and elevations
f. Photographs or videotape all pertinent items

7. Numbering of pieces

a. Tag/identify/number parts-include ground scars and obstacles struck
b. Number all main parts in succession from a reference point or number opposite sides of the centerline in succession (i.e., IL, 2L; IR, 2R)
c. While numbering important pieces, document the way their orientation and evidence of fire, impact angles, etc (Sketch as necessary).

C. Detailed Examination

1. Define piece/component and note its position and condition
2. Document evidence relevant to possible in-flight failure (separate ground impact damage from in-flight failure)
3. Document failure mode and sequence of failure
4. For structural failure, document fracture characteristics
5. Determine aircraft condition at impact.
   a. Control Surfaces
      (1) Ailerons
      (2) Trailing edge flaps
      (3) Leading edge devices (Flaps or slats)
      (4) Spoilers
      (5) Elevator
      (6) Rudder
      (7) Trim tabs
      (8) Other (canards, variable geometry, etc

   b. Control systems (coordinate with Systems Groups)
      (1) Position of control surface at impact (jackscrews, actuating cylinders, etc); look for witness marks.

(2) Examine all movables mechanisms for integrity prior to impact
(3) Trace control systems from cockpit to control surface for integrity.
(4) Measure travel of rudder, ailerons, and elevator

c. Fuselage- note telescoping, crushing, breaks
(1) Cockpit
(2) Entry/exit doors, emergency exits, and cargo doors (jammed, inoperative, etc)
(3) Fuel Tanks
(4) Windows (cracked/crazed, blown out, fracture patterns, etc)

d. Wings
(1) Evidence of pre-impact marks or damage
(2) De-ice or anti-ice systems
(3) Fuel system (tanks, vents, dump) for integrity or evidence of leakage

e. Empennage
(1) Pre-impact strikes
(2) De-ice boots

f. Landing gear
(1) Position
(2) Direction of failure
(3) Conditions of tires and brakes
(4) Wheel wells

6. Estimate impact attitude and velocity
(a) Flight path (angles and heading)
(b) Ground scars (Preserve and measure)
(c) Obstacles struck
(d) Terrain at principal impact and nature of terrain
(e) Terrain angle
(f) Crush line/angle

7. Analyze individual breaks and separations
(a) Check for evidence of pre-existing cracks/corrosion.
(b) Loading
(1) Type

(a) Tension
(b) Compression
(c) Bending
(d) Shear
(e) Torsion

(2) Direction

(3) Source
(a) Impact
(b) Aerodynamic
(c) In-service
(d) Explosion
(e) Fire fighting/rescue

(c) Determine need for laboratory study

(d) Include sketches when necessary

(E) Mockups.

Two-dimensional mockups are generally used when a control system problem, a fire, or an in-flight structural breakup are suspected. Three-dimensional mockups are usually limited to a critical section of the airplane, rather than complete structure, and are used to determine the locus of failure and sequence of structural breakup. No mockups should be started until the condition and location of all known parts have been documented.

1. Determine extent of mockup required
   a. Partial or complete
   b. 3-D or 2-D

2. Identify and label pieces/parts by looking for
   a. Part numbers
   b. Type of material
   c. Shape
   d. Dimension
   e. Color
   f. Marks

3. Supervise construction of support structure and reassembly of aircraft or layout of parts according to their position
4. Document damage and note any patterns on associated pieces.

(F) Fire Damage

1. Match up parts to determine what was burned
2. Be aware of parts that were not burned
3. Determine location and source of ignition
4. Determine when fire started (pre-impact, post-crash, etc)
   (a) Post crash fire may obscure or destroy evidence of in-flight fire
   (b) Document soot, heat, and fire patterns
   (c) In-sight fire may show effects of fire (soot, molten droplets) downstream of origin due to airflow.
   (d) Smoke and flames from post-crash fires will rise vertically or be blown in the direction of ground winds.
   (e) Caution- mishandling wreckage will obscure or destroy evidence critical to a fire or explosion investigation.
5. Determine laboratory study needs
6. Effects of fire
   (a) Flame temperature of in-flight fires (4600oF and above) will be greater than post-crash fires due to forced draft.
   (b) Apply evidence against known melting temperatures for materials
   (c) Soot will not attach itself to surfaces, which are over approximately 700oF.

(G) Composites

1. Found mostly on secondary structures
   a. Control surfaces
   b. Leading edges
   c. Fairings
   d. Interior Structure (panels, seats, etc)
2. Construction
   a. Skin-resists tension and shear loads
      (1) Metal
      (2) Fiber

b. Core—holds skins in place; resists buckling load
   (1) Metal
   (2) Fiber
   (3) Foam

3. For composite damage, document
   - interlaminar separation
   - direction of loose fibers
   - direction of adhesive flow lines

4. Bond failures
   a. Void failure
      (1) Indicates area that was never bonded
      (2) Smooth, clean sides between core and skin are apparent(no pull-out damage)
   b. Delaminating
      (1) Previously bonded
      (2) Slightly rough sides
   c. Adhesive failure
   d. Cohesive failure
   e. Resin Failure

5. Impact damage
   a. Localized breakage on leading edge
   b. Small areas of skin/adhesive separation
   c. Torn/crushed core
   d. Use gloves to handle (small slivers may penetrate skin)
6. Fire damage
   a. Amount of composite burned can indicate temperature
   b. Resins may burn, leaving fiber/cloth (approximately 1200oF)
   c. Dangerous residual particles could be inhaled (respirators may be necessary in closed areas)
7. Determine need for detailed laboratory analysis
   – field examination may be insufficient)

3. SYSTEMS GROUP

The system Group will be responsible for:

A. Cockpit Documentation

Documentation of post impact control lever positions, switch positions, and instrument readings, and recovery of flight planning information and other documents related to flight operations which are found in and around the cockpit (coordinate with Operational Group).

1. No other groups or individuals will be allowed in cockpit area until system documentation is complete. Coordination is required with other groups.

2. Describe actual condition – do not state "destroyed by fire or impact". Specify fire damage and extent of mechanical deformation. Resolve what documentation of normal or abnormal system operation can be verified by the evidence, despite the fire damage.

3. Do not move levers or switches until written and photo documentation is complete and group concerns are resolved

4. Use drawings from manuals to keep track of object identification.

5. The following information should be obtained where possible:

   Positions of all switches
   Position of engine/propeller control levers
   Position of flap and gear levers
   Readings from all instruments
   Settings of all bugs (e.g. heading, airspeed, altitude, EPR)
   Frequencies and settings from all radio tuning panels including volume controls.
   All trim settings
   Condition and documentation of electrical/circuit breaker panels.

NOTE: Key instrument and switch positions should be photographed before any effort is made to analyze those positions. Soothing or glass damage may temporarily obscure instrument readings but readings may be obtained by cleaning or removing the glass.

B. Subsystem Documentation

Determination of system integrity, component condition, actuator and valve positions, etc. priority and degree of concentration on a particular system will be dependent upon particular accident circumstances. Coordination with structures Group is a must (to coordinate access to the wreckage and to coordinate parallel group efforts). Documentation of the following subsystems and items is typically the responsibility of the System Group unless otherwise assigned by the IIC.

Air Conditioning – air cycle equipment, valves, bearings, impellers, ducting connections, thermocouples, switches.

Auto Flight – cockpit control settings, servomotors.

Communications– Operation and indications.

Electrical Power – wire integrity (continuity, shorts, arcing), switches, circuit breakers, electric generators.

Fire Protection– extinguisher bottles, discharge indications.

Flight Controls – pre-impact position and integrity, travel of control surface, control cable continuity.

Hydraulic Power– hydraulic fluid quantity and quality, valves, pumps, filters, tubing.

Ice and Rain Protection – anti-icing ducting, wiper controls. Instruments – needle imprints, internal gears, non-volatile memory.

Landing Gear – actuators, up/down locks
Lights - light bulb filaments, interior/exterior lights
Navigation– frequencies, control knob positions.
Oxygen– crew/passenger oxygen bottles, lines, generators.
Pneumatics – ducting, joints.
Vacuum/Pressure

1. Before documentation, ensure that immediate needs for preservation are being met (e.g. cover avionics if rain is forecast). Photograph the area and details first.

2. Use schematic diagrams from applicable manuals to document components and systems as they are identified

3. Describe location and actual condition of each component as found. Do not move or change position of actuators, valves, switches, or controls until documented.

4. Measure actuator extended length. Be certain to be specific in describing points of measurement. Photograph actuators, valves, switches and controls that are potentially relevant to the accident. Don't assume "non involvement" of any component.

5. Record the following information from each component that is potentially involved, when possible:

   Nomenclature
   Manufacturer
   Part Number
   Serial Number
   Position in aircraft

6. Determine whether electronics/avionics may have recoverable memory. Recover electronics/avionics with 12-18 inches of wire harness, rather than simply unracking the avionics box. Only disconnect at the plug connection if airplane is salvageable and memory retrieval is not possible or necessary.

C. Offsite Component Testing

If a particular subsystem component, or components, is critical to the resolution of the accident, a more detailed investigation may be required. This may include bench testing and disassembly. The group members will be expected to participate in such activity at the determined places and times. Components testing should not begin until an appropriate test plan has been developed and the group is briefed on its content. Test results will be documented in such a way that the test plan and results will be clearly understood by the researcher.

4. Maintenance Group

The maintenance records group is responsible for reviewing all maintenance records to ascertain the service and maintenance history of an aircraft involved in an incident or accident. The data will address the approved maintenance program, indicators of the adequacy of inspection, airworthiness directives, and service bulletin compliance that might be related to the occurrence, time, and cycles on the aircraft engines and applicable components, and time or cycles since overhaul or major inspections of the airframe or critical system components. This group's function will require coordination with the operator and this may be done at the maintenance headquarters of the operator. The investigation may extend into design, certification, manufacturing, and/or maintenance management. The areas could include standards and procedures, quality assurance, equipment and facilities, and maintenance personnel selection and training issues.

The collected data from all these areas of interest will be studied to determine the effectiveness of the maintenance system and its potential relevance to the issues associated with the accident. The investigator must consider operator differences and the regulations that govern them. It is therefore important to review the approved maintenance program with respect to the applicable operating specifications and rules.

The significance of improper or inadequate maintenance, servicing, or inspection of an aircraft becomes most evident after a thorough review o the relevant records. These data may indicate a need to explore further any records relative to the aircraft type under investigation. The adequacy of a maintenance program should never be assumed based upon the size or apparent sophistication of its operation or records system. The Maintenance Records group leader will alert the investigative team to any system or component that becomes suspect through the records review. In this manner, the Maintenance Records Group will reduce the potential for overlooking possible system or "hardware"-related accident causes. In general aviation accidents in which extensive modifications to the aircraft have been accomplished, the investigative process is expanded. This expansion will include modification and engineering data relative to supplemental type certificates (STC) and major repairs and modifications.

During the investigative process, the maintenance group should focus on the following specific objectives:

1. Collecting a sufficient amount of general maintenance history information to serve as a reference database for all members of the investigative team.

2. Researching and evaluating the maintenance aspects of specific issues presented to the maintenance group by other group leader or the IIC

3. Proactively analyzing previous maintenance activities and trends associated with the accident aircraft in an attempt to uncover issues that may not be discernible to other groups because of the destruction of systems and structures evidence

4. Reviewing the operator's repair station's, and contract maintenance provider's programs, policies, procedures, and work environ to determine whether any of these may have contributed to the accident sequence

5. Evaluating the NCAA oversight of the subject operator to determine whether any of these may have contributed to the accident sequence

Group Composition

At a minimum, the group should consist of the group leader, an NCAA participant, and a representative from the airframe and powerplant manufacturer. The group leader should also consider including an individual from the operator's maintenance quality assurance department or maintenance engineering department. This individual should have the ability to assist in deciphering aircraft maintenance log write-ups and have a good overall understanding of the operator's maintenance program. The group leader should also request that the operator to respond to the numerous requests for data retrieval and tracking system clarification that will be made. The request can also be made through the IIC.

Notification

Because the maintenance group will need to quickly gather information about issues that may provide direction for the IIC and other groups, the group leader should ensure that either he or the IIC notify the aircraft owner/operator about impounding all maintenance and service records pertaining to the accident aircraft. The owner will be responsible for the records' safekeeping until the group leader of the leader's representative arrives to take possession. These records may extend back to the date of the aircraft's manufacture.

During the initial contact with the owner/operator, it should be stressed that any and all records pertaining to the accident aircraft must be retained for AIB, photographing, or copying.

Before reviewing documentation that relates specifically to maintenance performed on the accident aircraft or the operator's maintenance systems, it is essential that the group leader brief the group about the maintenance program and activities they are about to review. Documents to be provided

1. Parts "D" and "E" of the Operating Specifications

    a. General aircraft maintenance requirements
    b. Short-term escalation authorization
    c. Leased aircraft maintenance program (Nigeria)
    d. Leased aircraft maintenance program (foreign)
    e. Parts-borrowing authorization/program
    f. ETOPS maintenance program authorization
    g. Maintenance inspection time limitations
    h. Minimum equipment list (MEL) and configuration deviation list (CDL) authorization/program
    i. Weight and balance control procedures

2. The operator's General Maintenance Manual

3. A diagram (with names) showing the structure of the maintenance management system. This diagram should delineate management positions down to the level of shop supervisor for each shop (e.g., avionics, engines, etc.)

4. A list of all maintenance and non-maintenance bases (to include the maintenance level classification of each base)

5. A list of all contract maintenance providers (to include maintenance level authorization and the primary point of contact at each station)

6. A copy of the components repetitive inspection list for the accident aircraft model.

7. A copy of the conditional inspections list for the model aircraft involved in the accident. These inspections are only performed when the aircraft

involved in the accident. These inspections are only performed when the aircraft has experienced some uncommon condition (e.g., severe turbulence, hard landing, flaps overspeed, etc.)

8. A copy of the general airframe and engine manuals

9. A copy of the aircraft's flight crew operations manual

10. A list of all of the operator's aircraft by make, model, and tail number

When these documents are provided, the operator should also include the following maintenance program topics:

1. Program type. Type of maintenance program authorized and under what NCAR Part it is performed.

2. Schedule and phase inspection program. Include type of checks, time intervals, locations where checks are performed, description of splitting checks into subphases or intervals, and a list of those checks performed by contract maintenance providers.

3. Contract maintenance program. Include scope and limitations of the program, method of coordination for on-call maintenance, operator oversight/guidance, records movement and tracking of work performed.

4. Deferred maintenance policy. Include tracking process, crew notification, and deadline extension.

5. MEL and CDL policy. Include tracking process, crew notification, and deferral extension.

6. Airworthiness directive (AD) compliance program. Include tracking system, repetitive inspection compliance methods, procedure for converting applicable portions of Ads to engineering orders (EO) or engineering authorizations (EA).

7. Maintenance record-keeping system. Include type of FAA-approved system, description of supplemental systems, method of data collection/entry, tracked items/events, and data retrieval/printout capabilities.

Immediate action items

1. Perform a cursory review of the accident aircraft's maintenance log entries and maintenance history printout for the last 46 days. This review should focus on maintenance discrepancies that appear to relate to systems that are tentatively suspect based on the limited accident sequence information already available.

2. Determine if either the operator or a contract maintenance provider performed maintenance actions on the accident aircraft in the last few days. If the have, now is the time to determine if drug testing of the individuals who performed the work will be requested.

3. Have the operator complete the Aircraft and Engine History Data Sheet.

IN-depth review of items specific to the accident aircraft

Review the following items for the accident aircraft:

1. Aircraft maintenance log for the last 90 days.

2. Aircraft maintenance history data printout for the last 120 days.
3. All non-routine work cards for the last periodic check and for the last "D" or "C" level Heavy Check. For a transport-category aircraft, there will probably be hundreds of cards from a "C" or "D" check.

4. All overhaul records for the aircraft's engines, propellers, and primary system components.

5. Routine work cards. If there is a suspect system or component, the routine work cards signed off during the last applicable inspection should be requested. Each action box on the relevant card should be reviewed for inspection findings and corrective actions taken.

6. Conditional inspection history for life of aircraft. Because these inspections are only performed if the aircraft has experienced a special or unusual condition, it is important to search the work cards for evidence of damage and repairs.

7. Contract maintenance before final flight. Talk directly to the contract shop supervisor to determine if maintenance was performed. The

operator may not yet be aware of all contract maintenance actions taken before the aircraft's last flight.

8. Aircraft damage report. This might be the only place that will say if the aircraft was damaged while out of service (e.g., service truck colliding with engine pylon while aircraft is parked at gate overnight).

9. List of major repairs and alterations. In one case in which the aircraft experienced an in-flight loss of control, reviewing this list helped to determine that the accident aircraft was the only one in the operator's entire fleet with the newest thrust reverser modification.

10. A list of all STC work that has been accomplished on the accident aircraft.

11. Engine condition monitoring data for the last 46 days. There may be a formal or informal program or just untracked data recorded on the daily aircraft maintenance log. If you are provided raw data only, ask the operator if it can display the data in a graphic format. Provide this data to the Powerplants Group.

12. Engine change log. This log will show you which aircraft within the operator's fleet the engines on the accident aircraft have been on in the past. If there is a suspect engine, you can review its maintenance history for the period it was on the previous aircraft.

13. Engine and airframe vibration monitoring data. Collect and provide to Powerplants and Structures groups.

14. List of MEL/CDL items currently being carried on the accident aircraft. Determine from the master MEL the category (A,B,C, or D) of any carried items, and whether any B or C category items are on an extension.

15. List of all Ads for the accident aircraft. Confirm compliance date and methods. If there is a suspected problem with a component or system that has any Ads written against it, review a copy of the EO or EA that was written by the operator to carry out the applicable portions of the AD.

16. Service difficulty reports (SDR) or maintenance defect reports (MDR) for any suspect component. Be very specific and narrow the request as much as possible (there may be thousands of MDRs for a specific model of aircraft.

17. List of service bulletins/letters, by title that applies to the accident aircraft and its components.

18. Operator's list of cancellations/diversions/deviations for the accident aircraft (and all others of the same model) for the last 6 months. If possible, have data listed separately for each maintenance base.

19. Weight and balance sheet. If weight or cg might be an issue, check the compliance date, location, and method used for the last weight and balance check. If electronic scales were used, check the method and date of calibration and certification.

20. Import and return-to-service documentation. If the accident or its engines were imported from a foreign country in the recent past, review all imports process documentation and the actions taken qualifying the aircraft to be returned to service. You may have to contact and possibly interview the involved designated airworthiness representative (DAR) who handled this process. You may also need to contact the NCAA office that provided oversight of the DAR.

In-depth review of operator's programs, policies, and work conditions.

In addition to the group's review of the accident aircraft's maintenance history, the following programs, policies, and conditions should be considered for review:

1. Maintenance training program. Look at the in-house training program for engine, airframe and systems, to include curriculum, instructor qualification/training, participation percentage, recurrent training on special systems, and record keeping. Determine percentage of participation in manufacturer's resident training course. Interview workers to get their opinion of initial and recurrent training. Also look at the in-0house training of the maintenance inspectors.

2. Environmental conditions/human factors. Evaluate the work conditions for line and hangar maintenance personnel (day and night shifts). Take a look at lighting, temperature, ventilation, dryness, noise, hazards (e.g.,

weak or unstable work scaffolds), size and roominess of work area, hazardous waste collection and disposal. Review assigned shift consistency, amount of overtime, and rest break adequately. Interview workers to get their opinion about relationships with supervisors, management, parent company, and unions. Get the workers opinion on the clarity of manuals, work cards, and oral instructions.

3. Shift-change. Determine how workers on the oncoming shift know the previous shift left off in the performance of any uncompleted maintenance tasks. Ensure the program is really being used and that it identifies any components or hardware disconnected or removed simply to gain access to the component being worked on.

4. Reliability program. How does the operator identify and track repeat write-ups, line and hangar maintenance rejects. (Completed maintenance tasks that were determined to be unacceptably performed at inspection sign-off), and part infant mortality (i.e., parts determined to be unairworthy when received new from the manufacturer). Get a copy of the operator's NCAA approved program.

5. Tool control program. Determine how personal and company-owned tools are accounted for after each shift change. Determine how a tool is tracked when temporarily at another base. Review the aging aircraft inspection status sheet for the fleet.

6. Supplemental Structural Inspection Program (SSIP). Review the operator's corrosion prevention control program. Make sure the required reports are being sent to the Aircraft Certification Office (ACO) and manufacturer for findings of level 2 and 3 corrosion.

7. Repetitive inspection program. Acquire a copy of the component repetitive inspection list for the model of aircraft involved in the accident. Review the program to ensure that all components for the accident aircraft are being inspected at required intervals.

8. Parts receiving program. If a specific off-the-shelf part is suspect, review the program by which the operator receives, inspects, and incorporates parts into its system. Review the documentation to make sure that suspect part was "approved" and "airworthy" when installed on the aircraft.

9. Foreign object damage (FOD) Program. Review program for hangar and line maintenance. Determine if the program is actually being used.

Review of NCAA Surveillance programme.

1. Look at the work program of the principal maintenance inspector (PMI). Document the extent of the PMIs responsibilities, percentage of time spent with operator, percentage of time spent in each major area, and any assistance provided by other inspectors). Evaluate the qualifications and experience of the PMI and any assigned assistant PMIs. Included in this review the subject individuals' pre-NCAA maintenance experience.

2. Interview line-maintenance workers, hangar-maintenance workers, and local NCAA inspectors not associated with the involved operator to get insight into the PMI's.

3. Working relationship with the operator's supervisory maintenance personnel.

The maintenance group report should cover at a minimum:

- Type of maintenance program
- List of documents reviewed
- Historical data on aircraft and engines
- Serial numbers

a. Times
b. Times since last major inspections
c. Times since last line checks
d. Selected maintenance actions and/or discrepancies, which may be relevant to findings or issues developed by other groups.

AIB Checklist

1. C. of R. Aircraft type and Mark No. registration marks, registered owner, operations of Service, Unit.

2. C. of., Number of Certificate, date of issue and last renewal, aircraft classification.

3. Date and time of accident.

4. Exact location of accident.

5. Nature of flight, whether public transport, scheduled - non-scheduled freight, aerial work, positioning, experimental private category, etc..

6. History of flight.

7. Weather conditions, forecast and actual, how forecast was obtained, conditions of light.

8. Captain's history, licences and experience (proforma to be used).

9. Crew's history, licences and experience (proforma to be used).

10. Passenger(s), injuries (Proforma to be used).

11. Loading and C.G. position, details of Load Sheet, calculated C.G. and weight for take-off and landing estimated C.G. and weight at time of impact.

12. Airborne navigational aids and/or special equipment carried including maps, charts, navigation documents and routes.

13. Ground aids available and ground aids used.

14. Control logs and/or transcript of voice recording.

15. Witness's statements.

16. Infringement of Regulations and/or control instructions operator's weather minima.

17. Date and time of coroner's inquest and findings.

18. Service investigation.

19 Rescue and fire services, action taken and by what Authority Investigating Officer's responsibilities.

20 Airframe history

21 Power Unit(s). type, Mark and history.

22. Propeller(s).type, Mark and history

23. Distribution of wreckage, diagram and photographs.

24. Fuselage, to include passenger safety aspect, i.e. seat straps, emergency exits, etc.

25. Centerplane.

26. Port main plane.

27. Starboard man plane

28. Aileron or elevons.

29. Flaps, air brakes, spoilers or slates.

30. Fin(s)

31. Rudder(s)

32. Rudder tab(s)

33. Tail plane

34. Elevator.

35. Elevator tabs.

36. Flying controls (a) Power assisted control mechanism

(b) Automatic Pilot.

37. Main undercarriage, nose and tail wheel.

38. Crew Compartments (a) All control settings as found.

(b Flying instruments including energizing system

(c) Seats and straps.

39. Oxygen, pressurization, cabin heater, de-icing Equipment, etc.

40. Power unit(s)

a. Installation. (a) Fuel and oil cock settings at cocks

(b) Fuel and oil contents.

(c) Specification of fuel and oil.

b. Fire in (a) air or (b) ground. Type of fire extinguisher system.

41. Safety equipment, life belts, dinghies.

42. Defects, S.T.I.'s S.I.'s etc.

43. Miscellaneous.

Civil Accidents – Damage to property in accordance with Standing Order No. 9 (series 2).

44. Interference with wreckage.

Pilot/Crew

1. Licences
2. Log books
3. training
4. periodic Checks
5. Route
6. Medical Examinations
7. Flying Hours; Total all types; This type: Day/Night
8. Flying Hours; Last Total all types; This type
9. Flying Hours; 84 days Total all types; This type
10. Flying Hours; Last Total all types; This type: Day/Night
11. Flying Hours 7 days Total types; This type; Day/Night
12. Duty Times Last 28 days
13. Duty Times Last 28 days (use the detailed forms)
14. Terms of Employment (if applicable)
15. Chief Pilot's or C.F.I.'s opinion

Operator/Owner

1. General Instructions to Aircrew
2. Operating "for aircraft type
3. Operating for particular task
4. Special-Emergency drill by cabin staff
5. Operating Limitations and restrictions notified

6. Authorization of Pilot.
7. A.O.C.

A.T.C. Services

1. Flight plan and flight plan signals
2. A.T.C. staff-licences
3. Recording tapes and transcripts.
4. All log books – A.T.C., approach, tower, F.I.R. radar etc.
5. Standing orders – A.T.C., F.I.R. tel., D/F., radar etc.,
6. Serviceability records
7. Airfield state certificate (if applicable)
8. Reports by individuals and sections.

Aerodrome

1. Standing orders – general
2. Standing orders – fire service
3. Standing orders – rescue
4. Standing orders – police,
5. Airfield state certificate, (If applicable)
6. service-log
7. Reports by services

Weather

1. Forecasts – Route/terminals/alternates
2. Actual – Route/terminals/alternates
3. Sigments
4. Broadcasts
5. Landing forecasts terminal/alternate

6. Significant changes
7. Specialists opinions/observations.
8. A.T.C.
9. Reports by order aircraft crews

Pilot/Crew

1. Statement
2. Authorization
3. Briefing (personal/other)
4. State of health and spirits
5. Duty and flight times (fatigue) – last 7 days (use the detailed form)
6. Previous flight
7. Previous flight this aircraft
8. Previous flight similar aircraft
9. Previous flight similar flight
10. Recent flying experience
11. recent flying experience this route
12. Total flying experience
13. Total flying experience this aircraft type/night/day
14. Log book/experience
15. Training records
16. Route checks
17. Licences, ratings etc
18. Last medical
19. P.M. report –pertinent information (P.M. – Post Mortem)
20. Chief Pilot or C.F.I.'s opinion of pilot

21. Flying hours – total night/day
22. Flying hours – last 84 days night/day; this type; all types
23. Flying hours – last 28 days night/day; this type; all types
24. Flying hours – last 7 days night/day; this type; all types
25. Seat and harness disposition
26. Clothing/helmet etc.
27. Previous accidents/incidents by pilot (background)
28. N. of K. (Next of Kin)
29. Legal personal representative
30. Queries – outstanding.

Owner/Operator

1. A.O.C.
2. Operations manual
3. Recommended navigational procedures, if any
4. Recommended operational procedures if any
5. Crew notes
6. Crew briefing
7. Navigation bag
8. Training records
9. Route experience
10. Crew duty times (fatigue)
11. Passenger information/state N. of K.
12. Disposition of seats.
13. Disposition of load
14. Opinion – regarding pilot/crew

15. Opinion/suggestions
16. Discrepancies
17. Queries – outstanding.

The Flight

1. Nature of
2. Flight plan navigational/operational
3. Flight plan A.T.C.
4. Flight Plan Deviation – actual
5. Flight Plan Deviations – Apparent
6. Relevant times
7. History of
8. Unusual occurrences
9. Weather forecast/actual
10. Weather – significance
11. Navigation aids – used
12. Navigation aids available in aircraft
13. Navigation aids available on ground
14. Maps/guides/operations manual guidance
15. relevant restrictions/limitations
16. Navigation and flight logs
17. Discrepancies
18. Queries – outstanding

Aircraft

1. Pre flight preparation

2. Fuel state and type
3. Loading and C. of G.
4. Dispatching details
5. Maintenance History
6. Log books
7. Special maintenance checks
8. A. P. S. form (Aircraft prepared for service)
9. Special equipment
10. Navigational equipment
11. relevant modifications
12. Recorder
13. C. of M.
14. C. of A
15. C. of R.
16. Manufacturer – aircraft
17. Manufacturer – pertinent equipment
18. Previous accident/incident
19. Previous flight if relevant
20. Queries – outstanding
21. Foreign Registered Aircraft – Maintenance clearance certificate.
22. **All Aircraft** – Permit to import aircraft.
23. **All aircraft** – Permit to operate in Nigeria.

Relevant Regulations etc

1. Ministry regulations etc
2. Operations manual

3. Flight manual
4. B.C.A.R.'s. F.A.R.'s, etc.
5. Standing orders
6. Local orders
7. Air pilot
8. Pilots/crew nots etc..

Fire and Rescue Services

1. Agency/agencies
2. Time alerted
3. Alerted by whom
4. Other times factors
5. No. Rescued
6. Method of rescue
7. Exits used and numbers per unit
8. Delays/obstructions/hazards/difficulties
9. Interference with wreckage
10. Comments
11. Reports
12. Log book records
13. Queries

Witnesses

1. Eye/ear
2. Crew/passengers
3. A.T.C.

4. A. T. C. tape recordings
5. Dispatches
6. Fire services
7. Aerodrome staff
8. Operations staff

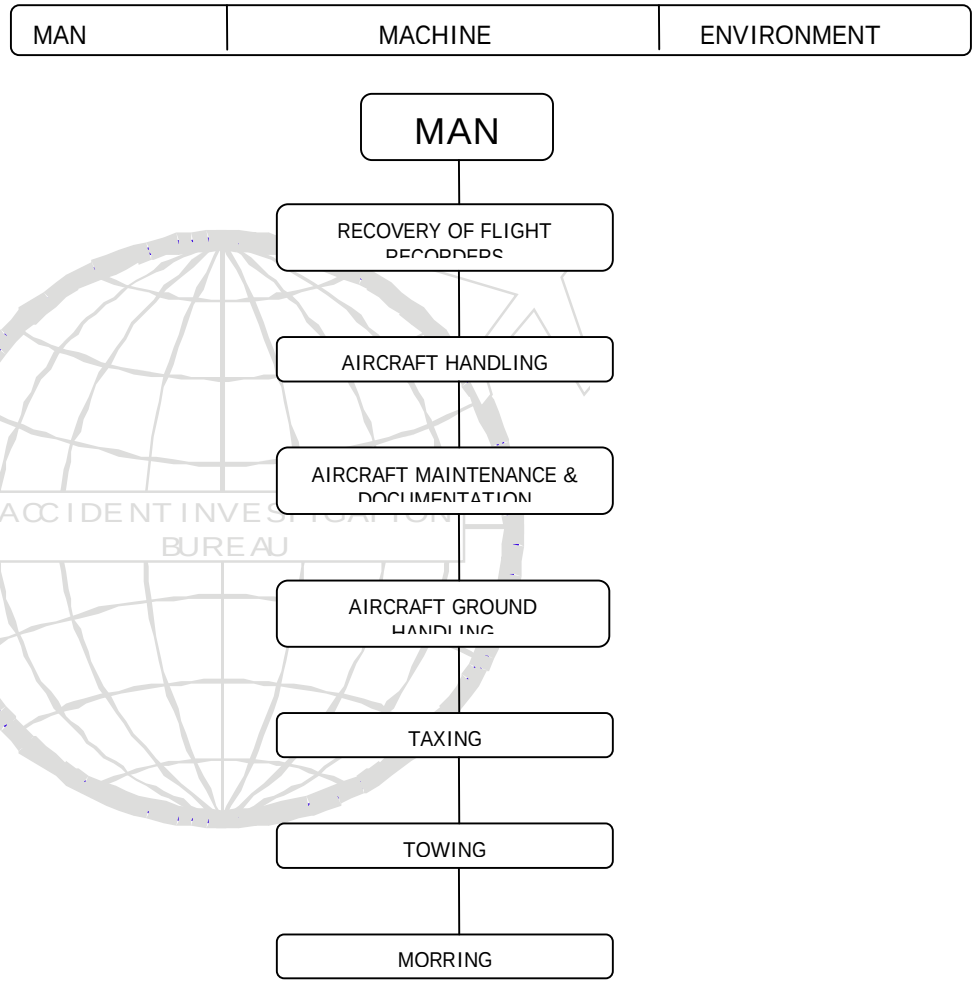
Accident

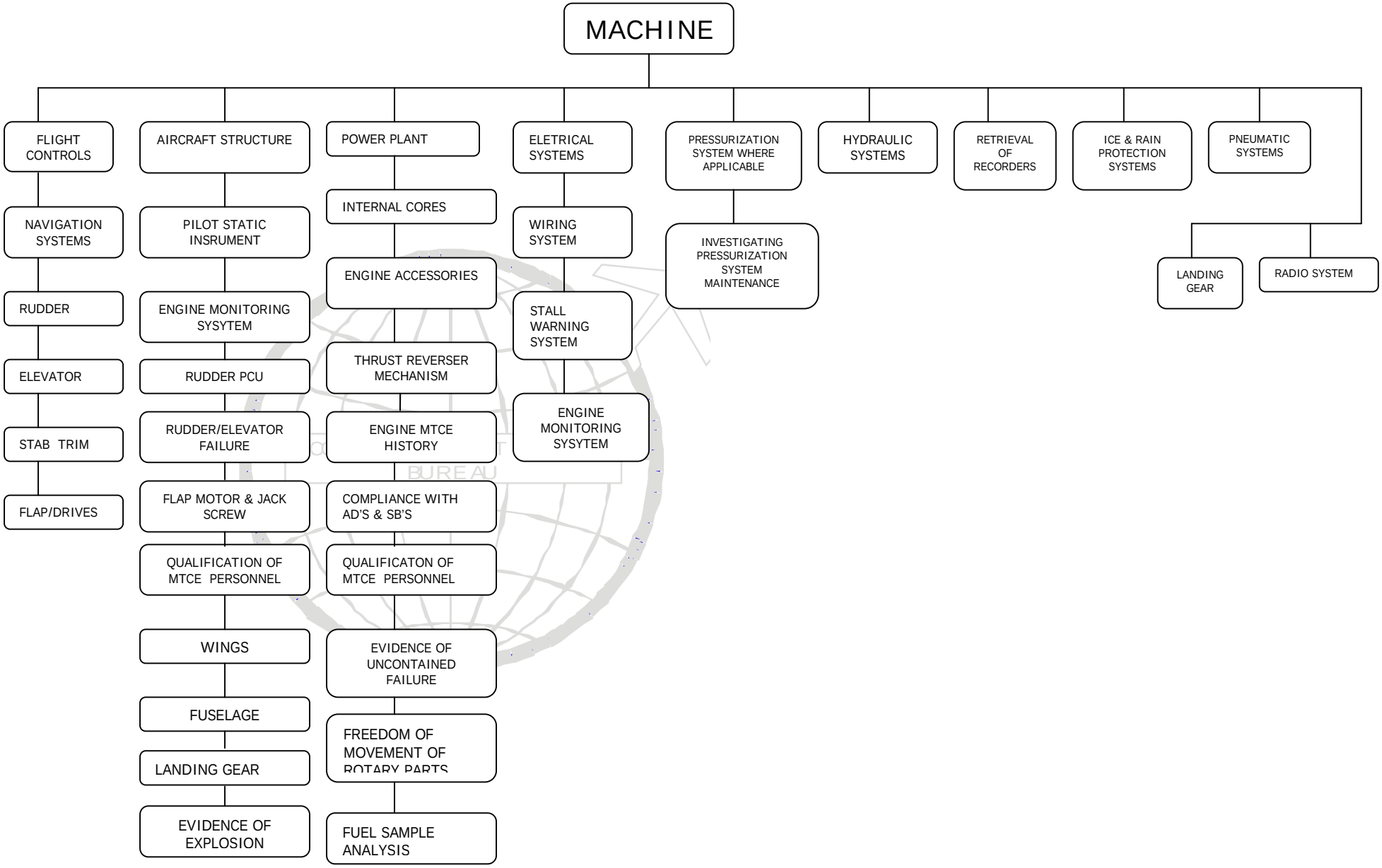
1. Time of
2. Type of
3. Accident site-location/altitude
4. Summary of damage to aircraft
5. photographs A.I.B./Press etc.
6. Pertinent measurements
7. Pertinent controls settings
8. Pertinent bearings (M)
9. Pertinent instrument readings
10. Wreckage plot
11. Hazards associated with accident site
12. Damage to accident site by aircraft
13. Damage to accident site by AIB
14. Owner of accident site
15. Removal of wreckage
16. Release of wreckage
17. Airfield state certificate if applicable

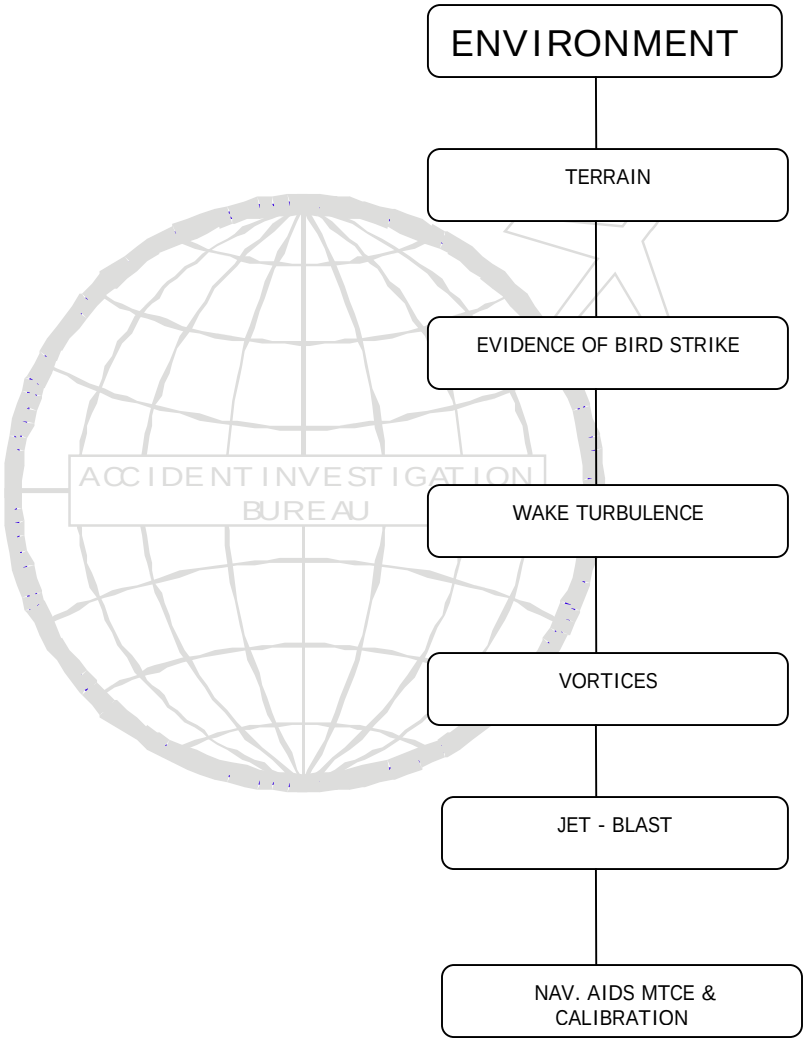
- This checklist is strictly for the use of Aircraft Accident Investigators who have been charged with specific duties on behalf of the Accident Investigation Bureau.

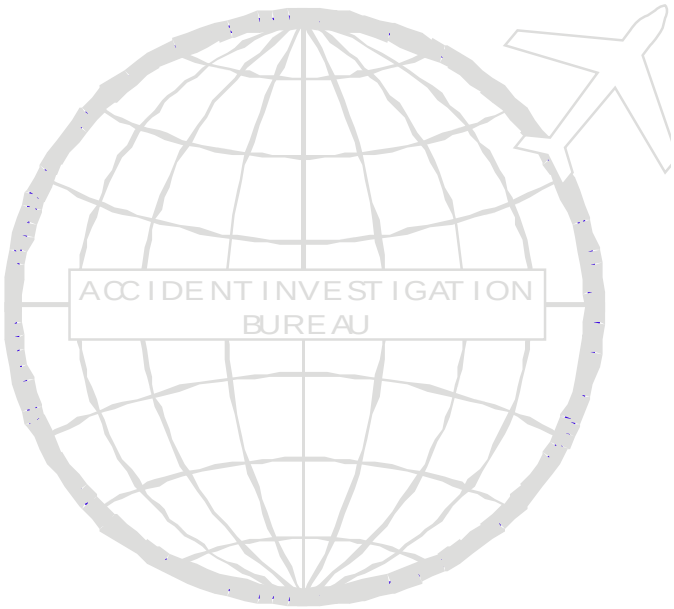
OTHER MATERIAL:

INVESTIGATIVE REASONING FOR A I B ENGINEERING DIVISION




MACHINE
FLIGHT CONTROLS
NAVIGATION SYSTEMS
RUDDER
ELEVATOR
STAB TRIM
FLAP/DRIVES
AIRCRAFT STRUCTURE
PILOT STATIC INSRUMENT
ENGINE MONITORING SYSYTEM
RUDDER PCU
RUDDER/ELEVATOR FAILURE
FLAP MOTOR & JACK SCREW
QUALIFICATION OF MTCE PERSONNEL
WINGS
FUSELAGE
LANDING GEAR
EVIDENCE OF EXPLOSION
POWER PLANT
INTERNAL CORES
ENGINE ACCESSORIES
THRUST REVERSER MECHANISM
ENGINE MTCE HISTORY
COMPLIANCE WITH AD'S & SB'S
QUALIFICATON OF MTCE PERSONNEL
EVIDENCE OF UNCONTAINED FAILURE
FREEDOM OF MOVEMENT OF ROTARY PARTS
FUEL SAMPLE ANALYSIS
ELETRICAL SYSTEMS
WIRING SYSTEM
STALL WARNING SYSTEM
ENGINE MONITORING SYSYTEM
PRESSURIZATION SYSTEM WHERE APPLICABLE
INVESTIGATING PRESSURIZATION SYSTEM MAINTENANCE
HYDRAULIC SYSTEMS
RETRIEVAL OF RECORDERS
ICE & RAIN PROTECTION SYSTEMS
PNEUMATIC SYSTEMS
LANDING GEAR
RADIO SYSTEM




ACCIDENT INVESTIGATION
BUREAU