PROCEEDINGS OF FOURTH ANNUAL SEMINAR

THE SOCIETY OF

AIR SAFETY INVESTIGATORS

"TRAINING"

FOR AIRCRAFT ACCIDENT INVESTIGATORS

EDITED BY: H. REID GLENN,
SECRETARY,
CANADIAN CHAPTER, SASI.

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FOREWORD

The Society of Air Safety Investigators, Canadian Chapter, hosted a Seminar on "TRAINING" for Aircraft Accident Investigators at the Hyatt Regency Hotel, Toronto, Ontario, Canada, August 28-31, 1973.

Special thanks and recognition are given to the officers and members of the Canadian Chapter and especially Major Bill McArthur and his hard working team from the Toronto area and those from the Seminar Committee. Recognition is also extended to the National Officers of the Society of Air Safety Investigators who participated to the fullest extent.

The Canadian members hope that the Seminar was found rewarding by all and we appreciate being able to host such a distinguished international group dedicated to the furtherance of aviation safety.

The international character of the meeting is apparent from the list of 152 registered delegates representing a total of 18 countries: Bolivia, Canada, Denmark, England, Iran, Israel, Japan, Mexico, New Zealand, Pakistan, Panama, Phillipines, Sierra Leone, Soviet Union, Switzerland, Trinidad, United States and Venezuela.

The first two and one half days were devoted to panel discussions and the final afternoon was spent observing the spectacular flying demonstrations of the Canadian International Air Show from choice seats reserved at the lake front in Exhibition Park.

The Society also thanks the following Corporate Members who responded to the host chapter's call and provided important financial support to the Fourth International Seminar:

Cia. Mexicana De Aviacion
Fairchild Industrial Products
Link Division, Singer-General Precision, Inc.
Magnaflux Corporation Testing Laboratories
Seaward, Inc.
United States Aviation Underwriters.

SEMINAR COMMITTEE

GENERAL CHAIRMAN	Major Bill McArthur Canadian Armed Forces
ORGANIZATION	Captain John Winship Captain Blake Hoffert Lt. Steve Olsen Canadian Armed Forces Dr. P.J. Dean Defence and Civil Institute of Environmental Medicine
PROGRAM	Mr. R.M. "Bill" Kidd, Canadian Air Line Pilots Association Mr. Paul Saunders Ministry of Transport Major Bill McArthur Canadian Armed Forces
WIVES ACTIVITIES	Mrs. Lynn McArthur Mrs. Patricia Winship
PUBLICATIONS	Mr. H. Reid Glenn Ministry of Transport
SECRETARY	Mrs. Pat Niblett

FOURTH INTERNATIONAL SASI SEMINAR ATTENDEES

NAME	ORGANIZATION
ABARBANELL, Captain O.	El Al Airlines
ALLEN, William H.	Transportation Safety Institute
ANDERSON, Major D.E.	Canadian Armed Forces - Air Defence
ANDERSON, Dr. I.H.	Health and Welfare, Canada, Civil Aviation Medicine
ANSON, Robert E.	Airclaims Incorporated
AOYAGI, Stanley T.	Japan Airlines
BALTZELL, LCol. Robert E.	USAF - Military Airlift Command
BALZER, Martin	Xonics
BATCOCK, Captain David J.	Canadian Armed Forces (DFS)
BATES, Michael J.	Douglas Aircraft Co.
BENNETT, Robert B.	Royal-Globe Insurance Co.
BESCO, Robert O.	American Airlines
BILLMANN, Barry R.	Army National Guard, U.S.
BLIZZARD, Dr. S.	Trinidad
BOULDING, J.G.	B.O.A.C.
BROADWATER, William E.	Federal Aviation Administration
BROWN, Bernard D.	British Aircraft Corp. (USA) Inc.
BYRNES, Charles T.	Associated Aviation Underwriters
CANTIN, Claude	Can-Air Claims Adjusters Ltd.
CLARKE, R.C.	British Aircraft Corp., Commercial Aircraft Division
CLAY, Dr. Wendy A.	Canadian Armed Forces
CLEMENT, Dr. Marcel	Civil Aviation Medicine, Ministry of Transport
COLLINS, Thomas J.	Federal Aviation Administration
CONLON, Samuel B.	Airclaims Inc.
CONTI, R.G.	F.E.I.A.
COULTER, Charles M.	Allied Pilots Association
COWSER, Captain Roland R.	American Airlines Inc.
CRAFT, C. Howard	Magnaflux Corporation
DAILY, Cdr. H.D. (Jr.)	U.S. Naval Safety Center

DANGOY, Petronilo V.	Philippine Airlines
DAVIS, Tom	Attorney
DELANEY, W.	Quebec, Canada
DELLANDREA, Dr. D.A.	Canadore College
DENNIS, Capt. Jerry T.	U.S. Army - Aircraft Accident Investigation Bd.
DIECKHOFF, Richard H.	USAIG
DONAGHY, P.H.	Ministry of Transport - Ontario Regional Office
DOUGLAS, D.J.	Ministry of Transport
DOW, G.S.	Federal Aviation Administration
DUBE, François	Health & Welfare, Canada Civil Aviation Medicine
EDWARDS, Laurie	British Civil Aviation Authority
EMBREE, Dr. Garth H.	Neurologist
FASSOLD, Robert	Canadian Armed Forces, CFHQ
FATHOLLAHI, Ahmad	Iran National Airlines
FAWCETT, H.	Ministry of Transport
FOX, Ken	Pan American World Airways
FRITSCH, Olof	ICAO Headquarters Accident Investigation
FURR, Capt. James A.	Eastern Air Lines, Inc.
FUTERMAN, E.	Toronto, Canada
GLENN, H. Reid	Ministry of Transport
GOLDING, H. Paul	Toplis & Harding (Lloyd's Agency)
GONZALEZ, Gilberto	Departamento de Seguridad Aerea, Republica de Panama
GRIFFIN, Capt. Charles K.	U.S. Army Arctic Test Center
HALL, David S.	University of Southern California
HARRINGTON, Jack G.	U.S. National Transportation Safety Board
HARVIE, E.F.	New Zealand Ministry of Transport
HAWKINS, Barry J.	Fairchild Industrial Products
HAWLEY, D.C.	Air Line Pilots' Association
HARTUNG, Dr. W.	President, Academy of Aeronautics
HARVEY, A.G. William	SASI - Washington Chapter
HEASLIP, T.W.	Ministry of Transport

HENSCHLER, Harri H.	Canadian Air Traffic Control Association
HODGKINSON, Major John	Canadian Armed Forces
HOFFERT, Capt. B.M.	Canadian Armed Forces
HOGUE, H. Prater	Boeing Company/Accident Investigation
HOLMES, David G.	U.S. Army Agency for Aviation Safety
HUFF, L.E.	Beech Aircraft Corp.
HYDORN, Marshall	Air Line Pilots' Association
JONES, Roys C.	Aviation Consultant
JACQUES, Dr. Thivierge	Quebec, Canada
JOHNSON, Jonathan A.	Director, Department of Civil Aviation
JOYCE, Dr. Malcolm S.	Canadian Armed Forces
KAZALBASH, Capt.	Pakistan International Airlines
KEIRSTEAD, Col. E.R.	Canadian Armed Forces
KELLY, Charles Ted	Air Line Pilots' Association
KEMP, Donald E.	Federal Aviation Administration President/SASI
KENNEDY, John B.	SASI, Washington Chapter
KHAN, Mushir A.	Pakistan International Airlines
KIDD, R.M.	Canadian Air Line Pilots Association/Safety
KRUSE, Jesse	FEIA
LAWLOR, Capt.	Canadian Armed Forces
LEAK, John S.	USAF Safety Center
LEDERER, Jerome	Flight Safety Foundation
LEE, Raymond C.	Flight Adjusters Ltd.
LESLIE, Dr. Scott	Health & Welfare, Canada
LINDEBOD, M.	D.A.L.P.A., Denmark
LIVINGSTON, James M.	Canadian Air Traffic Control Association
LOGAN, Robert M.	Ministry of Transport
MARGWARTH, John A.	Lockheed California Co.
McARTHUR, Dr. W.J.	Canadian Armed Forces, DCIEM
McCubbin, M.R.	Brouwer & Co., Canada

McGOWAN, Fred W.	Insurance Company of North America
McKEE, Robert D.	Aviation Safety Associates
McLELLAN, Donald A.	Ministry of Transport, Quebec Region
McLEOD, R.K.	Ministry of Transport
McPHERSON, V.H.	Ministry of Transport, Ontario Region
McWILLIAMS, James W.	Air Line Pilots' Association
MOORE, LCol. John F.	USAF - Directorate of Safety
MOUDEN, L. Homer	Eastern Air Lines, Inc.
MURASH, Archie	New York, USA
MURPHY, Donald J.	U.S. Army
NAPIER, Cdr. James (Jr.)	United States Coast Guard
NASSEY, R.D.	Canadian Air Line Pilots' Association
NELMES, Edwin V.	U.S. National Transportation Safety Board
NEWMAN, Richard L.	Allison Division of GM
NEWTON, Richard G.	Brouwer & Co., Insurance Adjusters
OLSEN, Lt. S.W.	Canadian Armed Forces
ORR, Robert G.	Boeing-Vertol Company
ORR, Robert H.	U.S. Federal Aviation Administration
OWENS, Mike	Cessna Aircraft Co.
PARKER, G.B.	University of Southern California
PATANE, Philip	Flight Engineers' International Association
PEDERSON, Willard L.	U.S. Federal Aviation Administration
PERRON, R.	Ministry of Transport
PETERS, Desmond J.	Ministry of Transport
PHILLIPS, Samuel M.	United States Army
PINEDA, Capt. Eduardo	Cia. Mexicana de Aviacion
POCIUS, Capt. C.F.	Flying Tiger Line (ALPA Acc. Rep.)
PUCCIA, George	International Association of Machinists
RENGER, Martin	Fairchild Industrial Products

REYNOLDS, Dr. Ed	Health & Welfare, Canada
RICHARDS, John T.	Ministry of Transport
RIDDER, Henry J.	Magnaflux Corp.
ROBERTSON, S. Harry	Arizona State University
RINFRET, Paul	Regional Aviation Medical Officer, Civil Aviation Medicine
ROMERO, Mario R.	Bolivia Civil Aviation
RUDICH, Robert D.	Air Transportation Consultants
SAITO, Hidekazu	Japan Ministry of Transport
SALAS-PARRA, José A.	Venezuela Department of Civil Aviation
SAUNDERS, George H.	University of Southern California
SAUNDERS, P.D.	Ministry of Transport
SHAW, Dr. R.R.	International Air Transport Association
SCHNEIDER, G. Don	Flight Engineers' International Association
SHORTILL, Capt. James	82nd Airborne Division, U.S.A.
SHULTS, Ernest H.q.	SASI, Los Angeles Regional Chapter
SKJENNA, Dr. Olaf W.	Health & Welfare, Canada Civil Aviation Medicine
SMITH, M.D.	Flight Engineers' International Association
SMITH, Melville W.	Solicitor
SMITH, Lloyd C.	SASI
SOLMAN, Dr. V.	Canadian Wildlife, Department of Environment, Canada
STAAL, Capt. D.W.	Swissair
STOKES, Ralph E.	U.S. Transportation Safety Institute
SUZUKI, Toshiro	Japanese Aviation Insurance Pool
TAYLOR, C.W.	Calgary, Alberta
TEMPLETON, J.F.	England - Civil Aviation Authority
TRIOLAIRE, A.B.	Ministry of Transport
TURNBOW, James W.	Arizona State University
TYLER, M.	Ministry of Transport
WAHLE, Jack A.	F.E.I.A.

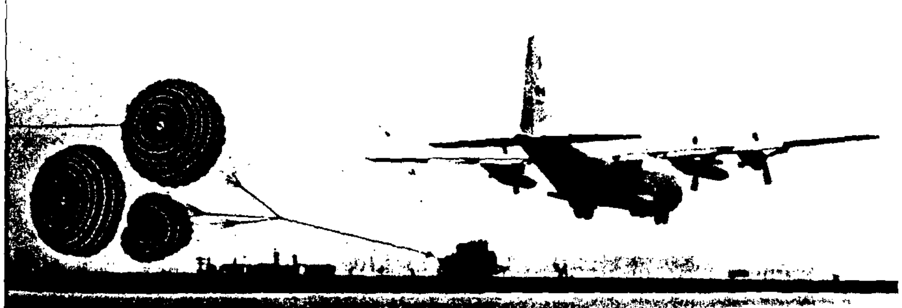
WIESMAN, E.I.	Air Line Pilots' Association
WINSHIP, Capt. John	Canadian Armed Forces, DCIEM
WOOD, Edward C.	U.S. Federal Aviation Administration
WRIGHT, J.B.	Canadian Air Line Pilots Association
VREELAND, Cdr. James M.	U.S. Navy
YOUNGBLOOD, Hugh E. (Jr.)	University of Southern California, Safety Center
ZHELEZNJAKOV, Youry D.	ICAO, Montreal

The "SOCIETY OF AIR SAFETY INVESTIGATORS" is dedicated to "promote that part of the aeronautical endeavor wherein lies the moral obligation of the AIR SAFETY INVESTIGATOR to the public".

BIENVENUE AU CANADA
CANADA WELCOMES YOU
BIENVENIDOS A CANADA

THE CANADIAN AVIATION SCENE

CIVILIAN AND MILITARY



CANADIAN CIVIL AVIATION STATISTICS 1968 - 1973

AIRCRAFT REGISTERED	LICENSED PILOTS
1973 - 13,495*	1973 - 44,125*
1972 - 13,157	1972 - 44,831
1971 - 12,066	1971 - 35,491
1970 - 11,315	1970 - 35,157
1969 - 10,772	1969 - 33,089
1968 - 9,973	1968 - 32,694

AIRCRAFT HOURS	REPORTABLE ACCIDENTS	FATALITIES
1973 - 3,400,000	1973 - 736	162
1972 - 3,100,000	1972 - 613	166
1971 - 2,818,201	1971 - 543	157
1970 - 2,633,347	1970 - 530	223
1969 - 2,586,690	1969 - 503	
1968 - 2,591,047	1968 - 462	

* - (Mar. 73)

Number of Canadian Commercial operators at present - 519

1970 Fatalities include 109, (DC-8/Toronto)

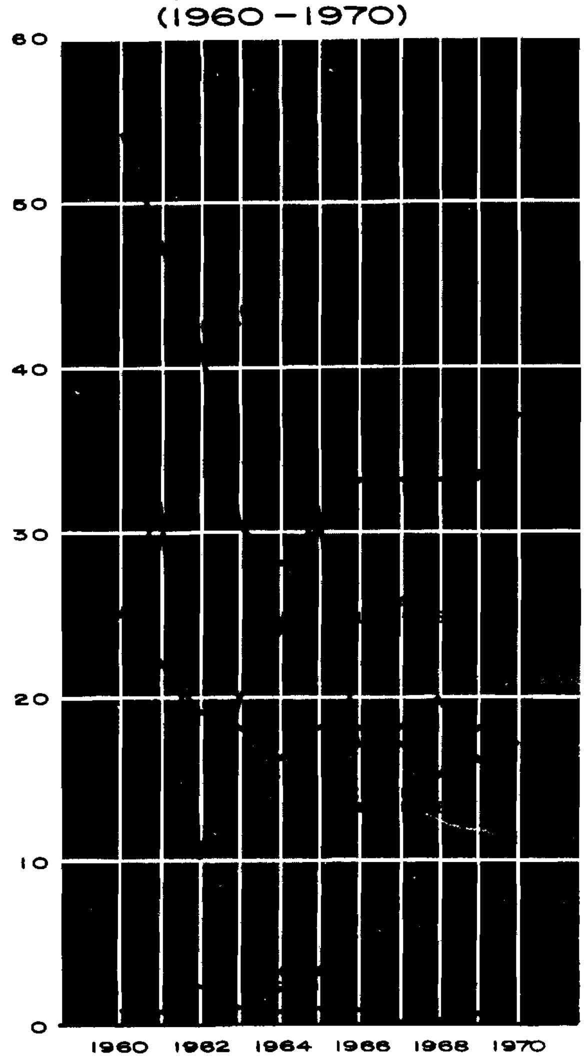
The MOT Accident Investigation Division determines the cause of all civil accidents in Canada. These findings are reviewed and analyized with the prime purpose of correcting unsafe practises, acts and thereby accidents. This is the role of the Division as provided for in the Aeronautics Act to ensure that the travelling public has a "safe" ride. The MOT has divided Canada into six regions and each is responsible for their particular geographic area. The Regional Superintendents report to the Division Chief, "Hal" FAWCETT, who is located in MOT Headquarters in Ottawa. The following are the Regions, Location and Superintendents:

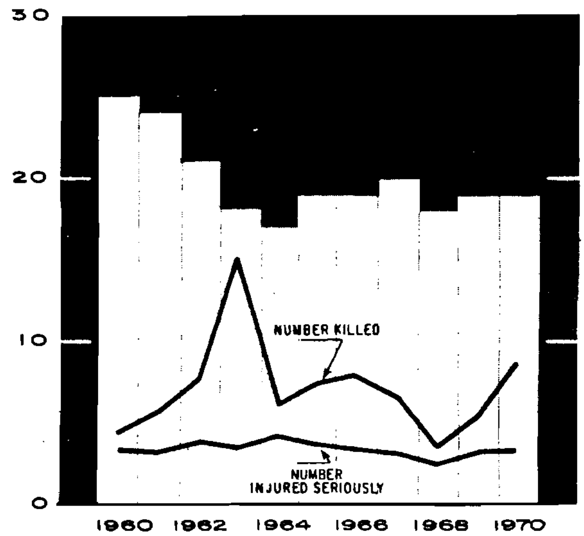
PACIFIC	Vancouver	Cy Leyland
WESTERN	Edmonton	Jim Dick
CENTRAL	Winnipeg	Gerry Saull
ONTARIO	Toronto	Vic McPherson
QUEBEC	Montreal	Don McLellan
ATLANTIC	Moncton	Harry Deyarmond

The Regions are backed up by a Headquarters Readiness "GO" Team who are on standby, and ready to proceed to an accident scene on short notice.

Over the last decade, although flying hours in Canada have more than doubled, accidents have increased by only sixty-five percent. The safest segment of the industry is scheduled domestic and international services which averaged only one accident each year per one hundred thousand flying hours. There were none recorded in 1967. Private flying records the highest rate, averaging forty accidents per hundred thousand flying hours.

ACCIDENTS
PER 100,000 FLYING HOURS
(1960 – 1970)





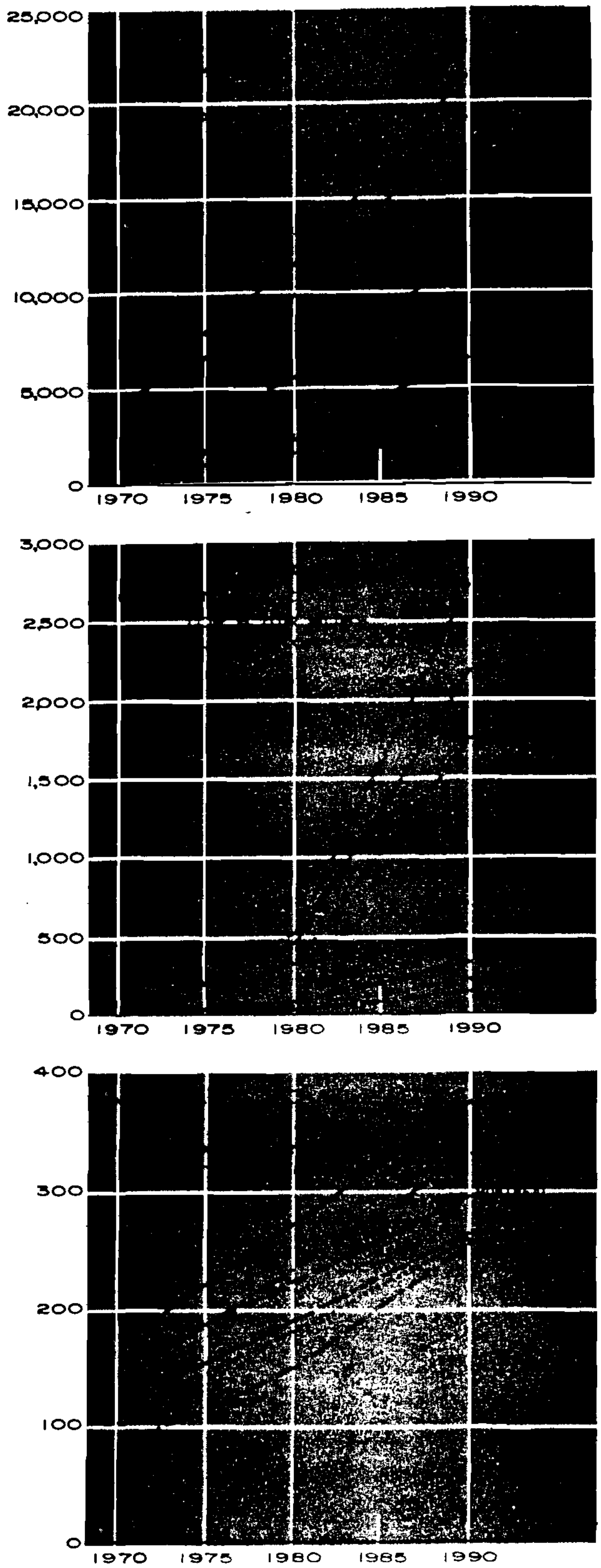
Data Source: M.O.T.

MOT forecasts for overall aviation activity to 1980 (Table 8.1) predict that the numbers of both aircraft registered and hours flown in Canada between 1967 and 1980 will approximately double. Expansions in commercial aircraft and services will be about seventy-five percent of present figures, with charter and specialty operations and scheduled domestic services growing the most rapidly.

In general, activity should continue to grow fastest in the extensive and largely undeveloped geographical areas of northern and western Canada.

FIGURE 8.1

M.O.T. FORECASTS AIR HUB ACTIVITIES TO 1990



Data Source: M.O.T. Air Transportation Statistics/Forecasts

CANADIAN

ARMED

FORCES

the '72 story

Col. R.D. SCHULTZ is the Director of Flight Safety for the Canadian Armed Forces. He reports to the Vice Chief of the Defence Staff at Canadian Forces Headquarters/Ottawa. The following lists the Commands, locations and respective Flight Safety Officers:

TRANSPORT	/ Trenton	/ Maj. Bob Last
MOBILE	/ St. Hubert	/ Maj. Wes Allen
TRAINING	/ Winnipeg	/ Maj. Gerry Langden
AIR DEFENCE	/ North Bay	/ Maj. Don Anderson
MARITIME	/ Halifax	/ Maj. Les East
CANADIAN FORCES EUROPE	/ Lahr Germany	/ Maj. Roy Barnes

The highlights of our 1972 accident and incident record are presented here. A detailed analysis has been completed and appears in the 1972 Annual Aircraft Accident Analysis.

MILESTONES

- The 1972 accident rate and the total number of accidents was the lowest ever.

- There were fewer ejections than in any year since the introduction of ejection seat equipped aircraft. The success rate was 100 per cent for ejections attempted within the ejection envelope.

- The number of fatalities in 1972 was an all-time low.

AIR ACCIDENTS

The chart shows a total of 26 accidents - the fewest in any year since 1949. Our accident rate was 0.80 per 10,000 hours, down from 1.17 in 1971. During 1972 there was a small reduction in the total number of flying hours - a continuation of the general downward trend over the past 17 years.

AIRCRAFT DESTROYED

Seven accidents resulted in writeoffs - down from 15 aircraft destroyed in 1971.

FATAL ACCIDENTS AND FATALITIES

The 1972 record of four air accidents involving fatalities was identical to 1971. However, based on records back to 1 Jan 1946, the 1972 total of four fatalities was an all-time low.

GROUND ACCIDENTS AND INCIDENTS

The Canadian Forces sustained six ground accidents and 252 ground incidents. Of the reported ground occurrences, 155 resulted in damage to the aircraft. The number of injuries rose to one major and 21 minor - a significant increase from 9 minor injuries in 1971. All told there were 50 vehicle strikes on aircraft.

AIR INCIDENTS

Reported air incidents decreased in 1972 to 2567, down seven from 1971. This extensive use of the reporting system is important; the reports often enable preventive measures to be applied in time to prevent an accident.

AIR ACCIDENT CAUSES

The 26 air accidents in 1972 were assigned 59 cause factors. Forty-four causes, a reduction of nine from 1971, were assigned to PERSONNEL. Next came MATERIEL, with six, followed by ENVIRONMENT with six. The remaining three cause factors were listed as UNDETERMINED.

	T33	CF104	CF101	CF5	CF100	TUTOR	ARGUS	CUH-1N	CH113A	SEA KING	HERCULES	DAKOTA	BUFFALO	TOTALS
Destroyed	1				1	2		2		1				7
B Cat										1				1
C Cat	3	4	1	1		1	2	1		1	1	1	1	17
All Acc	4	4	1	1	1	3	2	3	1	3	1	1	1	26
Fatalities	1					2			1					4

DFS/Flight Comment

THE SOCIETY OF AIR SAFETY INVESTIGATORS
FOURTH ANNUAL SEMINAR TRAINING

WEDNESDAY, 29 AUGUST 1973

CHAIRMAN OF THE DAY:	Captain David Batcock Directorate of Flight Safety Canadian Armed Forces
8:00 A.M.	REGISTRATION
9:00 A.M.	WELCOME Dr. W.J. McArthur President, Canadian Chapter Head, Accident Investigation Group Defence and Civil Institute of Environmental Medicine, Toronto
	OPENING REMARKS Mr. D.E. Kemp President, SASI Chief, Accident Investigation Staff Federal Aviation Administration Washington, D.C.
	"FORMAL TRAINING FOR AIR SAFETY INVESTIGATORS" Panel Chairman: Dr. W.M. Hartung President, Academy of Aeronautics Flushing, N.Y.
	INTRODUCTION OF SESSION Dr. W.M. Hartung
	Mr. S. Harry Robertson Assistant Director Crash Survival Investigator School Arizona State University
	Mr. William H. Allen Program Manager, Aviation Safety Transportation Safety Institute Oklahoma City, Oklahoma
	"EVERYTHING YOU WANTED TO KNOW ABOUT ACCIDENT PREVENTION BUT WERE TOO BUSY TO ASK" Mr. David S. Hall Aviation Safety Consultant Faculty Member University of Southern California
	Mr. Ed. Nelmes National Aircraft Accident Investigation School Washington, D.C.

"ARMY AVIATION SAFETY PERSONNEL TRAINING"
Mr. David Holmes
Air Safety Specialist
U.S. Army Agency for Aviation Safety
Fort Rucker, Alabama

12 NOON

SOCIETY LUNCHEON
Guest Speaker: Brig. Gen. M.F. Doyle
Director General, Air Operations
Canadian Armed Forces, Ottawa

2:00 P.M.

"THE INVESTIGATOR AND THE MAN"
Panel Chairman: Dr. R. Besco
Aviation and Engineering Psychology
Consultant in Flight Crew Systems
University of Southern California

INTRODUCTION
Dr. R. Besco

"ENGINEERING EDUCATION REQUIREMENTS FOR INVESTIGATORS
Mr. G.H. Saunders
Lecturer, Aerospace Safety
University of Southern California

"TRAINING OBJECTIVES FOR THE INVESTIGATOR"
Mr. J.A. Johnson
Directorate of Civil Aviation
Ministry of Transport and Comms.
Sierra Leone

"TRAINING OF PROFESSIONAL INVESTIGATORS - AIMS & LIMITATIONS"
Mr. R.C. Clarke
Manager, Flight Safety Department
British Aircraft Corporation Ltd.
Weybridge, Surrey, England

"WITNESS INTERVIEWING TECHNIQUES"
Mr. Ralph E. Stokes
Program Manager
Intermodal Safety Management
Transportation Safety Institute
Oklahoma City, Oklahoma

"AIRCRAFT ACCIDENT INVESTIGATOR TRAINING FOR PHYSICIANS"
Dr. I.H. Anderson
Adviser, Civil Aviation Medicine
Department of National Health & Welfare
Ottawa, Ontario

OPENING REMARKS

DONALD E. KEMP
PRESIDENT
SOCIETY OF AIR SAFETY INVESTIGATORS

Good morning, ladies and gentlemen.

It is my pleasure once again to participate in the Society of Air Safety Investigators' Annual Seminar.

This is the Fourth Annual International Seminar of the Society of Air Safety Investigators, Our host, the Canadian Chapter of SASI, has selected as the theme of this year's seminar, "Training". Training, of course, may be a better word than "Purpose" as stated in our Constitution and By Laws, but I'll let you be the judge of that.

Paraphrased briefly, the purpose of this Society is to promote the development of improved aircraft accident investigation procedures through lectures, displays and by the exchange of information - the end product - Improved Aviation Safety.

Aviation safety is the end product of many interrelated efforts. Those engaged in equipment design, safety training, establishing maintenance standards and operating policies, using equipment, inspection and compliance procedures, establishing standards and safety regulations, as well as safety managers, government administrators and air safety investigators, must all be cognizant of a body of knowledge which includes appropriate safety considerations.

Of critical importance is defining this body of knowledge and integrating it into the "Education" and "Training" programs of our multidisciplined society. The terms "Education" and "Training" are often used synonymously. However, in terms of total human development, they are separate but related tasks. They are usually undertaken at different times during the life span and career of an individual, at different institutional locations, and with different objectives.

The term "Education" usually refers to the process of cultivating and disciplining the mind so as to acquire knowledge and understanding of a broad spectrum of activities or within a particular subject area.

"Training" usually refers to the process of acquiring the specific skills required to do a particular job.

I know that there are many of the delegates here that will disagree with this definition - and I hope that you do - because disagreement is a basic tool for learning. In our society we normally don't use the word disagreement - we use the word discussion.

Discussions can involve any number of people from a few up to the number of delegates attending this seminar. Also, a discussion can involve only one person - but you must be able to answer your own questions.

I have discovered that there are many definitions, or perhaps, better yet, opinions, as to what training really is. From the discussions we must define what our needs are and structure our training to satisfy these needs. Also, we must be flexible. The training requirements of today will not be the training requirements that are needed to keep up with the advanced technology of tomorrow.

So, it is an ever changing need - "Training" - and we must work as a team to satisfy this need - the aircraft, engine and equipment manufacturers, government agencies, military, airlines, pilots, flight engineers, mechanics, air safety investigators, etc., are all part of this team and it is through their inputs that we will be able to keep training at the so called "State of the Art" level.

Our program at this seminar cannot possibly cover all the facets related to training, but I believe that the program will leave you hungry for more.

Formal training for the air safety investigators is the key as to how well air safety investigators will be able to perform his or her particular job assignment. Their assignment is a complex one in that it involves the man-the machine-and the environment. An endless number of possible combinations of parameters on a single accident.

I believe the general conclusion (my opinion) is that all air safety problems result from the actions, or interactions, of the man-machine-environment framework within which any nation's air transportation system must operate. It is the responsibility of all of us here to insure that we have a worldwide air transportation system that is safe.

Therefore, if the air safety investigators are properly trained to utilize improved accident investigation procedures and techniques, we will have the desired end product - IMPROVED AVIATION SAFETY.

Thank you.

Aviation, to an even greater extent
than the sea, is terribly
unforgiving of any incapacity,
carelessness or neglect... !

WILLIAM ALLEN

PROGRAMME MANAGER
TRANSPORTATION SAFETY INSTITUTE
OKLAHOMA CITY, OKLAHOMA, U.S.A.

The Transportation Safety Institute is an activity of the Office of the Secretary of Transportation. The Institute was established in 1971 at the Transportation Department's FAA Aeronautical Center in Oklahoma City to provide accident investigation, accident prevention, and security training for all of the modal administrations within the DOT.

As of this date, the Institute offers 21 courses and seminars covering all modes of transportation. These are listed in the course catalog which is available at the desk.

Getting more specifically to aircraft accident investigation, the Institute presently conducts three courses. Two of these are for the Federal Aviation Administration, and each of the FAA courses is 2 weeks in duration. The first is a fundamentals course which prepares the FAA inspector to participate in accident investigations and fulfill the duties of the Administrator.

The second course, Advanced Aircraft Accident Investigation, qualifies the inspector to conduct those investigations which are delegated to the FAA by the Safety Board.

The third course was developed in response to inquiries from individuals and organizations within the aviation community who may have occasion to participate in aircraft accident investigations. This is a 40-hour course which covers such areas as statutes and regulations, organization and management of the investigation, accident reporting and uses of the data in accident prevention.

We do not have a large number of "stock" courses, as we do not subscribe to the philosophy that what is good for one is good for all.

We develop courses to fill needs as the needs are identified. Our training objective is to prepare the students to do their specific job more efficiently.

The cost of any course is dependent upon the course content and supporting materials, however, up to this time we have been able to hold the cost to approximately $115 per student per week. We have achieved this through use of program managers in each mode, and an associate staff, as well as cross utilization of assigned staff members.

The size of the classes are no more than 20 students. With this class size, individual attention can be given where needed.

The classes are all given in English (American dialect), but the staff has trained many students from other countries with much success.

As I stated earlier, the Institute is located at the FAA Aeronautical Center in Oklahoma City. More specifically, the Institute occupies one-half of the third floor of the newly completed Multi-Purpose building.

The Institute has a laboratory, laboratory classroom and formal classrooms. At the present time, outdoor display areas are being developed.

I appreciate this opportunity to give you this information concerning the Transportation Safety Institute. I will be happy to answer any questions you may have or you can write to the Institute at the address in the catalog.

Thank you.

EVERYTHING YOU'VE ALWAYS WANTED TO KNOW ABOUT ACCIDENT PREVENTION BUT WERE TOO BUSY TO ASK

DAVID S. HALL
LECTURER IN AVIATION SAFETY
THE SAFETY CENTER, UNIVERSITY OF SOUTHERN CALIFORNIA

I consider it a real privilege to take part in this seminar, and congratulate the board on their selection of this subject and the beginning of an involvement of SASI in curriculum development for air safety investigators.

It is, of course, facetious on my part to infer that I could cover "everything" about accident prevention in a lecture or even a college course on the subject. It is also true that only lip service is given to the serious study of prevention in much of the training of investigators. The reason for this oversight is that we tend to think of everything that we do as accident prevention. Accident prevention is sometimes defined as "the discovery, naming, and doing something about accident causes". I would like to discuss the implications of the words "doing something about".

In the past, most investigator training has been provincial, that is, it was specifically geared to the immediate technical needs of the agency paying the bill. That was an economically rational point of view. It is now becoming more apparent, as we learn more about accident causation, that there is less difference between types of operation (civil vs. military for example) than was previously believed to be true. Dr. Gordon pointed out years ago the similarity between disease causation and accident causation[1]; today government bodies are using the same methodology we air safety troops feel is our own on cars, buses, trains, pipelines, ships and consumer products.

It is apparent that much of the aerospace technology that we are discussing here, and all of the non-technical material, is applicable to the whole spectrum of accident prevention. My remarks, therefore, should be taken as applicable to any safety investigator's training, not just air safety.

[1] John E. Gordon, M.D. "The Epidemiology of Accident", American Journal of Public Health, 39:504-515, 1949.

It has been our experience at USC that the majority of students who come for training are already involved in safety in some way. They come because they, or their supervisors, sense that they need additional capability to perform their increasingly complex tasks. Much of what we are discussing here will emphasize this fact, that the technical level of the investigator must rise at least as fast as the system in which he functions.

It is also increasingly apparent that the transportation system, of which Air is but one subsystem, is a complex interaction of many people, resources, requirements and environmental constraints. The investigator who allows himself to take a narrow view of his technical specialty area, and fails to see the bigger system of which he is a part, cannot do a complete job, or an effective one.

At USC we feel very strongly that the emphasis must continually be on Prevention. While we go to great length to increase the technical ability of the investigator in the specific areas of study, we include in each course some basic, fundamental principles of accident prevention. It is our firm conviction that accident prevention is a function of the management of the system. Mishap data must then be presented in a form useful to management for it to have effect on the system.

I would recommend that any investigation training include the following minimum exposure to these managerial concepts.

I. The Etiology of Accidents.

The safety community has almost completely swung away from the idea of the single or "primary" cause of accidents. Two years ago Chuck Miller mentioned his desire to change NTSB rules to mandate discovery of "probable causes". The USAF is currently considering the removal of their long standing requirement for identification of Primary Cause.

We now consider that accidents are the product of unsafe acts and unsafe conditions, occurring over time and interrelated by other conditioning events until the undesired result, an "accident" as specifically defined in the given system, occurs. We know these unsafe acts and conditions are symptoms or results of underlying basic causes relating to lack of proper control of, and by, the system. We know that the responsibility to identify and remove these unsafe acts and conditions and their basic causes rests with management. We know that the hundreds of thousands of accident records currently on file in data banks around the world contain the "known precedents" to current accidents and this data is available to management if they know where, and take the time, to look. One of the real problems in prevention is getting management to effectively use what we already know.

There are a number of excellent reference texts which give a conceptual basis upon which to build an investigative philosophy. Without a conceptual basis of the accident sequence, an investigator concentrates on effects, on "what" happens, instead of "why". The bibliography of this paper lists only a few of the available texts in this area.

II. System Safety.

Currently the most effective approach to employing what we already know about equipment design safety is the field of System Safety. It is based on the well established premise that if safety actions are to be most effective, they must be taken over the whole life of the system, from concept to retirement. The traditional fly and fix concept has a built in need for accidents to provide specific system data. System Safety has no such need. As Jerry Lederer puts it, System Safety is "organizing to put your hindsight where your foresight should be in the identification and management of risks".[2]

Historical data on other systems, similar or not, are studied and distilled into general hazard data. The system under discussion, in its conceptual stage, is analyzed in the light of known hazard data and the concept is modified to minimize the hazards, within other system constraints. Well established analytical techniques are being used in these studies. As the system progresses through its life cycle, to development, design, testing, production, operation and retirement, specific steps are taken to preplan and design for safety.

[2] Jerome Lederer, in the forward to Willie Hammer, Handbook of System and Product Safety, Prentice-Hall, Inc. 1972.

For example, a preliminary hazard analysis will be conducted during conceptual design of the first airline spacecraft. This will reveal that refueling will be required with passengers on board. Data developed during today's Apollo program, current airline experience on refueling techniques, USAF, NASA, and NTSB data on refueling accidents and basic engineering knowledge will be applied systematically to minimize the danger involved.

The retirement phase is often a time of critical problems of maintenance, supply and general wear-out in any system. The current problems of how to get rid of radioactive waste and chemical weapons are examples of failure to plan for safe retirement during conceptual design. Investigation of accidents to DC-3, 6 and 7 vintage aircraft is providing data to designers of DC-11 and 12 era aircraft to foresee problems relating to old age and plan for them.

The accident/incident reporting system is an important feedback loop in System Safety, both for the system in use and also for the general hazard data bank. A conscientious investigator, who realizes that his work has implications regarding the safety of systems not yet conceived, will do a more complete job of investigating and reporting.

III. Management.

As systems become more sophisticated, their management requirements become more difficult. It is generally conceded that regardless of the amazing technical excellence of the Apollo program, it would never have succeeded without superb management by NASA and industry. The basic functions of planning, organizing, staffing, directing, and controlling are learned abilities, and the manager who wishes to be successful must study and prepare himself for the task.

If the results of an investigation of a mishap are to be meaningful to a manager they must consist of more than just the bare facts of the occurrence. The report must answer the question "Why?" At what point did planning fail, was the organization adequate to the task, was staff appropriate, etc.?

Why do pilots err? The report that says the pilot did something wrong, but fails to address the question of why he did it wrong, provides a manager no data applicable to other pilots except to say "don't YOU do it". If, by indepth study we can identify a lack of skill or knowledge, then the manager has something to work on which can prevent repetition of the occurrence. If Human Engineering discrepancies are discovered, the manager can plan for changes, develop procedures or otherwise minimize the danger involved in the identified hazard. If organizational procedures allowed the error to occur undetected, a good investigator will describe these procedures and recommend changes, which management can implement.

At times management itself is a cause factor, and this can only be understood and evaluated by an investigator who know how management works. Figure 1 is a diagram of the interrelationship of the basic categories of accident cause factors. The familiar man - machine - medium complex, interacting with the mission's characteristics and requirements, and encompassed by the system's management authority and responsibility.

What is important here is that the investigator must understand how a manager prevents accidents in order to provide him with data useful to an accident prevention program. Figure 2 models the accident investigation portion of an ongoing system, providing current data to improve the system and hazard data for use by designers of future systems.

IV. A Case Study.

Many examples of this indepth investigation can be found in NTSB files but one will suffice. The turboprop aircraft in this case suffered a propellor failure in flight which severed the fuselage and was fatal to all on board. The technical investigation was straightforward. Aircraft reconstruction and metallurgical examination revealed the specific events of the accident sequence. A single part of the aircraft had been improperly manufactured; it had failed to get the proper surface hardness treatment. A less thorough investigation would have stopped here, material failure, and closed the book. But this investigation touched on the following areas as well.

1. Design of the part. This particular failure mode had not been considered in design, testing, or certification. The investigator needed to know how aeronautical parts were designed, tested, and certified, as well as the technical details of how they were made. Other designers of similar items now consider this failure mode. Current System Safety analytical techniques would probably have discovered this failure mode, had they been available and applied when this part was designed.

2. Management control. How could a part of improper quality pass through a system designed to detect and remove it? The total management set-up of the organization was studied. Specific changes resulted which gave management greater control and assurance that faulty parts would not be released to service. Better procedures to respond to field failure data and field service problems were established. The investigator needed to know how a manufacturing plant was structured to produce parts and insure the required quality, and to respond to field problems.

3. Government surveillance. The check and balance of government regulation and surveillance was studied. Numerous changes in procedures have resulted, regarding reporting of defects, set-up of quality control organizations and inspection procedures. The investigator needed to know the relationship between private and government sectors in their regulatory responsibilities.

The key factors here are that an indepth investigation took place, and that the things the investigators needed to know or learn related to the field of management far more than to any one technical discipline.

We cannot teach everything to a new investigator coming into the field. However, we can provide him with a fundamental understanding of how accidents happen, the basic methods by which they are prevented, and the fundamentals of how people work together to get the job done, the thing called management. He can then build his technical skills and specialities on a firm foundation, understanding how he fits into the bigger picture, and thus be an effective part of the Safety effort.

As for the experienced investigator, he also must continue to learn or he will be left behind. SASI's part in this program must include the publication of papers, conduct of meetings and seminars, supporting of schools, and other activities to facilitate the professional growth of its members. This meeting is a step in the right direction.

ACCIDENT CAUSE FACTOR RELATIONSHIPS

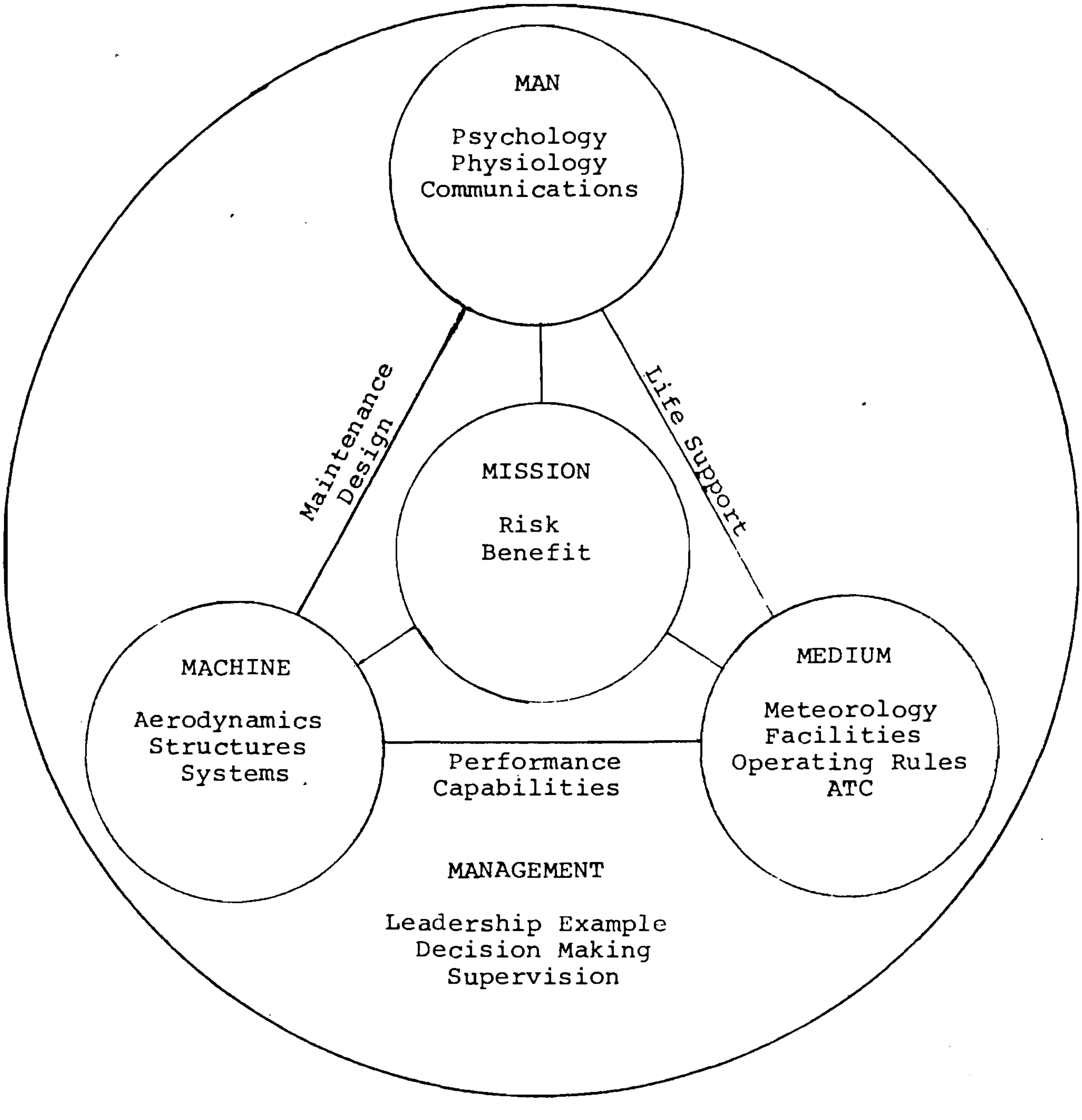
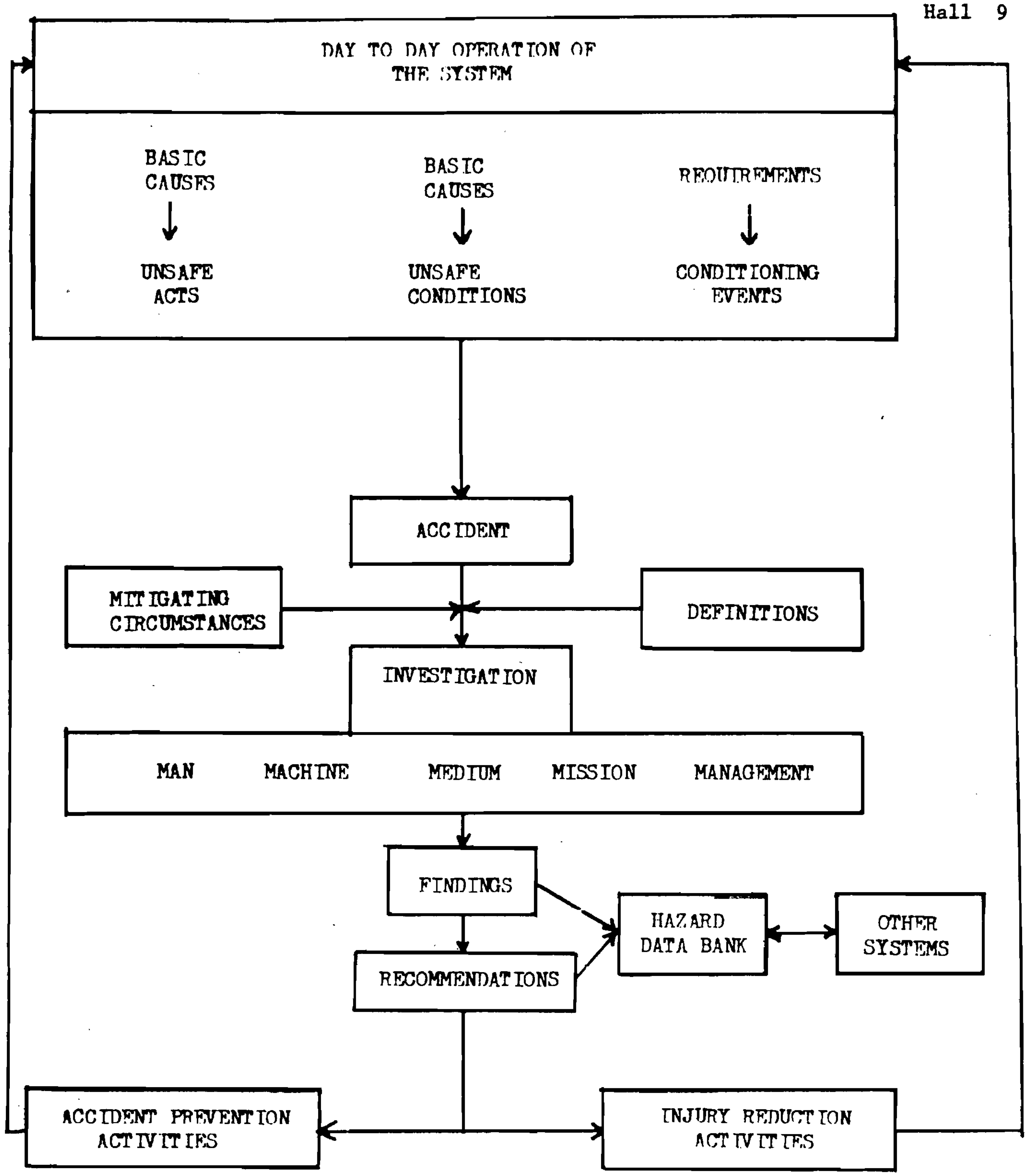


Figure 1



ACCIDENT INVESTIGATION FEEDBACK LOOP

Figure 2

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THE THINGS WE DO AT NAAIS

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Sometimes I'm asked whether training is really necessary for our investigators. In fact, one experienced man in the business has advanced the idea that a new hire is already an investigator when he reports for duty because of the criteria used in hiring him. The thought was offered that indoctrination was all that was necessary. If a man runs into problems, all he needs to do is use common sense. I have a definition for common sense, I can't remember who wrote it, but it goes like this:

"Common sense is that logic by which we determine that the world is flat".

This definition, as well as anything expresses the importance of not only basic instruction in accident investigation, but also a continuous program throughout an investigator's career. Common sense alone will not suffice.

Some people have said that a little knowledge is a dangerous thing. I suppose there is some truth to that. The thought reminds me of a man and wife who were sitting quietly at home one evening. Suddenly, she leaped to her feet, dashed over, and kicked him in the leg.

"What the hell was that for?" he asked.

"That's for being a lousy lover." she replied.

He immediately retaliated by kicking her in a beautifully formed portion of her postier anatomy.

"What was that for? she demanded.

"For knowing the difference." he said.

As you can see, we believe that a lot of knowledge is needed, and this is what we strive for in our program.

investigation techniques and procedures, but it will also provide an opportunity for those desiring only half of the course to attend. Also, the opportunity exists for one to take the entire course in two-week increments by attending courses given at different times. The scope of the Basic course covers the investigation process from the notification through the prevention function. The classroom is equipped with reverse projection for use with visual aids and numerous samples of wreckage, powerplants, and systems for use in laboratory examination. Field trips to the NTSB laboratories in Washington are part of the course. The students are asked to bring suitable clothing to wear in the field, because at the close of the first two weeks, the students will go to the scene of an aircraft accident in a wooded area on the Dulles Airport. The wreckage has been strewn in the same manner in which it was found at the actual site. Provided with the opportunity to gather all the evidence, including that obtained by actual witness questioning, the students will investigate the accident and write a factual and an analysis report.

Team investigation, taught during the second two weeks, will be presented by Bureau of Aviation Safety specialists from NTSB Headquarters in Washington who regularly chair the various groups which make up the team. During the last two weeks, visits will be made to the cockpit voice recorder, flight data recorder, and metallurgical laboratories. In Washington, the students will also see the Safety Board's automatic data processing in action, and learn its uses in aviation safety.

Another activity at NAAIS is the recurrent training seminar program. These are held every couple of weeks when the basic course is not in session. Selected study areas such as logic diagramming, legal implications, or investigation management are presented to NTSB personnel from the field offices as well as the Washington office. The seminars are prepared and presented by the various branches of BAS (Bureau of Aviation Safety) who are specialized in the subjects. Such seminars provide new knowledge and a better understanding of the workings of the different facts of the Safety Board. Thus, a more meaningful interface between the groups of an investigation will result.

Other training programs take place outside of NAAIS and are selected to improve the knowledge and skills of our investigations by keeping them up to date with the latest developments in aviation. Courses are taken at aircraft, powerplants, and systems manufacturers. Some air carriers have made courses available. Another external course is the familiarization flying training for our pilots. These are controlled courses also designed to keep our investigators current with the latest developments.

At present, the only course that persons other than NTSB employees may attend is the Basic Aircraft Accident Investigation. The selection of students is on a priority basis as follows:

NTSB personnel.

Personnel from other Federal Government agencies, including the military.

State Governments.

Foreign Governments.

Aviation Industry.

In order for personnel from the aviation industry to attend, they must qualify, or be expected to qualify, as a party to the investigation as defined in PART 431 of the Safety Board's regulations. In this manner, we assure more profound investigations because we are teaching people who are, or will be, working with us.

I know that quite a number of you here attended the NAAIS when it was located in Oklahoma City, and that some have attended since the School has been relocated at the Dulles International Airport. Students from all facts of aviation make for rich learning experience because of the sharing of information. Thus, all of us learn - instructors as well as investigators. We want to enjoy more of such learning experiences, so we are looking forward to seeing you in our future classes.

LUNCHEON TALK

BRIGADIER GENERAL M. F. DOYLE

First of all, I would like to extend General Carr's apologies for being unable to speak to you today, as he was scheduled to, but as so often happens he was caught up in the swirl of unexpected events which, unfortunately, demand his presence in Ottawa. He has asked me, under these circumstances then, to present to you his thoughts on aircraft accident investigation.

When he accepted this invitation to speak to the Society, General Carr immediately asked a friend of long standing, Colonel Joe Schultz, Director of Flight Safety for the Canadian Forces, for some ideas.

They apparently agreed immediately that aircraft accident investigation is not the most appetizing subject for a luncheon speaker but they also agreed that the subject couldn't and shouldn't be ignored completely. After all they reasoned, that is your common interest and the reason that you're all here. However, now that it has fallen in my lap, I think it would be presumptuous for a relative layman in the aircraft accident investigation field such as myself to make a frontal assault on this very complex subject. But if a frontal assault is not possible, neither is a full-fledged retreat from the subject. So, in true military fashion, I will try to gain the advantage by attacking it from the hopefully safe "high ground" of a member of the senior management of an organization operating a fairly significant fleet of aircraft.

Perhaps I could digress here for a moment and say that in our business it has now become fairly popular to submit many things that lend themselves to systems for analysis by a group of people who have become known as - yes -- systems analysts. These, as you may know, are very hard working people and they deal in terribly complex fields and they do great work but I'm sure that you would not find it surprising to hear that every now and then one of them breaks down. The particular chap

I'm thinking of had a nervous breakdown, in fact, and wound up in the psychiatric ward where he spent many months being cured. Finally, the day came, however, when he was judged fit to return home and as he was leaving the hospital with his wife, the doctor took her aside and said: "Your husband is cured but he has had a pretty rough road to travel and you must expect he may express some pretty funny desires from time to time. If he does, just humour him and cater to his desires as best you can". Well, the next morning she asked him what he would like to have for breakfast and he said "one fried egg and one poached egg". She thought that was pretty weird but remembering the doctor's advice, that's what she served him but when she put the plate down in front of him, he started to cry. "What's wrong, dear" she said. Through his sobs he replied "You've fried the wrong one".

Well, so much for systems analysts -- if there are any present, it's all just in fun - you do do great work for us.

Now my understanding is that most of you, in your role as aircraft accident investigators, work for an organization whose aim may include such obligations as "to enhance aviation" if you are with MOT or FAA, or "to maintain operational effectiveness" if you are a military man or simply "to make profits" if you happen to be with an airline. As a member of whatever organization you belong to, however, your personal aims cannot be in conflict with the aims of your organization -- your aims must be the same -- your short term goals must contribute to the attainment of your organization's aim.

You know, in these days of huge bureaucracy and computerized decision making, it's getting very difficult for most people to sit back at the end of the working day and say: "There, I've really done something for the company today...". As air safety investigators though you can say that when you have determined what caused an accident. However, in developing the skills to do this, through your training and experience, you can develop other skills that I, as a manager of an aircraft fleet, would want you to employ and would expect you to employ.

These skills are: first, to develop effective and workable preventative measures; second, to sell those measures to me; and third, to help me to sell them to the aircraft operators. I would like to say here that I recognize that for some of you, the terms of reference of your organization only allow you to investigate accidents - but do not allow you to take the next three steps I have just mentioned. I will continue with this line of discussion anyway since times will change and there are indications that this particular shortcoming is being overcome.

Let me tell you why I think that these three steps require as much skill and daring as investigation itself.

Possibly your organization is like mine in the Canadian Forces. During and just after the Korean War, there was a very rapid build-up of aviation in the Canadian military; flying activity expanded very very quickly, reaching a peak in about 1954-55. Regrettably, along with that peak in flying came a peak in the number of aircraft destroyed and, of course, tragically, the number of people killed in aircraft accidents. The peaks were so alarming, in fact, that even the simplest preventative measures had to produce beneficial effects. Furthermore, the appropriate preventative measures were immediately obvious in most cases as soon as a reasonably thorough investigation was complete. They were often so obvious that not much of a selling job was needed. Those days are long past now. We are in an "era of fine tuning" where fewer catastrophic mistakes are being made, but those mistakes are several orders of magnitude more costly in terms of resources lost. The potential mistakes are more difficult to foresee and are, therefore, harder to prevent. Let me give you an example of what has happened to the simplest of all preventative measures.

As you know, the traditional preventative measure in the military was to simply write an order precluding the activity that contributed to the accident. Now in our "era of fine tuning", as I have called it, we risk stifling initiative and aggressiveness of having too many orders. We also risk fostering the attitude that "if it isn't prohibited by a written order, then why shouldn't I do it?" That attitude clearly stifles a common sense approach to aviation. What I am trying to say is that workable, effective preventative measures rarely fall out directly from the accident investigation. The development and selling of preventative measures is becoming very demanding. We all know that we cannot afford to forget the relatively elementary lessons that we learned in the past, but like other fields of endeavour, that knowledge is expanding so rapidly that it is very difficult to keep track of it, let alone communicate it to those who need to have it.

If we combine the problems of remembering past lessons with the problems of developing preventative measures for newly recognized hazards in this "era of fine tuning", our approach, I would think, will have to be very disciplined and systematic. I think the concept of systems safety is an excellent example of this disciplined approach.

However, a word of caution is needed here. The direct result of this disciplined approach will, in every likelihood, be the development of a new language. It has been my experience that new technology brings with it a new language. The thing that must be avoided is allowing this new language to become a barrier in communications between you, the accident investigator cum developer of preventative measures, and people like me who will have to be sold on these preventative measures before they can be adopted. Another danger of this very detailed systematic approach is that you will become so involved in the sciences of accident investigation and development of preventative measures that you will have no time for the operational aspects of the organization and you may lose touch with my problems. If those two things happen, then not only will you not be able to sell your preventative measures to me - but, if you did, they may be completely out of context with the operational needs of my organization.

Let us assume that you avoid these pitfalls and you wish to sell me a preventative measure. You must recognize that I have limited money to pay for improvements and I have myriad other projects all competing for the same dollars. If you want to sell me on your proposal, be absolutely objective - know and clearly describe the pros and cons of your proposals.

Have a good feeling for the other projects that are competing for the same dollar that you want. Don't assume that any project with the word "safety" stamped on it must take priority over any other project I have.

I'm sure your training shows you how to use statistics to make a point and I would want to see the pertinent statistics; but statistics can be misused and we all know it. If I ask you for Raquel Welch's measurements, for example, and you answer "an average of 30 inches", you may be quite accurate but you've missed the point - or, perhaps, I should say points.

To be as concise as possible -- I'll trust your statistics only as far as I'd trust you --- no further.

Assuming that you've sold me on your program, I'll now need your help to sell the people in the field. I'll need your advice on how similar preventative measures have succeeded or failed in the past. I'll need to know what the best approach is. Is a regulation needed -- is publicity needed -- is an education program needed -- or are all these measures required? You need to not only know what I can do, you must know what will sell to the people. You may think this strange coming from a military man, but I am a realist. I know that regulations are being broken daily and, in some cases, almost habitually. The reason they are being broken is probably simple -- they are stupid regulations or they were poorly implemented. I need your help to avoid those sort of pitfalls.

I'm going to descend from my high ground now, but not before I say that, in my opinion, your Society's contribution to aviation depends on fostering and maintaining the highest standards of professionalism from all its members. Accepting anything less will not achieve our aims.

ENGINEERING EDUCATION REQUIREMENTS FOR AIRCRAFT ACCIDENT INVESTIGATORS

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It is not clear why this paper was accepted for presentation today under the theme "The Investigator and the Man", rather than in tomorrow's session "The Investigator and the Machine". The subject matter of engineering has historically been concerned with the understanding and invention of machines, rather than that of understanding man himself. There are cross-over areas such as "human engineering" and "biomedical engineering" which do not clearly fit into just one of the two classical disciplines studying either machines or man separately. What is meant in this paper by engineering, however, is the traditional definition involving the subjects usually taught in mechanical, civil, electrical or aeronautical engineering curriculum. Consequently, I would have thought I'd be speaking tomorrow rather than today, so I would simply ask you to consider what I am about to say as ideas whose time have not yet come.

Incidently, I first heard the term "human engineering" while taking an introductory psychology course at Carleton University in Ottawa and on one multiple choice exam a question was: "Human engineering is...?" There were five responses, one of which was "a sincere effort to make engineers more human". My future wife was also in the class and I found out the other day she had chosen that response, not because it was the right answer, but because she thought it was such a worthy cause.

Despite the alleged failure of engineers as human beings, I am firmly convinced that a solid grounding in certain technical disciplines is an absolute prerequisite for a competent accident investigator. In this talk I will illustrate the degree to which engineering plays a role in the various courses of study taught at the Institute of Aerospace Safety at USC, the scope and depth of that instruction, and why engineering plays the important role it does. I will add some further comments, based on my outside consulting activities, of the need for a higher level of understanding in engineering matters amongst the individuals currently involved as private accident investigators, insurance investigators and expert witnesses in litigation of aircraft accidents.

To put things in perspective, first of all, consider the basic elements of any course in safety as shown in Figure 1. We have lumped classical management theory, communication, prevention and investigation under the general, broad heading of safety management; whereas the specific technologies inherent in all of those, both of the man and of the machine, are lumped under the general heading "technology". This talk concentrates on the engineering education associated with the technology of machines and involves specifically those areas of mathematics and physics and the well understood engineering disciplines.

In Figure 2, I have illustrated briefly some of the short courses as well as two degree programs in safety currently being offered at the Institute of Aerospace Safety at USC. In that figure I have also indicated the total number of classroom hours and the number of hours devoted to engineering subjects. One sees from an inspection of Figure 2 that engineering plays a role to the tune of as high as 60% in the case of the Systems Safety course and as low as 16% in the case of the Senior Officer's course. The time spent in engineering subjects as opposed to other disciplines, is a function not only of the importance of that subject to the objectives of the course, but also to the level of understanding of the students in that course. Consequently, we find, for example, in the Aviation Safety Officer's course of 12 weeks -- some 25 hours of the 132 engineering hours are devoted to a basic review of high school math and physics so that all students are starting out from the same basepoint in their future discussion of engineering topics related to the kind of aircraft they fly. In general, as can be seen from Figure 2, an average of approximately one-third of the students' time is spent in subjects that fall under that engineering category. In the degree programs, both in the bachelor and the master programs there is considerable latitude depending on particular student preferences as to the degree of technical subjects the student can take. For example, in the bachelors safety program you can see that as low as 26 of the 128 required semester units may be in technical subjects or for the more technically oriented as high as 83 of those 128 total.

I have chosen to examine more closely the aviation safety officer program to give you some idea of the kinds of subjects which are addressed in the 132 hours devoted to engineering and the depth to which that instruction takes place. Figure 3 shows, first of all, the breakdown of the total 371 classroom hours into the various subjects; including management theory, prevention, investigation, psychology, physiology and engineering -- again showing the total of 35% for engineering subjects. The 132 engineering classroom hours are spent as shown in Figure 4. The course is divided into four parts; the first being the roughly 25 hours of mathematics and physics review usually at the freshmen level in basic algebra, trigonometry, physics (especially mechanics ideas of force, velocity, acceleration, energy, power, work, torque, moments, etc.). It has not been found necessary to the objectives of the course to insist that a student have any grasp of calculus and most of the problems can be formulated and solved without the use of calculus.

The second part deals with aircraft structures and some 35 hours are spent, first of all, in the basic mechanics of materials, concepts of strength, stiffness, service life considerations such as fatigue, creep and corrosion, various characteristics of different materials commonly used in aircraft structures, concepts of stress and strain and the way they relate to the crash worthiness of the vehicle and also a number of hours dealing with the failure analysis of components. The student is expected to be able to analyze to a certain degree via visual means the magnitude and sense of the forces or moments which cause a part to fail in a particular way. Instruction in aircraft structures is extremely useful to the accident reconstruction process which goes on in the investigation course and in particular the analysis of a number of actual accident wreckages which we have at our Norton Air Force Base facility.

Next, we talk about basic concepts of aerodynamics, in particular the generation of aerodynamic forces on airfoil surfaces, on wings in the case of the army class with special emphasis on helicopter main rotor and tail rotor blades. We look at the basic characteristics of air flow both in terms of lift and drag, force capability and also of their pitching moment capability. We examine power plants; talk about the factors which affect power available and later on discuss the factors which affect the required power for a particular flight condition.

The most lengthy portion of the engineering curriculum deals in this case with an analysis of helicopter performance, stability and control. Starting out with the aerodynamics of hover, we look at the kinds of factors that affect hovering performance both in terms of maximum hovering height and maximum gross weight capabilities using quite often the kinds of performance charts found in the pilots' manual. We relate the nature of the performance curves to the basic formula which we have derived in our aerodynamics section to illustrate where the curves came from. We spend a lot of time talking about particular problems of helicopter flight which show up in the accident statistics. In particular, we spend a great deal of time talking about autorotation; not only the aerodynamics of autorotation, but the piloting factors associated with a successful autorotation from various entry conditions. All aspects of helicopter performance are considered here --- including level flight, hovering, climb performance, descent performance, performance in wind conditions and performance in turbulence. We also look with some degree of depth at the characteristics of modern flight control systems currently found in aircraft and how they impact flying qualities and in particular the degradation in flying qualities experienced under various failure modes.

While Figure 4 quickly outlines the subjects, it might be helpful to choose one subject from each of the four parts and give a representative quiz question, which illustrates the depth to which the student is expected to have grasped the subject. Figure 5 illustrates the typical problem in which the student is given a three-view of the helicopter with all its dimensions and asked to determine various aircraft attitudes required to achieve particular conditions. Figure 6 is a typical failure analysis question showing some typical buckle patterns on the tail boom of an OH-58 and qualitative questions asked with respect to the manner of loading required to achieve that particular pattern. Figure 7 shows an example from our basic aero curriculum, in this case a question on airfoil shapes. Lastly, Figure 8 illustrates a typical helicopter performance problem involving the autorotation characteristics of the UH-1C. The student is expected to have not only a qualitative understanding of the phenomena but a moderate quantitative understanding as well. He is expected not only to be able to work out reasonably simple problems quantitatively, but to explain the physics of the problem qualitatively, either in writing or orally.

I want to use the remaining time to offer some observations on the engineering expertise, or the lack of same, which exists in the community of individuals engaged by government, insurance companies and attorneys to investigate aircraft accidents. These observations come from my association as a technical consultant and expert witness in a number of general aviation accidents in California.

Since engaging in this activity, I have been continually amazed at the low level of technical expertise which this group brings to bear in their investigations. In many cases their clients, unknowingly, are being seriously let down by either incorrect analysis of physical evidence or, more often, by a cursory interpretation of physical evidence in favour of other areas in which they are more familiar - such as operational and piloting factors.

When you examine the background and experience of this group, it becomes immediately obvious that a disturbingly high percentage come from the same mold -- former military pilots, most full termers. Looking further, you find that of the ones which have a university degree, only some of these are in engineering or science. Moreover, they have not directly practiced these disciplines during their 20 years of military service.

There is no doubt that a knowledge and understanding, of the pilot's viewpoint, of the airways system and of other operational factors is an asset to an investigator - no doubt about it - but it by no means automatically qualifies a man to call himself a professional investigator.

As an ex-military pilot myself, it has been my observation that the attaining of senior officer rank is a testimonial to a man's astuteness as a politician rather than a technician. Further, the fact that a man has managed to exist 5,000 hours in the close confines of a cockpit has only the remotest relationship to his true understanding of the physics going on around him. What I learned in the first year of civilian engineering test piloting far exceeded my cumulative experience as an Air Force pilot.

I believe that it is time for a general upgrading in the basic engineering skill level of air safety investigators currently practicing and a tightening of requirements in this area for people entering the field. For the latter group, a Bachelor's degree in aeronautical or mechanical engineering is a minimum requirement, in my view.

When I discuss this situation with some people, I get back the argument that there is no need for such a requirement since a good investigator can call in an expert in the particular area involved. I also hear, and you will hear in a talk tomorrow, the virtues of the "team" approach to investigation whereby a panel of experts from various disciplines collectively attacks the problem. There can be no argument with the desirability of such an approach, but the fact of the matter is it only gets applied in accidents involving massive loss of live and property damage. Only when it is within the economic feasibility of the manufacturer, airline or plaintiff's attorney is such a team approach employed.

There were over 4,000 general aviation accidents in the U.S. in 1972. We all know that the vast majority of these were initially investigated by only one man. In the percentage of these which resulted in litigation, again a one-man-team is usually employed, often just the attorney, perhaps with the help of one private investigator or expert. The plain fact is that this will continue to be the case -- the question is how well equipped is this one man? In particular, what is the depth of his understanding about the machine itself? What ability does he have to intelligently sort out evidence from a smoking mass of tangled airframe? How capable is he of identifying potentially significant aspects requiring expert analysis and how good is he at posing the problem to the expert, monitoring the expert's activities and placing credence on the expert's findings?

I submit that the only way in which an investigator can adequately conduct himself in this area of inquiry is to have been exposed to and demonstrated competence in the many sub-disciplines of engineering which were utilized in the first place during the aircraft's design and manufacture. This exposure can be had initially through a bachelors or masters program in engineering or science followed by continuing an up-to-date education either on-the-job or in various extension courses.

I stress the term "up-to-date" education because of the phenomenal increase in aeronautical technology that has occurred over the past ten years. A graduate of 1948 who has not been vigorously engaged in his field simply cannot bring to his accident investigation the insight which is demanded by today's highly complex aircraft and their subsystems. Moreover he is not in a position to bring analysis techniques, state-of-the-art in aircraft design, to the investigative problem. Let me illustrate this last point with two quick examples.

First, the area of computer graphics has enjoyed an enthusiastic acceptance in the preliminary layout of new aircraft. Virtually all large aircraft manufacturers now employ the ability of a computer program to generate perspective drawings of aircraft shapes on a cathode-ray screen. By simple control knob functions, the operator can rotate, translate, enlarge or shrink the image so that its shape can be viewed from any aspect and at any range. Additionally, the c.g. of the aircraft can be driven by the equations of motion for the aircraft, which is being "flown" by either manual or programmed commands.

The application of this technology to the analysis of mid-air collisions will be obvious. It would be a simple matter to program two aircraft simultaneously. The motions of one, as seen from the pilot or co-pilot's eye position in the second aircraft, can be displayed, followed by the view of the first a/c from the second. Further the determination of impact conditions can be had by viewing both a/c from a third external location. By driving the a/c with the signals obtained from the flight recorder, or simulated from witness statements, we could relive the collision. Relative velocity vectors, points of initial and subsequent impact could be determined and correlated with physical airframe evidence.

An investigator unfamiliar with the technique or who doesn't know how to set it up, where to go to have it set up, how much it may cost, etc., will not be bringing to bear on the problem an available resource, the application of which might play a vital role in cause and fault determination.

The second example is the area of wreckage trajectory analysis. It has long been possible, using either analog or digital simulation, to predict the trajectory of an aircraft component which departs the aircraft in flight, given the initial conditions of aircraft attitude, altitude, velocity vector, and wind conditions. The inverse problem is not so easy -- that is, given the wreckage distribution on the ground and the winds aloft, where was the aircraft in space, what was its heading and velocity when the first component broke away, and what was the following sequence of break-up?

Applying recent knowledge in the area of mathematical optimization, which can now be handled on existing digital computers, some significant work has been done, notably here in Canada, which clearly demonstrates the potential this technology has in aircraft accidents involving in-flight disintegration. Again, the impetus for further development, and ultimately for this technique to be used as a standard tool, requires cognizance of and appreciation by the investigators themselves.

The stakes in aircraft accident litigations are high and growing faster as product liability legislation expands and is being defined in the courts. More and more accidents require, and can afford, a thorough and professional technical investigation. It is the duty of every investigator, as it is the duty of this safety society and educational institutions such as ours at USC, to further the cause of solid engineering education so that the development of technologies can be meaningfully applied to a most important aspect of air safety - the investigation itself.

TRAINING OBJECTIVES FOR THE AIRCRAFT ACCIDENT INVESTIGATORS

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Distinguished guests, ladies and gentlemen. In presenting this paper it is thought fitting to firstly give the broad but very concise aspects of Training Objectives for Aircraft Accident Investigators then move on to analysing the individual items in my conclusion.

It is often thought that a good investigator should stem from either the engineering of pilot cadre. Although this does not mean that other interested subjects cannot become experts in the art. The reason is obvious, for in both instances these subjects are familiar to some degree with the aeroplane, its lay-out, systems and functions.

The point that the investigator should have some knowledge of the aircraft's structure and its function must therefore become paramount in their training programme. With this in view the aspect of aircraft standardization must become significant. If aircraft designers conform to more standardization practices the investigator's task may not be as irksome as at present.

In the present era, aviation technology has developed in very diversified modes; some countries design the bigger craft, others the faster ones, whilst some blend both. All these craft today are heavily instrumentated; even the lighter craft carry far more instrumentation than their counterparts of yesterday. Consequently, in the event of a crash there is much more to work on. Admittedly, some of these instruments are mainly to aid the investigator. But even with these modern equipment, he has much more to solve.

There is of course the set pattern of approaching the accident, be it big or small. Yet with all these orthodox methods some accidents have remained unsolved. In aircraft accidents, there are so many variables, and in this age when aircraft speeds have reached supersonic, these variables present much complex problems. One very disturbing variable which investigators must have to contend with is the weather. A crosswind component can deviate a large fully loaded transport aircraft beyond its computer tolerances on the glide path on finals, resulting in a fatal crash. There would be no evidence of such an element unless the pilot survives the crash or a black box if installed, records some parameter pointing to such crosswind. In the absence of these, the investigator will be lost for want of a solution. It could be presumed that a crosswind has caused the crash, but there will be no positive evidence.

The investigator's training therefore must aim at obtaining all facts pertinent to the accident within the shortest possible time. This would involve:-

(a) Obtaining as much information on the flight crews, especially the pilot and co-pilot.

(b) Prevailing weather at time of accident.

(c) Terrain of locality and altitude of aircraft.

(d) Knowing the aircraft's final attitude before the crash either as can be determined by the pilot, black box, assistance from ATC or reliable independent observers/ witnesses.

(e) Knowing enough about the aircraft, (its history and systems), to be able to decide on likely probabilities.

Analysing these we have (a) information on flight crews is always essential in any accident investigation. The human factor element is so difficult to eliminate. The complete history of the pilot and co-pilot especially, would be vital if an error in manoeuvring is suspected - fatigue. Apart from their complete medical record, the pilot's last duty and port of embarkation, his activities during the last few hours before the flight, the people he met, places he visited, etc., could all be of some importance. These information will become more so necessary if neither the pilot nor co-pilot survives the crash when the arrow still points to human error.

Another point which falls under this heading is the activities of the other flight crew members like air hostesses. (Imagine a fully loaded transport aircraft taking off. The pilot detects something amiss, does a few circuits, ejects fuel and comes back in to land. It could be one engine on fire. The pilot and co-pilot could position the craft safely on the runway; but because other flight crew members do not give prompt and correct instructions or act correctly about passenger evacuation, no one can survive what could easily have been an incident.) All these are points which must be considered before arriving at a conclusion. Ground services like fire and refuelling crews can likewise contribute or prevent fatalities in aircraft accidents. No one's task connected with the aircraft, no matter how minor should be viewed lightly. His or her activities could or could not have contributed to the crash.

Moving on to (b) prevailing weather at time of accident, meteorological offices today are really keeping pace with the rapid flow of air traffic. Depending on prevailing weather, they could supply TAFs as often as required. The difficulty with weather is usually when the crash occurs in some remote areas, where reliance has to be given on the last Sigmet or Volmet in conjunction with latest information by ATC. In most cases the actual time of crash can not even be determined so that obtaining the actual weather at time of final loss of control is impossible. Trainees should know and appreciate this difficulty which will remain a problem for sometime yet.

As for (c), depending on the place where the crash occurred, terrain may or may not be important. There had been numerous cases of fatal crashes in mountainous regions due to faulty altimeter settings. Naturally trainees will learn all about this type of accident. Also in those areas weather can be a nuisance - sudden change of wind direction, hill fog and the likes are all dominant hazardous elements in bad terrain areas.

As regards (d) the modern generation of the large transport aircraft carry black boxes. These are reliable aids to the aircraft accident investigators which when handled correctly will lead to an early determination of the accident's cause. This is one of the areas where designers could practice standardization, so that black boxes will always be installed in the same safe position in every aircraft. Trainees could then be instructed where to look. Read-outs of black boxes as of now are a job for the experts, and these experts should be known to the trainees so that they alone can undertake that task. From the data available, the aircraft's final attitude before the crash, another vital ingredient in an investigation will be known. Sometimes black boxes do not survive crashes, the investigators will then have to rely on the pilot, co-pilot or independent observers or witnesses. The last two should be handled with extreme caution. The independent observer usually tends to exaggerate facts like altitudes and attitudes. Naturally any layman observing an aircraft accident is bound to be excited and most times this excitement is tinctured with a certain amount of fear. In this regard, it is worth mentioning that given the right questions, children can sometimes be the best of witnesses. Therefore, trainees should be taught the type of questions to ask. Usually aircraft accident investigating organizations keep set forms with questions for witnesses - questionnaires. But even with these, it is sometimes difficult to get the facts required. Re-creation of the final flight path can be essential. Air Traffic Control staff can be of tremendous help regarding this aspect in instances when the crash occurs in the vicinity of the airport. Their evidence regarding altitude and attitude will be reliable. Trainees should therefore be given an insight into the role of ATC.

Finally for (e), the team of aircraft accident investigators, of course with special bias to a major accident, will comprise various groups, with each group having a specific task; one such task would be to collect as much history of the aircraft in order to be able to rule out structural fatigue problems, malfunctioning of systems, components, etc. In other words, this group should be able to make sure that the airworthiness requirements were satisfactorily met during the subject flight. Trainees should be made conversant with all current Airworthiness documents especially so during these days when variations in airworthiness standards still exist between States.

As regards systems and functions, it is always possible to co-opt experts from manufacturers who are always too willing to help, once a likely section of the aircraft is under suspicion. Manufacturers will also put any special test equipment at the disposal of the team to help ascertain or otherwise such suspicions. Malfunctioning of instruments also falls under this heading. A faulty altimeter is as dangerous as a wrongly set one. There are recorded instances of sticky needles of the A.D.F. (Automatic Direction Finder), mis-reading of common instruments like the artificial horizon, etc., etc., by most experienced pilots causing fatal crashes. A good number of these errors can be traced back to those pilots or co-pilots doing too longer duty periods, whilst the rest could be due to a minor pre-flight drill not being adhered to or deliberately avoided. Everyday, the aircraft is being made into a safer machine, and handled in the prescribed manner, will always give efficiency and satisfaction. As investigators, one should be able to trace back, when an error is the machine element, to some minor procedure not being undertaken, causing one or other minor malfunctioning to remain unnoticed thereby resulting in the crash. But truly, this is more easily said than done.

Assessing probabilities is the art of accident investigation and this is not something that one can obtain readily from the plato in any lecture room. This is a technique which has to be developed through experience and wide knowledge of different accidents and their causes. For this aspect, trainees can read various reports of accidents to appreciate how probable causes are arrived at. Whenever possible they should enter into lively discussions on probable causes. They could be made to read up accident reports devoid of the concluding sections and encouraged to deduce likely probabilities which could then be compared with actual causes published for such accidents. They should be encouraged to take a very broad perspective of individual team findings in order to develop very objective and unbiased ideas, and also made to rely only on the available facts or results, and where doubts exist, these should be thrashed out without regard to any personal feelings or interest that could exist among members of the team. In fact should such interests or feelings be suspected among any in the team, it would be conducive to a more realistic outcome for such person or persons to declare thus, and excuse themselves from the final discussions.

In ending I am to stress that the training of aircraft accident investigators can by no means end in a lecture room or laboratory. The investigator's skills develop more without than within those confines. He will doubtless be equipped with the correct tools for the job in both places; but production of the best type of work will ultimately depend on the situation he finds himself and how well he employs such tools.

TRAINING OF PROFESSIONAL INVESTIGATORS
AIMS AND LIMITATIONS

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What I say here today and any opinions I express are entirely my own. Any experiences I relate have occurred to me on duty, either as a former member of the United Kingdom Accidents Investigation Branch, or as Flight Safety Manager of the British Aircraft Corporation.

When I learned that the theme of this year's seminar was to be focussed on Training, I found it almost unbelievable that, at last, we were getting down to basics, i.e. to highlight the primary origins from which the investigator started to learn his profession and thereby carry out his vocation efficiently, which depends so much on the quality of training in the first place.

In 1903 - just 70 years ago - the Engineering Editor of that much revered and oft quoted English national daily "The Times", wrote:-

> "Attempts at artificial aviation are not only dangerous to human life but foredoomed to failure from the engineering point of view."

which shows he had not polished his crystal ball that day and spoke from abysmal ignorance. Whilst there is every reason for the professional investigator to omit crystal balls from his brief case or his accident reports, he cannot afford to be ignorant. So now where do we start?

Be he a pilot, engineer, doctor of medicine or any other appropriate professional, at what point in his career should an individual start if he has the call to become an investigator? Even if he thinks he wants to do the job, how is he to know if he is suitable, both as a professional and as a person? Equally, how does the Authority to whom he applies for the job decide that the applicant is a right and proper person to fulfill this vocation? For gentlemen, it is a vocation in the truest sense of the word and there are two virtues which have to be built in for a start - humility and integrity, which means you will have to be prepared to be the point where the buck stops and admit it when you drop a clanger -

everyone makes mistakes - not many admit it! No matter how efficient the theoretical training and neat the office paperwork, there are no substitutes for good results. It is from those alone that the Authority can decide whether or not the embryo investigator will become a good all-round professional.

We all know that the most desirable personal qualities of an investigator are enumerated in the I.C.A.O. Manual of Aircraft Accident Investigation (Part II, Chapter 1) and I feel that provided the individual has, and his Authority knows he has these qualities, as well as theoretical training, all that he lacks will be experience, the best instructor of all.

By experience I mean total embroilment in every facet, not just participation - a woolly expression - and signifies to me that anyone who "participates" is really only on the fringe and of probably one aspect only. A good investigator benefits from being deeply involved in all the different stages of investigation which will give him overall experience which he must learn to co-ordinate. But to return to my first rhetorical query - at what point in his career should he start? Although there are exceptions to every rule, I feel a candidate will have completed his basic training in whichever speciality he chose and is a corporate member of an appropriate professional body, thereby giving an indication of his capability. However, academic qualifications are insufficient and I think a candidate should also have had a few years' experience in his chosen field, but not too many years - too many years could mean he has worked his way into a rut and has set ways - and an investigator must be imaginative and mentally flexible. Additionally an investigator is never an expert. "An expert is someone with a shut mind." I forget who coined that phrase, but it is true.

When the embryo investigator joins the Investigating Authority, I feel most strongly that he should undergo specialized investigators' training at a recognized tutorial institution for this purpose and only thereafter given dual instruction with an experienced investigator in the field. How long this embryonic stage extends will depend to a great extent on the number of accidents in which he will assist an experienced investigator and most certainly on what impression he makes on his seniors. It is essential that the Investigating Authority has complete confidence in the new investigator's work before he is let loose on his own.

I feel I must emphasize the previous stage regarding investigation instruction at a tutorial institution. There are some countries, signatories to I.C.A.O. Annex 13, who do not have any formal tuition for new entries to the ranks of their Investigating Authority. This is, I think, a weak point, but one can understand the reason in that as there are few vacancies in the Authorities' ranks, (being a fascinating job, many want to do it, hence the low pay offered), there is not much point in setting up a National School to instruct in that subject alone, for to do so is an expensive undertaking. Consequently, I advocate that all those countries who have new men joining their Investigating Authorities' ranks, and who do not yet do so, should send them for a recognized course of instruction in the art of investigation, even if it means sending them overseas. This will be a new idea for some countries and it is still frequently true that trying to sell a new idea is like making love to an elephant - it takes about two years before you get any results and you may get sat on in the process! Nevertheless we might and I feel we should, as the only Society of Professional Investigators, suggest to I.C.A.O. that that body should recommend a course of formal training for all new investigators, with refresher courses from time to time to bring all investigators up to date in the various techniques. I would go further, if these were agreed, I suggest that under I.C.A.O. auspices, a Central School of Accident Investigation be set up which could evolve as the authoritative and only recognized International School of Instruction to cover every aspect of aircraft accident investigation. In that way at least there could grow an agreed global standardized procedure better than we behold it today, and it must improve to cope with the increasing complexities. If you do not believe this you shouldn't be in the business.

I, for one, would be delighted to grasp the opportunity if it were offered, to make a contribution to such a venture. I believe all of us should be prepared to skim off the cream of our knowledge (sometimes hardly bought) for the benefit of the rising generations of professional investigators, who are bound to follow us whilst aircraft still fly.

There have been, and still are, difficulties with some investigations today, regarding differences in legal systems and customs. One of these which can be a cause of difficulty in making an immediate start on an investigation is when an accident occurs in a country whose laws are based on the Napoleonic code. There have been occasions where the examining magistrate has impounded everything to do with the accident including the aircraft wreckage, and in the case of fatalities, the bodies also. I hasten to add that both the French and Belgian legal and investigating authorities seem to have arrived at a reasonable and workable understanding more in keeping with the spirit and intention of Annex 13, but it would be of inestimable value to safety if all those countries from whose traditional legal codes such difficulties arise, would examine the problem in a practical light and reconcile their interests, rather than sweeping the whole thing under the carpet until next time, pretending in the meanwhile that it did not exist, and I for one do not wish to be the embarrassed audience in witnessing the ludicrous spectacle of an examining magistrate threatening legal action against his own Civil Aviation Authorities. To such I put it bluntly - neither wreckage nor dead bodies improve with keeping in the open air and when left lying around, vital evidence will disappear whilst valuable time is squandered over government interdepartmental wrangles. Nevertheless, whilst we still have such occurrences with us, they are valuable experiences for new investigators and an object lesson in training him to be patient no matter how frustrated he may feel and to demonstrate one way the job should not be done. In essence I am saying the investigator never finishes training - he can never know it all and must, if he is to be successful to a certain extent, always be willing and never too proud or big headed to learn more, even if he's been in the profession for 30 or 40 years. Indeed, if you have spent that length of time on the job, you will probably need a refresher course anyhow, as the actress may have said to the bishop!

Now, every investigator worth his salt realizes that he cannot possibly know all there is to know about every aircraft which might become a casualty and require his attention, so I ask you who are now responsible, or may become responsible for training embryo investigators, PLEASE ensure that your pupils know the best way to use the available facilities, and in particular, the aircraft manufacturer's Flight Safety Representative. Some Authorities, I have noticed in the past, seem to be at worst suspicious and sometimes indifferent to the offer of his firm's facilities. This is short-sighted, for it is through this Representative that the Investigator-in-Charge can obtain, with the minimum of delay, all the necessary references to performance figures, structural details, systems operations and similar data. In addition, the manufacturer's Flight Safety Representative can call in firm's personnel who are specialist on that particular aircraft or a particular system of that aircraft. Finally, I deplore the attitude of some Authorities who will not give a copy of the Flight Data Recorder readout to the aircraft manufacturers without delay. Much time can thus be lost, for as a general rule, those who need to make an accurate analysis of the readout will require the type performance figures and to work out the analysis with the manufacturer's specialists in the end. A responsible manufacturer is as keen as the investigator to find the truth. He will not continue in business very long if his reputation becomes tarnished by reluctance to co-operate in full.

The new investigator should experience both types of investigation, the one of full co-operation and the other of grudging acquiescence - it is highly educational in more ways than one.

However, I have been on both sides of the fence personally in the past and know what it can be like - you can become so frustrated that you feel like knocking peoples' stupid heads together, for you know, and so should all the others on the job, that in the end co-operation must prevail if the truth is to be found.

There is yet another training aspect. Whilst there are established procedures for the reporting and interchange of information on a formal basis, I am certain there is no substitute for personal contacts with Investigating Authorities, Manufacturers' and Operators' Flight Safety personnel, to ensure full and frank discussion between those responsible for operational safety in its widest sense. I applaud the initiative taken by organizations who encourage their personnel to visit their opposite numbers world-wide in Airlines, Investigatory and Standards Authorities from time to time to discuss general problems in their fields. Personal visits engender trust and confidence. Should an accident occur, a close personal working relationship established in the past pays handsome dividends in this circumstance. Do not underrate this value. Individuals get to know and respect each other over the years, so consequently when working together as a team on an accident investigation, they co-operate to the maximum with the minimum risk of misunderstanding - a desirable state of affairs not easily achieved when working under stress with strangers. I believe that personal visits to the Aeronautical Authorities by Manufacturers and Operators' Safety Staff, not only helps to keep them in touch with individuals, but also abreast of accident and incident investigation procedure and the interpretation of the regulations. I consider this human angle to be part of continuation training of the accident investigator - good human relationships in this particular field have far more influence for good and trouble free co-operation in an accident investigation than many may believe, enabling every effort to be put into productive use to solve the problem.

We, as accident investigators, must remember at all times that we are brothers-in-arms in a common cause to find and present the truth. Nothing must be allowed to stand in the way of the advancement of Safety in Flight.

To sum up - forward progress and success of Flight Safety will only be assured if the investigator has been thoroughly trained in the basic groundwork, whose integrity is absolute and who is given every opportunity to enlarge his experience and encouraged to contact others of his kind all over the world to discuss mutual problems and their solutions. We must all remember that investigation and detection in many fields are not only two of the oldest professions, they are also two from which we may continue to learn as long as we are active in this, our chosen field of service to humanity.

WHY WITNESSES REPORT AS THEY DO

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How can two or more people observe the same occurrence, under the same conditions, from the same vantage point, at the same time, and report conflicting events?...the answer, of course, is people! People differ widely in their ability to accurately report their observations.

Basically, and oversimplifying the problem, the reasons for discrepancies in observations may be placed in one of three categories: Environmental, Physiological, Psychological.

Environmental reasons for errors include such factors as fog, darkness, glare, proximity, noise or speed.

Physiological reasons for errors in reporting include hypoxia, vertigo, stress, physical condition, and of course, consideration of any previous witness activity which may have affected visual acuity.

Psychological reasons for errors in reporting include prejudices, attitudes, beliefs, witness personality, and interviewer personality.

This presentation will attempt to create an awareness of some of the psychological reasons for errors in reporting observations.

Personality often determines why witnesses report as they do. The extrovert, braggart, or highly self-confident individual makes a convincing witness because of the positive, adamant manner displayed when relating observations.

The introvert, reticent, or self-conscious individual creates doubt in the mind of the interviewer because of lack of assurance and the indecisive manner displayed when relating observations.

The suspicious witness is reluctant to get involved. He is not excited about accident prevention, and is more concerned about what is to be done with the information, or how he is going to avoid appearing in court as a witness. The suspicious witness often asks so many questions concerning his personal involvement that the interviewer gives up and goes on to question a more cooperative, but not necessarily more reliable, witness.

Interviewing the excitable witness is sometimes as bad as listening to the fisherman tell about the one that got away. The excitable witness is usually honest, but tends to exaggerate, elaborate, and unintentionally stretch the truth.

Sooner or later, if enough witnesses are interviewed, one will be questioned who is intentionally lying. Witnesses, like most people, will lie for one reason or another. The reasons are not significant at this time, but the behaviour which indicates untruthfulness is. Make a mental note of these seven signs of lying.

The sincere witness: The psychological effect of the sincere witness on the interviewer can be very subtle. The trained investigator can usually recognize and deal successfully with the extrovert, the introvert, the emotional, the inquisitive, the lying, or the excitable type of witness. The sincere witness, however, displays none of the more obvious witness traits that would assist the investigator in judging the witness. In fact, the interview with the sincere, straightforward witness usually flows with such deceptive ease that the investigator accepts the information at face value. The investigator neglects to follow up with specific questions to clarify areas that the witness covered only in general.

CAUTION!! Sincerity is not necessarily a guarantee of exactness.

Witnesses are often influenced by the personality of the interviewer. For example: the over-eager investigator not only asks the questions, but leads the witness by suggestion, or by giving a choice of answers.

The bullmoose investigator may intimidate or frighten the witness into silence, or worse yet, press for information in an area where the witness has no facts.

A timid, apologetic investigator raises doubt in the mind of the witness as to whether or not the investigator knows his business.

The excitable interviewer reacts to witness' answers, and may find that his nervous attitude influences the witness to over-cooperate by telling what the witness thinks the interviewer wants to hear.

The trained interviewer realizes that probably the best overall approach is one reflecting sincerity, and stressing accident prevention.

What other psychological factors are there that influence witness observations, other than personality traits?

Motive is a key factor influencing why witnesses report as they do. It is difficult for a witness to be objective if he realizes that the truth will result in dismissal.

No one wants to incriminate himself or his fellow crew members. Witness observations must be critically evaluated where the situation involves the family, friends, livelihood, property, or the job of the witness.

Judgment is another psychological factor affecting why witnesses report as they do. Witnesses evaluate their observations, and during their initial "free narrative", relate primarily those events which they judge to be the most significant. Unfortunately, spectacular events that the witness considers highly significant may have no bearing on the accident.

Witnesses often attach no significance to the sequence of events; they place the cart before the horse. After all, what difference does it make to the average witness whether the smoke or the fire appeared first?

Most witnesses are anxious to help and to tell what they observed; they appreciate the seriousness of accidents, and are usually eager to talk -- sometimes too eager. Witnesses with this attitude are easily carried away with the excitement of an accident and are particularly susceptible to:

1. Multiple questions.
2. Choice of answers.
3. Leading questions.

Everyone likes to feel important, and witnesses are no exception. They are flattered to have been selected as a witness, and often take the attitude that "once I tell this investigator the facts, he will wrap up the investigation". The proud witness hates to admit that he may have missed something, and hates to be pinned down. The proud witness finds it even more difficult to retract a statement if others are present. The trained investigator isolates the witness during an interview.

The prejudiced witness is not psychologically suited to report objectively. The trained investigator should be able to detect certain telltale signs of prejudice, for example:

An "I told you so" attitude; "I knew this would happen sooner or later"; and, "It's about time we stopped all this flying!"

The psychological effect of the delayed interview can influence witness testimony in several ways:

1. Witnesses forget with the passing of time.
2. Witnesses may take the attitude -- "If my observations are so important, why wasn't I contacted three days ago?"
3. The longer the delay, the more chance of witness exposure to other witnesses and news media reports.
4. Rationalization goes hand-in-hand with delay.

Witnesses think about their observations and begin to analyze, reason, and conclude. Rationalization is particularly common in accident situations where the witness was personally involved. An early, frank admission by the pilot who forgot to lower the landing gear changes after the pilot has time to rationalize:

1. "The tower should have told me."
2. "Where was the wheel watch?"
3. "There should be a louder wheel warning horn."

No one likes to admit a mistake, and can usually rationalize that it really was not all his fault.

Even a seemingly unimportant factor such as the "interrogation versus the interview" atmosphere can have a definite psychological effect on a witness. If an "interrogation instead of an interview" atmosphere is created, an otherwise cooperative witness may withdraw and stop the flow of voluntary information simply because he dislikes the investigator's attitude.

Interviewing witnesses always has been, and will probably continue to be, a part of accident investigation. Unfortunately, witnesses are people, and in dealing with people there is no guaranteed, foolproof, standard approach to interviewing.

Different witnesses require different approaches; if the interviewer is to be effective, he must realize that sooner or later accident investigators will interview a witness. Interviewers should be aware of the need to adjust their interviewing technique to the personality of the witness. The interviewer must, if he is to question effectively, make judgments concerning witness prejudices. Is the interviewee being frank and honest, or is he being evasive? The interview is in fact a give-and-take situation in which the witness also learns a good deal about the personality of the interviewer.

This presentation has cited some of the more obvious psychological reasons why witnesses report as they do. Hopefully, this reminder will make the interviewer cautious in accepting as reliable even the most plausible of witness observations.

REQUIREMENTS AND TRAINING OBJECTIVES FOR MEDICAL OFFICER INVESTIGATORS

DR. I.H. ANDERSON

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For the foreseeable future there will be a requirement in this country for medical personnel to assist with accident investigation. Only in the case of major air accidents and national disasters do we anticipate the formation of the multi-disciplinary human factors team and in these cases there is a requirement for a trained pathologist and an aviation medicine specialist to examine pathology and the medical history. No military or civil flight surgeons are assigned exclusively to air accident investigation duties at the field level but all are given basic training and accident investigation and prevention is a recognized part of their duty description.

Before considering training objectives for medical officer investigators, it is important to be clear in your mind what the end product should be. The ideal aeromedical investigator is probably a doctor between 30 and 50 who is doing the work of his choice. He should have at least five years of practical clinical medicine experience and have an excellent bedside manner. He should be a pilot himself with deep-rooted aviation interests and a firm knowledge of basic principles of flight and airmanship. He should be unequivocably committed to preventive medicine practice and have undergone advanced aviation medicine training; his undergraduate interest in pathology, psychology, biochemistry, epidemiology, biostatistics and mathematics should have been enriched and applied during his post-graduate training. He should be much in demand as a lecturer and teacher in his subject and should be pursuing long-term studies from his accident investigation experience.

The personal properties of this medical man or woman are identical to those of the full-time investigator in that he should be of an unperturbable nature, moderately extroverted and a good mixer. A high tolerance to frustration is essential as is a logical mind that is able to grasp and hold on to fundamental issues. He must be physically fit and willing to work long and unexpected hours. He must expect others to take credit for his work but remain content as long as the safety objectives are achieved. He should be a natural teacher with an excellent command of his working language as well as being diplomatic, discrete and photogenic. His wife will also be quite a remarkable woman as she will accept with equanimity a telephone call at three on a Friday afternoon requesting that she pack his bags and bring them to the airport as he will be departing in an hour's time on an accident investigation of indeterminate length. She will long have accepted the fact that the family is not about to join the ranks of the wealthy.

It will be obvious that a degree of selection is necessary if some of these characteristics are to be instilled or reinforced in any training program. In practice this selection process lasts from three to five years and the attrition rate is understandably high.

The initial training of medical officer investigators is carried out in Canada at the Defence and Civil Institute of Environmental Medicine where it is an integral part of the military flight surgeons course. Military applicants for this course are generally young service medical officers who wish to receive basic flight surgeons training and who are or will be stationed at a flying base. The civil participants are newly recruited Aviation Medicine Officers, usually of an older age group who have been selected for their jobs because of their interest and previous experience in aviation and aviation medicine. Most are already private pilots or better and all will eventually be trained private pilot standard. The course content itself contains a great deal of information that is directly applicable to accident investigation as well as to the clinical and educational aspects of their flight surgeons duties and more than a week is devoted to the theory of accident and incident investigation; it is this initial program that I would like to discuss further.

An attempt is made to get four basic principles across to the medical officers in this course. The first is that active and intelligent participation in accident investigation can be a most rewarding challenging activity. The second is that they must apply their existing knowledge and already practised techniques to the problem-solving process as well as to subsequent preventive measures. The third is to learn how to apply and utilize the technical and operational aspects in the air accident diagnostic problem. Finally, the vital importance of adhering to a strictly advisory role is stressed.

The first thing the trainee investigator is taught is the importance of prior preparation for the inevitable accident. He is encouraged to make early acquaintance with professional accident investigation and flight safety staff and to establish a degree of rapport with local authorities such as police forces and coroners. He is advised about the equipment and protective clothing that he should have pre-assembled and is encouraged to read all the accident and incident reports that he can obtain. The theoretical aspects of accident investigation are broken down into eight stages for teaching purposes.

The first stage is the accident site inspection and acquisition of time critical data. The importance of interviewing medical authorities who treated or examined surviving crew members is stressed as well as the necessity to attend autopsies where fatalities have occurred. The importance of initial site visit to establish the possible lines of investigation (differential diagnosis) is stressed so that the pathologist can be acquainted with the early data available and the reason for special examinations can be explained even though they may subsequently prove to be unnecessary. Some time and trouble on the part of the medical investigator in impressing the pathologist that he is a vital link in the investigative process will normally ensure a useful and complete examination. The second stage involves interview of surviving crew members and general liaison with the investigation team in the examination of data recorder information, air traffic control tapes and key witness statements. The third stage is detailed examination of the accident site, cockpit area plot and familiarization with the flight sequence and cockpit environment of the accident flight. Next is the acquisition of information necessary to acquire a personality inventory of deceased crew members and this normally involves a considerable number of informal interviews with friends, relations and employers. The difficult subject of persuading the timid witness with valuable information to make a formal statement is also discussed. On reaching this point the medical investigator is encouraged to formulate preliminary theoretical accident sequences and to discuss them mutually with the other members of the team; it is stressed that the remaining process must be a team effort with the objective of determining how the accident occurred and the most probable reason why. The last two stages consist of consideration with the other investigators of cause factors and preventive recommendations and finally consideration of secondary factors or findings of a flight safety interest. Medical investigators are encouraged to document all human factor reasoning processes including negative information in the human factors report so that the chief investigator is aware of the scope of the inquiry. They are encouraged to use their judgment where proof is unavailable and to indicate the degree of probability of their conclusion. It is repeatedly stressed that the chief investigator has the responsibility and the right to interpret this report in any way that he chooses and the hallmark of a good investigation is unanimity of opinion by all investigators concerned.

To augment the theoretical lectures of the basic course, each student is provided with a selected accident investigation document and requested to analyse it and present it to the rest of the group. Likewise syndicate exercises on complex accidents are held with the objective of stimulating individual lines of thought and unaccustomed application of mechanical and mathematical data to assist them in arriving at a diagnosis. Following the basic course the flight surgeons and aviation medicine officers return to their aviation environments and participate in several accident and incident investigations before further training is given.

In both cases an obvious career commitment to this type of work results in advanced training in aviation medicine and in accident investigation. On the civil side training to private pilot standard is provided if necessary and in many cases a similar standard of familiarity can be achieved in the service. In both cases the small outlay involved in the initial training is considered to be a good national investment as all practicing physicians, whether they be involved in accident investigation or not, are increasingly called upon to contribute to the prevention of man-machine accidents - the often quoted "twentieth century disease".

THURSDAY, 30 AUGUST 1973

CHAIRMAN OF THE DAY:	Mr. D.J. Peters Flight Safety Division Ministry of Transport, Ottawa, Ontario
9:00 A.M.	"THE INVESTIGATOR AND THE MACHINE" Panel Chairman: Mr. Mushir Allam Khan Flight Safety Inspector Pakistan International Airlines Karachi, Pakistan
	INTRODUCTION OF SESSION Mr. M.A. Khan
	"THE AIRCRAFT ACCIDENT LABORATORY'S ROLE IN TRAINING INVESTIGATORS" Mr. Hugh E. Youngblood, Jr. Instructor Aircraft Accident Investigation The Safety Center University of Southern California
	"AN ENGINE MANUFACTURER'S APPROACH TO HELICOPTER ACCIDENT INVESTIGATION" Mr. J.M. Wetzler Chief, Product Safety Detroit Diesel Allison Indianapolis, Indiana
	"ACCIDENT RECONSTRUCTION TEAM" Mr. H.E. Craft Mr. G. Thomas Cornwell Magnaflux Testing Laboratories Los Angeles, California
	"STRUCTURES INVESTIGATION" Mr. T. Heaslip Superintendent Accident Investigation Laboratory Ministry of Transport, Ottawa, Ontario
12 NOON	LUNCH
2:00 P.M.	"THE INVESTIGATOR AND THE MEDIA" Panel Chairman: Mr. H. Fawcett Chief, Accident Investigation Division Ministry of Transport, Ottawa, Ontario
	INTRODUCTION OF SESSION Mr. H. Fawcett

"THE FIRST TWELVE HOURS"
Dr. S. Harry Robertson
Assistant Director
Crash Survival Investigator School
Arizona State University

"CRASH SURVIVAL INVESTIGATION"
Dr. James W. Turnbow
Director
Crash Survival Investigator School
Arizona State University

"BIRDSTRIKE"
Dr. V. Solman
Chairman, Associate Committee on
Bird Hazards to Aircraft
Canadian Wildlife
Department of the Environment
Ottawa, Ontario

"CYCLIC ACCIDENT PATTERNS"
Dr. P.J. Dean
Head, Statistical Analysis Section
Accident Investigation Group
Defence and Civil Institute of
Environmental Medicine
Toronto, Ontario

"CALPA'S ROLE IN ACCIDENT INVESTIGATION"
Captain Doug Nassey
Accident Investigation Member
Canadian Air Line Pilots Association

Professor George Parker
Head, Accident Prevention/Investigation
The Safety Center
University of Southern California

"BACK SCATTER RADAR SYSTEM" for tracking
aircraft trailing vortices
Mr. Martin Balser
Senior Vice-President
Xonics Inc.,
Van Nuys, California

6:30 P.M. - 7:30 P.M. COCKTAILS

7:30 P.M. SOCIETY AWARDS BANQUET
Guest Speaker: Mr. Alastair Paterson, OBE, Q.C
Toronto, Ontario

INVESTIGATOR AND THE MACHINE

MUSHIR ALLAM KHAN
SAFETY MANAGEMENT OFFICER
PAKISTAN INTERNATIONAL AIRLINES

In the field of accident prevention and safety orientation, air safety investigator plays a very important role, and wherever the investigator fails and deviates from his actual role, things begin to fall apart and the core of safety begins to shake. In this context, I may take you back in the mythecal story of ancient Greeks, where Deadalus and his son Icarus attempted to fly away from the island where they were imprisoned. Deadalus was perhaps the first investigator of a flying contraption, and at the same time he was the first air safety investigator, for he found out the limitations of the contraption he made, he fully investigated the capabilities of the contraption, and where the violation of safety rules would disintegrate the contraption. He passed relevant information to his son, but he being a poor air safety investigator violated the instructions of his father and eventually crashed in the sea. But his father who made no violations, strictly adhered to the rules remained alive. Investigator's foremost and paramount duty is that he should strive hard to find out the limitation and the loop holes of all types of machine used and employed in the aviation industry, discuss them with the designers, with the people who fly or operate them, and if investigator finds any such drawbacks or shortcomings, that may trap the flyer or operator, he must not be shy to project it forcefully and agressively and see that the findings are followed and alterations and improvements made, with no reservations.

The air safety investigator should build an aura of information and knowledge around him. He must have adequate information in support of his arguments and findings. He should not talk hypothically but should talk directly and concretely. It has been on many occasions that in the aviation industry certain types of equipment are used on ground, and on the aircraft, they unfortunately do not have adequate provisions to provide suitable all round safe and convenient parameter for the operator, and when the poor operator operates them in the vicinity of the aircraft, they have many disadvantages and encounter many odd situations, that at times are difficult to manage or negotiate, and ultimately lead to economic or near fatal impacts. There was one aircraft support equipment, where the operator's cab was so poorly designed, that it had very poor all round vision, with no eyebrow vision, that is so important while positioning equipment on the aircraft. This equipment was ultimately examined and inspected by one air safety investigator when it was found out that, it had certain design discrepancies. They were immediately brought to the notice of the concerned people.

Here it may be emphasized that if this discrepancy had not been timely projected, the poor operator would have continued to be at disadvantage, and there would have been many accidents. It has been observed on various occasions that the equipment for the aircraft, and certain components on the aircraft itself, are so tailored, and designed that they hardly have any features that would contribute towards prevention of mishaps and accidents. Some of the recent aircraft evacuation equipment and devices, have been just located on the aircraft with a lot of fancy frills to fascinate or attract the customers, but with inadequacies in the employment or use of the same; there have been injuries during evacuation due to poor design features. Under such state of affairs, if the investigator goes down deep to study the contraption, safety features can be further incorporated.

When problems and critical situations hit on face, he must wake up, endeavour to orientate himself for immediate remedy. If he sleeps over it, even for a few hours, it is criminal, and if this situation continues, he should stand accused.

The poor operator, the flyer, the passengers, are in many ways, stand committed to him, and air safety investigators must come up to their expectations and see that people develop confidence and do not find failings in duties and responsibilities of investigators. He must nip the hazardous situations in the bud and not allow them to build up and enlarge.

The tenticles of hazards should not be allowed to grow, like the tenticles of Octopus, which grow again after they are chopped. The remedy lies in the elimination of source; and the investigator should always attack the base, the core of the problem. He should bite the apple to the core, and then only he achieves the goal.

In this seminar, I am happy to know about the role of small team engaged in developing an appropriate electronic contraption for detecting the presence of wing tip vortices over the runways approach areas and climb out surfaces. In this pursuit and endeavour, I see a great devotion and a sincere purpose. They have indeed conceived and developed a device that would one day fully eliminate the hazards of vortices. This is called the actual role of "Investigator". An endeavour to control things before they get out of control. They have indeed visualized hazards that are being created by the current era widebodied aircraft, and if a suitable device is not given to the aviation world, the widebodied aircraft will make the short haul aircraft operation hazardous. Air Safety Investigators should endeavour to extend all help and assistance to these magnificant personalities and see that they handsomely contribute in this task and make the aviation safer by the early introduction of the electronic device.

The paper on the witness interrogation is an excellent effort. It gives the psychology of witnesses, how they should be handled; how information is to be extracted; and how it has to be assimilated for correct application, for task of eliminating accidents, and for the purposes of accident prevention. An investigator should so build himself up that he correctly understands the man; who can be a pilot, a mechanic, a technician, a designer, a manufacturer, then only the investigator will be able to bring about the correct and true concept of safety orientation and proper application of accident prevention techniques. An investigator must know that a surviving pilot, or any other person surviving an accident, is a significant storehouse of valuable information. They should be handled with love, affection, and benignity, they should be given all the opportunities and freedom of expressions, they should not be cornered or humiliated, they must be made to speak with an assurance of no penalty, and then only an investigator will be appropriately locating himself in the field of accident prevention. Air Investigator, therefore, must keep looking into the future all the time and remain ever alive to the distant and near hazards, which if not kept away the aviation industry will continue to encounter perilous situations.

Reverting back to the man, machine media concept, I would say with stress that man is the most important link in this system. It is the man who makes the machine, it is man again who operates it, and it is the man again who provides the media for the operation of the machine, and assign mission for the machine and its operator. If the man is made safety orientated, he can bring about an ideal coordination for better functions of the entire system. 'The air investigator must so educate himself and so familiarize himself with the various aspects, that he fully understands the man, the machine, the media and the mission. He must go down to the very bottom to unearth things that remain lying dormant.

The air safety investigator must always endeavour to know the limitations of the human beings. He must also evaluate and find out, where the design concept has been subjected to compromises, that at times have to be tolerated for various operational and other needs; and provide suitable compensations, and suggest ways and means to control them and to remain on guard for them.

The great explorers in the early days of hazards and perils explored the universe, found out dangerous things, locations; told and educated people about them; taught how to go about on the surface of the earth, over the seas, through the forests. It was on account of their efforts that things became safer and safer on earth. Their role was of investigators.

Likewise, air safety investigator must go out into the aviation world like an explorer, bring back information, and present and project it in such a manner that aviation industry becomes safer and safer day by day.

The aircraft or the equipment must also be thoroughly examined and inspected preferably at the blueprint stage, in order to find out whether further improvements can be made to achieve still better standards of safety.

Here I would say that a person who is devoted to safety, and has made himself conversant with all conditions and environments could be in a position to take or initiate correct actions in time. For instance, an elaborate emergency evacuation system may appear to the operators good and fantastic, but may appear confusing to passengers at the time of need.

The escape chute that can be installed both in inverted and in correct position on the aircraft can be dangerous, and there have been occasions, when the drawbacks caused problems during emergencies. In a situation like this, an air safety investigator with his experience and knowledge may be able to advise the manufacturers more appropriately and help them to have equipment that is more practical and straightforward.

The air investigator has a stupendous task ahead of him, of making aviation industry safer and safer; and this can only be done if he keeps himself close to the man, machine and media.

This seminar has brought to each individual knowledge of many things, new horizon and opened rich avenues; let us go forward and act for the greater safety.

THE AIRCRAFT ACCIDENT LABORATORY'S ROLE IN TRAINING AIR SAFETY INVESTIGATORS

HUGH YOUNGBLOOD, LECTURER OF SAFETY
THE SAFETY CENTER
UNIVERSITY OF SOUTHERN CALIFORNIA

Introduction

The University of Southern California's Institute of Aerospace Safety and Management, now known as The Safety Center, located in Los Angeles, California, for the past twenty years has utilized an off-campus Aircraft Accident Laboratory as an effective teaching tool in the training of Air Safety Investigators. The Laboratory provides a realistic environment for simulating, as nearly as possible, those conditions found at an actual aircraft accident site. Since all aircraft accidents generally occur as a result of a complex set of circumstances, it is only appropriate that the accident laboratory be built around actual reconstructed aircraft accidents.

The Laboratory is utilized extensively in the military Flying Safety Officer courses taught by The Safety Center to the U.S. Army, U.S. Air Force, and foreign military students under the State Department's Military Assistance Program. These courses run for twelve and ten weeks respectively with twenty-one hours of Accident Laboratory instruction and utilization in the Army, Air Force, and Military Assistance programs. The Accident Laboratory is also used extensively in The Safety Center's Aircraft Accident Investigation courses which are short courses of two week's duration with a Laboratory instruction and utilization period of fourteen hours.

The Laboratory is utilized for a four-hour seminar in general accident investigation methodology in a graduate course taught in The Safety Center's Masters of Safety program. The high utilization and integration of the Accident Laboratory into the various safety courses taught by The Safety Center have played an important part in The Safety Center's successful role in training all types of safety investigators.

While each aircraft accident in the Accident Laboratory has been selected to best illustrate the various types of aircraft accidents, each accident is also utilized to teach the basic principles of aircraft accident reconstruction methodology using deformation and damage analysis. The Laboratory then becomes doubly effective as a teaching aid in air safety investigation training.

Resources and Equipment

The University of Southern California's Aircraft Accident Laboratory is presently located at Norton Air Force Base, California. The Laboratory facilities consist of approximately ten acres of fenced, level, desert terrain and a 2000 square feet air conditioned classroom display building. Both fixed and rotary wing aircraft make up the types of aircraft accidents being utilized at the Laboratory facility. These accidents are set up around the Laboratory at a reduced scale when it is necessary to properly orient the wreckage debris within the Laboratory acreage. Complete aircraft mock-ups are utilized to illustrate the techniques and importance of this technique in air safety investigation.

Numerous jet and piston engine displays are used to instruct the student investigators in powerplant accident investigation techniques. These engines are located both inside and outside surrounding the laboratory classroom.

All of the engines have been secured from actual aircraft accidents. Some of the engines have been torn down, while others are in the actual state of damage experienced in the accident. Cut-aways piston and jet engines are used to illustrate the principles of operation.

Methods of Laboratory Instruction in Damage Analysis

The Man, Machine, and the Environment have been recognized for quite some time as embodying the three primary cause factors for any type of accident. The Accident Laboratory is a demonstrative example of the fact that if the Man, Machine and the Environment can be better understood and studied, aircraft accidents need not occur. The sequence of damage involved in any aircraft accident can be considered through aircraft accident reconstruction methodology. This allows the investigator to accurately reconstruct the failure sequence of the crashed aircraft and better assess the Man-Machine-Environment involvement in the accident.

Aircraft accident reconstruction methodology, utilizing deformation and damage analysis, considers the following three principles to exist in any aircraft accident:

1. A characteristic deformation of the structure will occur.
2. There will be a continuity of contact surfaces depending on the origin of the damaging loads.
3. A priority of deformation damage will exist.

These principles then can be used to establish the sequence of damage involved in any aircraft accident where sufficient wreckage debris exists.

Future Role of the Laboratory

The Accident Laboratory, while having played a very important role in training air safety investigators over the past twenty years, can look forward to an even greater role in the training of accident investigators.

Voice communication boxes similar to the ones utilized at Lion Country Safari and other large amusement parks are being considered for possible use at the Laboratory. This type of voice box explanation of each accident's historical events damage patterns, and wreckage idiosyncrasies would enhance the student's understanding of the complex circumstances and situations which created the various deformation and debris patterns. The voice box system would also reduce the student-instructor ratio, which would allow the student to gain a deeper insight from air safety investigation techniques.

The addition of new accidents to the Laboratory will expand laboratory capabilities in the future. The staff of The Safety Center is continually searching for exceptional aircraft accidents which would better exemplify the principles of aircraft accident investigation.

Only through continued improvement can the Aircraft Accident Laboratory meet its responsibility to train air safety investigators to have the deep understanding and lasting consciousness of the principles to meaningful air safety investigation.

WHAT IS ART?

G. THOMAS CORNWELL (M-248)
MAGNAFLUX TESTING LABORATORIES

Webster defines ART as, "The disposition or modification of things by human skill to answer the purpose intended. Creative work generally, or its principles. Skill, dexterity, or the power of performing certain actions acquired by experience, study, or observation. EXPERTISE OR GREAT PROFICIENCY IN DOING SOMETHING".

The something that we are doing is accident reconstruction following the team concept. ART - "A" as in Accident, "R" as in Reconstruction, "T" as in Team - "ART".

The principles of ART involve techniques applicable to any type of investigation. ART, in short, involves an indepth multidisciplined study by a team of unbiased experts for the development and documentation of all related facts to establish the proximate cause of a given accident.

The ART concept is married to no one and makes no distinction between a Plaintiff or a Defendant.

In Transport Category Air Carrier accidents, a team is formed immediately following the accident to inquire into the probable cause of that accident. Included on that team are representatives of the Airline involved, the Crew's Union, the Airframe and Powerplant Manufacturers, as well as anyone who may have something constructive to contribute. It has been stated that many of the parties involved in any such investigation, "Have an axe to grind". Of course they have an axe to grind. They should have an axe to grind. Thank God that they do have an axe to grind! The truth of the matter is, the more talent that can be involved and heard from in any such investigation, the better. The more axes, the better! The sharper each axe, the better!

The name of the game is accident prevention. Very little will be accomplished in preventing accidents unless we know what is causing them to start with. Our ultimate goal is improved air safety. To accomplish this goal, we must first determine the cause of a given accident, and then take appropriate steps to prevent, if humanly possible, a recurrence.

To me, determination of the cause of an accident that took one life is as important as the determination of the cause of an accident that took one hundred lives. I for one, look forward to the day when the General Aviation accident will be given the same attention as an Air Carrier accident.

The ART concept in General Aviation aircraft accident investigation is here, and it's here to stay. ART was conceived out of necessity and born to fulfill an urgent need within the industry. Like a new baby, it has much to learn. We do not present the ART concept here today as an accomplished science. We must learn to walk before we run, and consequently we solicit the guidance as well as the criticism of all concerned in the advancement of the state of the art of aircraft accident investigation.

The need for ART becomes more evident daily. For example, we cannot expect the NTSB Air Safety Investigator, or the FAA Inspector, who may be called upon this year to investigate 30 or more accidents involving numerous different types of fixed or rotary wing aircraft, to be an expert in each and every one of the aircraft involved. It seems quite obvious that he must be given the authority and the funds, to consult as necessary with the many fields of expertise involved in the multidisciplined study related to aircraft accident investigation, if he is to accomplish his assigned objective the way he would like to accomplish it.

At this point, it would seem appropriate to point out that there is no individual hero on the accident reconstruction team. Like the Three Musketeers, the ART Team is one for all and all for one.

The size of an accident reconstruction team is variable and subject to the numerous fields of expertise that may be called upon as dictated by the particular accident under investigation. Thus, an ART team may involve only two or three experts, but as many as ten or even twenty could be called upon in its final form.

The identity of the first ART team member may vary. As we have suggested, he could be an NTSB Air Safety Investigator or an FAA Inspector.

He may be the President of a firm involved in the manufacture of a product related to the accident under investigation. He may be a Corporate Officer of an Airline, designated to represent them on a Board in a current investigation of an Air Carrier accident. He may be an insurance executive for an underwriter providing coverage for one of the parties involved in an accident. Whoever he may be, he has a bona fide interest, a legal right, and a recognized need to find out, "What really happened".

For the purpose of this paper, let's assume that he is a Trial Attorney, Plaintiff or Defense, who wants his case evaluated. He wants the bad news as well as the good. He wants to know where he stands. As discovery proceeds, he will want to know if his position will weaken or get stronger. Is the opposition doing their homework? If so, are they following the ART concept, or do they have just one so-called expert who is trying to wear several hats on one head. His objective is to win the case, or to obtain the best possible settlement. To accomplish his objective, he will require an indepth multidisciplined study by a team of unbiased experts for the development and documentation of all related admissible facts, to prove, if possible, in a court of law, the proximate cause of the accident. His field of expertise is the law. He requires technical assistance in the field of Aircraft Accident Investigation.

Thus, we see the necessity for the second ART team member - the Air Safety Investigator. This is the individual who will act as the ART Coordinator, if and when his preliminary review and report convince the Trial Attorney that the accident in question warrants the establishment of an accident reconstruction team in order to win his case or negotiate the best possible settlement.

Just what is an Air Safety Investigator - ART Coordinator? He is an expert in the field of Aircraft Accident Investigation. He is not an expert in the art of flying, although he may be a certificated pilot. He is not an expert in aircraft maintenance, although he may very well be a certificated Airframe and Powerplant Mechanic. He is not a Metallurgical or Mechanical Engineer. He is not an Aeronautical Engineer or Cartographer. He is not an expert in Flight Operations, nor is he a Meteorologist. He is not, nor does he ever pretend to be, an expert in any field of endeavor other than his own - Aircraft Accident Investigation. Years of training and experience has made him eligible for full membership in The Society of Air Safety Investigators. As an experienced highly qualified Air Safety Investigator, he does have a sound working knowledge of the many fields of expertise called upon in the multidisciplined study of Aircraft Accident Investigation. Thus, he is qualified to review existing data, advise, counsel, recognize the need for an expert in a given field, possibly recommend the experts required, and consequently, coordinate the efforts of all involved to accomplish the given objective. He is, in brief, a Jack-Of-All Trades and master of one - Aircraft Accident Investigation. He has One Head and wears One Hat!

INVESTIGATING WITH AN IMAGINATIVE, INNOVATIVE, OPEN MIND

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SUPERINTENDENT, ENGINEERING LABORATORY
AIRCRAFT ACCIDENT INVESTIGATION DIVISION
MINISTRY OF TRANSPORT, OTTAWA, ONTARIO

INTRODUCTION

The investigation of a major accident can appear to be an awesome task at best when you are confronted with nothing but aircraft fragments and the remains of 109 souls mixed among the bits and pieces. Where do you start? How can the sequence ever be untangled and the causes of the accident disclosed? In Canada we have a major accident investigation plan called PIP (Planned Investigation Program) which provides the basis for rational organized actions by the team members amidst the atmosphere of confusion and awe that surrounds an air disaster. The flow chart is illustrated in Figure 1*. Each group is supplied with checklists (an example of a partial checklist is shown in Figure 2) which clearly delineate the areas of responsibility and are flexible in their application. But PIP tells you WHAT you must do not HOW.

TAKING OFF THE BLINDERS

It's the HOW that this presentation is going to explore. New investigators and old hands must be encouraged to be innovative, imaginative, searching, and open-minded in gathering, examining, and analysing the needed information to put the puzzle back together. We all must take off the blinders!

To explore this concept I've taken a particular accident, the DC-8 crash at Toronto in 1970 to demonstrate the variety of possible sources of valuable information. Every accident is different but this one should serve as a vivid example of the typical and untypical resources, techniques, and procedures that can be used to gather pertinent information. The lesson is that a good air crash detective must let his mind roam and use to the fullest extent every bit of information at hand.

*This presentation included some 31 slides, but it is not practicable to reproduce them all in these proceedings. Only the line diagrams have been included.

TORONTO DC-8 CRASH

Only the investigation carried out by the Structures Group will be considered, which will include evidences disclosed by other Groups that directly related to the Structures Group analysis. The accident, you may recall, involved premature deployment of ground spoilers, a subsequent heavy touchdown on runway 32, in-flight explosions during the go-around, and finally loss of control approximately 7 miles north of the airport with the aircraft crashing, killing all on board.

CRASH SCENE

The MOT 'go-team' was notified through the standby system within minutes of the accident. Many members of the team were on the scene within hours of the accident. At the final crash site the disintegration of the aircraft was extensive. The top priority at this stage was to find the flight data recorder. From the wreckage distribution, we tried to project the recorder ground location. After a few hours of futile searching, the recorder was found sitting completely exposed in an intact portion of the tail section. It was a Leigh Instrument Recorder which, as was determined later, contained the last 30 minutes of cockpit voice conversations and approximately 56 hours of some 73 data parameters. Our attention then turned to evidence back at runway 32.

RUNWAY 32

At the runway we found severe main gear 'judder' marks from the tires, heavier on the right side. There was no evidence of tires bursting. The tail bumper and rear fuselage had impacted the runway heavily as shown by markings and a deep gouge. The No. 4 engine and pylon were found at the side of runway 32. Examination of the attachment fractures showed all were overload with no evidence of fatigue or other premature cracking mechanism. The runway markings disclosed that the engine hit the runway well after aircraft touchdown, Figure 3; therefore, it was concluded the engine was not scrubbed off the wing by wing flexing. In fact witnesses saw the engine fly ahead of the aircraft a short distance. A considerable number of rivets, bolts and small pieces from the engine and pylon structure were found on and around the runway. But most significant of all was the discovery of a large piece of wing plating off the right side of the runway.

FLIGHT PATH

The next day we trudged through the fields along the flight path from runway 32 where aircraft wreckage had been found. Considerable debris was found on one particular lot where a large section of wing plating hit the house. We determined that it was lower wing plating from outboard of No. 4 engine. The section was severely bowed and exhibited an adherent soot layer on the inner surface of the plating. Pieces of wing spar, tubing, etc., were distributed nearby, which came from the same general area of the wing. At this point we wondered about the possibility of an in-flight explosion.

About 1/2 mile further along the flight path, the No. 3 engine was discovered. Our main interest was in examining the attachment failures. I found that the attach bolts to the vertical shear plate had sheared due to pylon motion vertically downward. Also, two small pieces of lower wing plating were noted lying nearby. The significance of these two observations will become obvious later in the discussion.

A few miles further in another field, the complete outer 20 feet of the right wing was found but severely affected by a fuel-fed fire on the ground. From this location to the crash site, considerable debris from the right wing was scattered in the fields. One more large section of upper wing plating which came from about the No. 3 engine was discovered. This panel was significantly bowed and displayed an adherent soot pattern on the inner surface. The fractures were basically tensile in nature. We were now convinced that in-flight explosions had occurred.

WITNESSES

The Witness Group had obtained some pertinent observations from a large number of aviation and non-aviation oriented witnesses. It was evident that during climb-out from runway 32, the aircraft was losing fuel on the right side. Intermittent fire was seen and after a few minutes, 2 or 3 torches or plumes of fire originated from the right side of the aircraft which subsequently went into an uncontrollable dive into the ground. It was estimated that the aircraft had attained approximately 3000 feet above ground level.

RECONSTRUCTION

At this stage in the investigation, it was decided that we (Structures Group) were primarily interested in determining the catastrophic sequence of right wing break-up from the runway touchdown to the crash site. Therefore a reconstruction of the right wing remains was initiated. The locations of the pertinent wing pieces were surveyed along the flight path and at the crash site. During the search for significant aircraft pieces, we obtained the services of Ontario Provincial Police scuba divers to probe the depths of a pond. All that was found was a section of an electrical wire bundle which later, however, became a very significant part of the evidence. This bundle was forwarded to the aircraft operator's electrical installation experts for identification.

The next few days were spent in getting right wing pieces located and removed to the hangar along with the engines and pylons. The pieces were laid out by effectively splitting the wing down the trailing edge and opening it as though the leading edge was the hinge point. This allowed us to put the upper and lower wing plating pieces back together like a jigsaw puzzle.

The lower wing plating in the area around the No. 4 pylon attachment displayed a missing piece. This piece was found to be still attached to the No. 4 pylon. This pylon, I mentioned earlier, became detached at runway 32. We also discovered that the section of wing plating found near runway 32 fitted adjacent to the missing piece in the reconstructed wing. These pieces act as part of the floor for the No. 4 alternate fuel tank. Therefore, it was apparent that the aircraft took off from runway 32 with a hole in the bottom of the wing plating of 4' x 4' x 5 1/2' through which fuel escaped. Figure 4 shows a composite of the right wing break-up. Wing plating sections (5) and (6) are the subject pieces which left the aircraft at runway 32.

EXPLOSIONS

Analysis of the reconstructed right wing pieces showed the possibility that 2 or 3 explosions occurred in the wing during flight. The question was, what were the ignitors. At this stage the operator's experts identified the bundle of wires from the pond. It was No. 4 pylon electrical wiring. A close examination of the wires disclosed that one end of the bundle displayed clean fractures which indicated that the bundle had been suddenly cleaved. Whereas, the other end of the bundle displayed globulized copper wires and burnt insulation on the wires. We then theorized that the sequence ran as follows:

(a) The electrical wiring bundle broke at runway 32 when the No. 4 pylon detached from the aircraft.
(b) The wiring then trailed back into the escaping fuel.
(c) The wiring was sparking.
(d) Sparks caused the intermittent fire.
(e) As fuel flow lowered, turbulence allowed ignition of vapours in the fuel cell.
(f) First explosion resulted.

A similar explosion occurred in the No. 4 main fuel tank after the sections (3) and (4) became detached from the aircraft along with the No. 3 engine and pylon, allowing fuel to escape. There was also evidence of a third explosion at the wing tip.

A few weeks later El Atalia dropped a DC-8 in at New York losing three engines. A member of the Structures Group visited the scene and confirmed that the electrical wiring would cleave on pylon separation allowing the wire ends to trail back sufficiently in an airstream to coincide with the resulting hole in the lower wing plating.

PHOTOS

While the Group was involved in the analysis of the reconstructed wing, some significant photographs turned up. An individual in a taxi on his way to the airport had noted the aircraft in trouble and he took two photographs from the moving taxi. The photos showed that the aircraft had been subjected to three explosions. The photographs were used to plot the trajectories of debris as shown in Figure 5. The exact location where one photograph was taken was determined by the Mississauga Construction and

Engineering Department who took bearings on the lamp posts which were used to interpolate bearings of the critical items (in the air and on the ground).

SEQUENCE OF EVENTS

The bearing data was correlated with an in-flight break-up trajectory analysis (a technique which involves the use of wind velocity, aircraft velocity, heights, dimensions and weights of objects to determine basic break-up parameters), data recorder read-outs, and witness statements to come up with a sequence of events and probable flight path as shown in Figure 6. The projections and bearings showed exactly what items originated from the puffs of smoke. The trajectory analysis projected the wing panel item 14 (see Figure 4) to the third explosion.

From the data gained from the Flight Recorder Group and the Structures evidence, a flight profile from the runway approach to the crash site was determined as illustrated in Figure 7. The touchdown to final impact time was established as almost exactly three minutes. When the aircraft lost major portions of the right wing structure, it rolled right and descended to the ground in an uncontrollable dive as shown in Figure 8.

WHY?

The question is - what went wrong at runway 32 and why did the crew fly on, apparently unaware of the impending catastrophe ahead? The accident of the DC-8 was effectively investigated as two accidents by the team:

(1) Up to runway touchdown (impact).

(2) After touchdown.

I won't expand on the ground spoiler deployment aspects except to state that the First Officer did activate ground spoilers in flight, approximately 60 feet above the threshold of runway 32, dumping 60% of the lift. The critical descent parameters at touchdown, shown in Figure 9, were obtained from the flight recorder data. It can be seen that the runway impact descent velocity at C of G was 18 ft/sec. Douglas Aircraft specialists determined that a vertical acceleration of 5G at C of G corresponds to 18 ft/sec. Also, an undercarriage force producing 5G at C of G would cause 6.5G and 7.0G at No.

3 and No. 4 engines respectively. These values were consistent with failures at pylon to wing attachments, i.e No. 4 fractured completely and No. 3 was severely damaged (partial failure at touchdown), because the Douglas design philosophy provided separation of pod and pylon from the aircraft when 7G vertical is experienced by the engines.

ATTACHMENT FAILURES

The pylon is attached to the wing structure at the front spar, as shown in Figure 10, by a vertical shear plate. It carries the vertical loads to the wing through an adapter. Angle attach members connect the pylon planks to the wing lower panel. These run chordwise and transfer the longitudinal thrust load to the wing.

According to Douglas design, the separation should have occurred sequentially:

(1) Vertical shear plate attachment bolts.

(2) Horizontal attach angle bolt fasteners progressively from front to rear.

(3) Aft attach bolt.

During the No. 4 engine separation, some attach angle fasteners failed to rupture, therefore, lower wing plating tore away. There was a side component of force (i.e. right wing low on touchdown) which may have affected the failure sequence. Stress analysis showed that as the fasteners fractured sequentially towards aft, a more flexible zone was reached and the stringer skin beams deflected excessively due to compression. The compression loads were due to (1) fastener loads; (2) fuel load and (3) wing bending load. Therefore, the stringer webs failed and the fasteners held allowing the unsupported panel to tear away.

The No. 3 engine separation occurred in two stages. The vertical shear plate bolts failed in shear at touchdown but the remaining attachments for the No. 3 pylon maintained the engine position under full thrust loads on climb-out. However, the first explosion literally shook the engine free by failing the remaining attachments.

NOTE

It should be apparent to you by now that if the aircraft had hit runway 32 slightly harder, it would have stayed down, or if it had hit slightly lighter, it would have recovered with little damage. Unfortunately, the pilot not knowing he had lost an engine, not knowing he was losing fuel in which wires were sparking, and having full power on three engines, flew confidently on towards disaster.

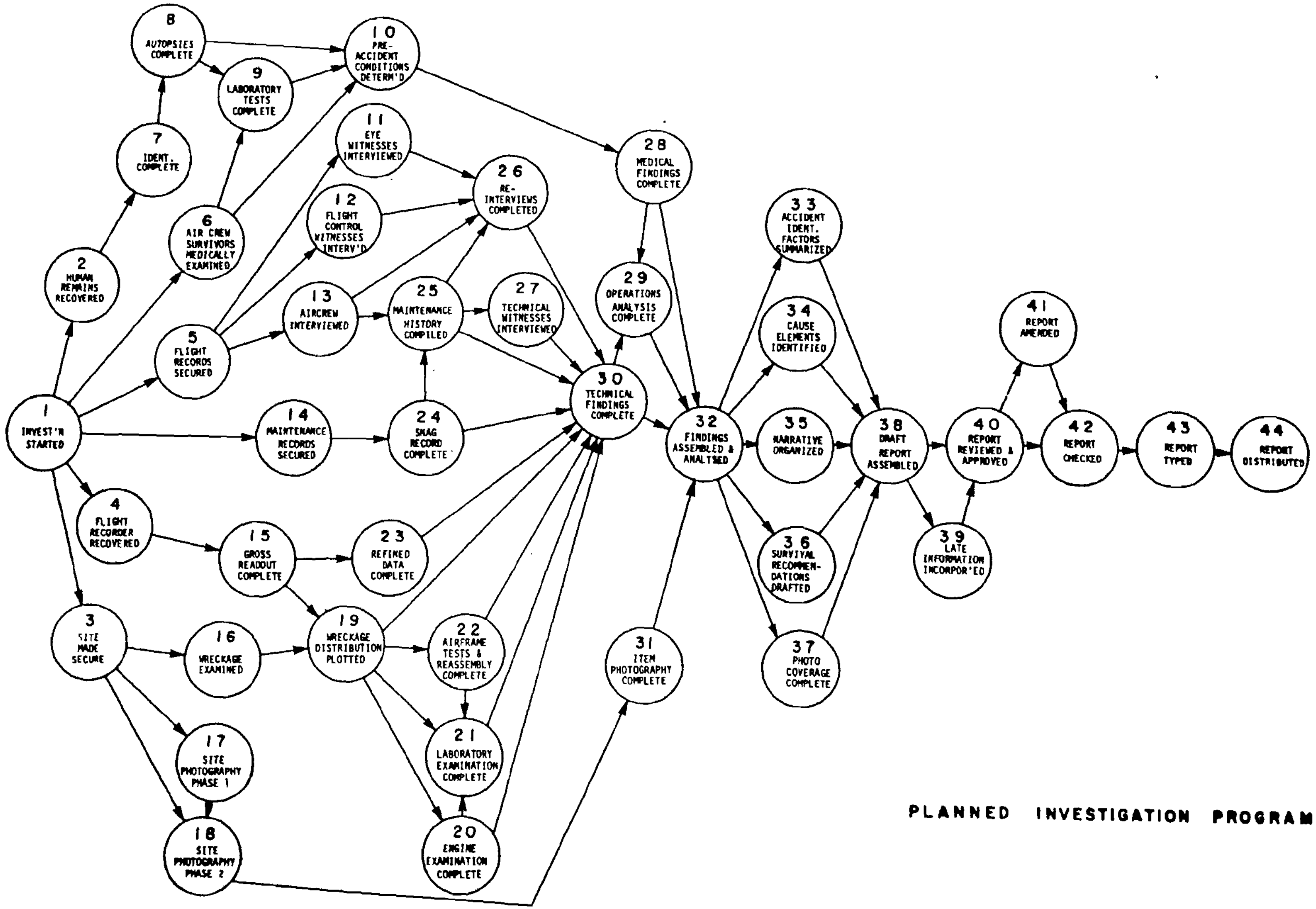
CONCLUSION

This STRUCTURES investigation was analyzed in depth to indicate a variety of typical and untypical sources and techniques utilized in gathering evidence. Each source played a key role in the structures analysis: i.e.:

(1) Ontario Provincial Police scuba divers for pond search;
(2) Witness photographs of fatal flight;
(3) Mississauga Roads and Construction for bearings;
(4) Manufacturer for design considerations;
(5) Stress analyst for pylon separation analysis;
(6) Another similar accident (El Atalia) to confirm electrical wiring and pylon separation theory;
(7) Witnesses;
(8) Flight recorder data for touchdown and climb-out information;
(9) Wreckage surveys - site, flightpath and runway;
(10) Reconstruction of right wing;
(11) In-flight break-up analysis;
(12) Wreckage and fracture analysis;

and there are many other sources of information I have not enumerated.

In summary, investigators must be encouraged to let their minds roam, use ingenuity, and be innovative in gathering the necessary data to analyze accidents.



PLANNED INVESTIGATION PROGRAM

Figure 1

PIP GROUP CHECKLIST

EVENT	ITEM	
3	1	Broad limits of accident site determined
3	6	Rough sketch of accident area prepared for Investigator-in-Charge
16	1	Probable distribution of all wreckage determined from cursory examination of angle of impact, speed and pre-impact integrity indications
16	2	Area requiring search delineated
16	3	Method of search determined
16	4	Necessary material resources determined and allocated
16	5	Necessary personnel resources determined and allocated
16	6	Technique of marking and fixing wreckage positions determined
16	7	Search commenced
19	1	Wreckage found (as far as practicable)
19	2	Markers placed at wreckage locations
19	3	Items of wreckage identified, tagged and catalogued
19	4	Position of each item determined as prescribed in Technical Note 1/5 "Guide for Crash Site Survey and Layout"
18	1	Wreckage photographs taken with position reference markers in place
18	2	Detached items of wreckage found and photographed in position

FIGURE 2

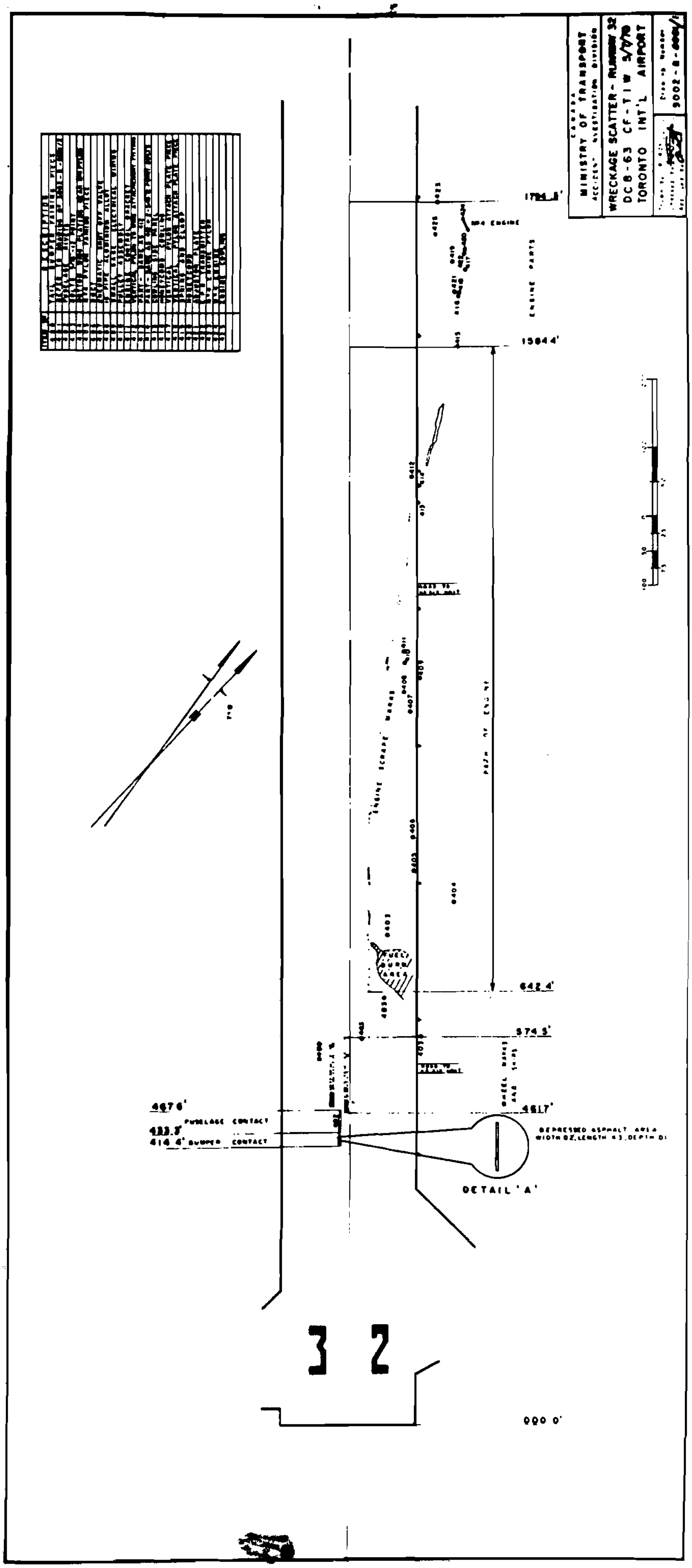

CANADA
MINISTRY OF TRANSPORT
ACCIDENT INVESTIGATION DIVISION
WRECKAGE SCATTER - RUNWAY 32
DC8-63 CF-TIW 5/7/70
TORONTO INT'L AIRPORT
1794.3'
1584.4'
642.4'
574.5'
461.7'
467.6'
FUSELAGE CONTACT
433.3'
414.4' BUMPER CONTACT
DEPRESSED ASPHALT AREA
DETAIL 'A'
ENGINE PARTS
PATH OF ENGINE
ENGINE SCRAPE MARKS
FUEL BURN AREA
WHEEL MARKS AND SKIDS
3 2
000.0'

Figure 3

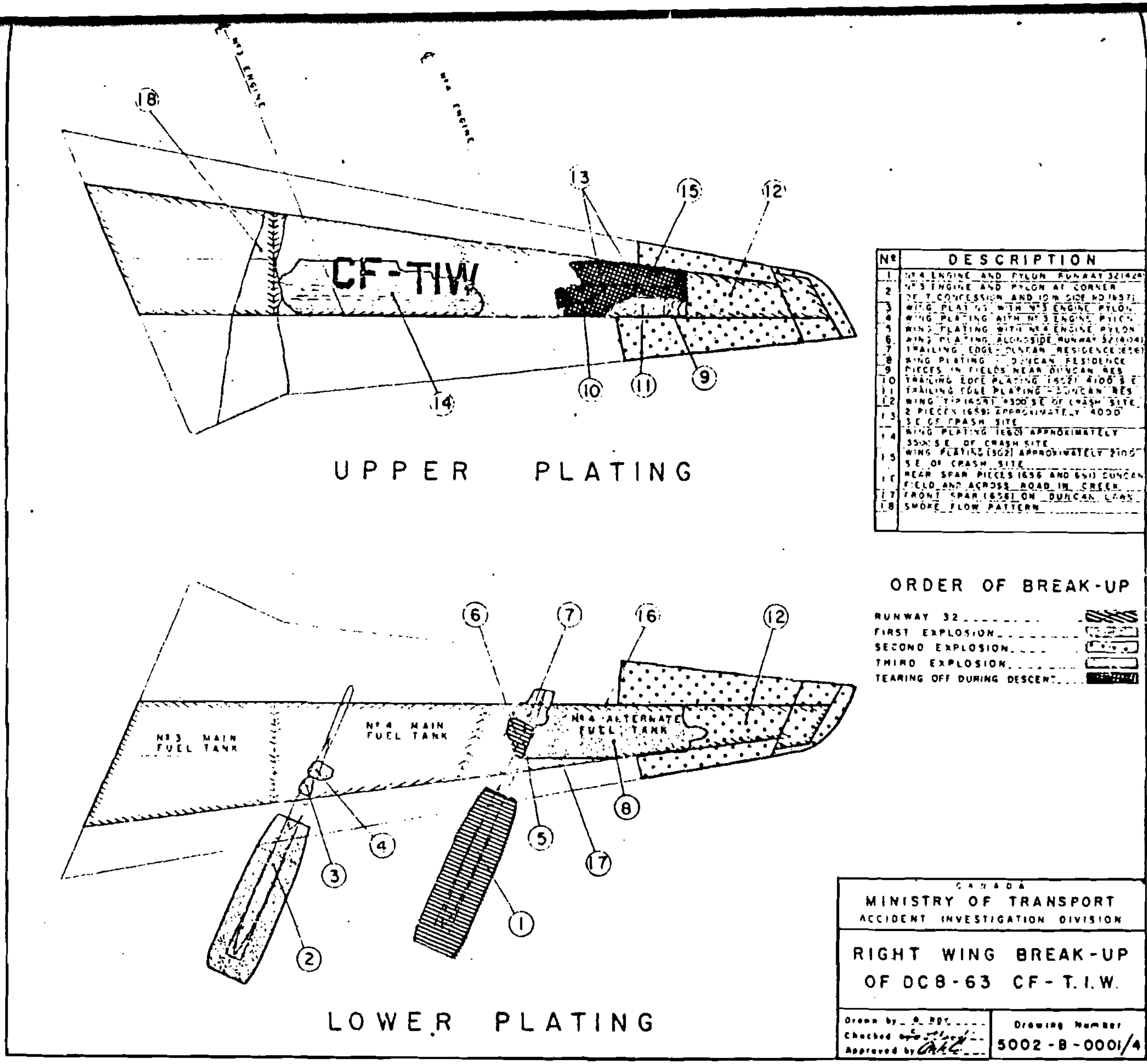

N° 3 ENGINE
N° 4 ENGINE
CF-TIW
UPPER PLATING
LOWER PLATING
N° 3 MAIN FUEL TANK
N° 4 MAIN FUEL TANK
N° 4 ALTERNATE FUEL TANK
N° DESCRIPTION
1 N° 4 ENGINE AND PYLON RUNWAY 32(424)
2 N° 3 ENGINE AND PYLON AT CORNER OF 7 CONCESSION AND 10 M SIDE RD (657)
3 WING PLATING WITH N° 3 ENGINE PYLON
4 WING PLATING WITH N° 3 ENGINE PYLON
5 WING PLATING WITH N° 4 ENGINE PYLON
6 WING PLATING ALONGSIDE RUNWAY 32(404)
7 TRAILING EDGE - DUNCAN RESIDENCE (656)
8 WING PLATING - DUNCAN RESIDENCE
9 PIECES IN FIELDS NEAR DUNCAN RES
10 TRAILING EDGE PLATING (652) 4100' S E
11 TRAILING EDGE PLATING - DUNCAN RES
12 WING TIP (651) 4300' S E OF CRASH SITE
13 2 PIECES (659) APPROXIMATELY 4000' S E OF CRASH SITE
14 WING PLATING (660) APPROXIMATELY 3500' S E OF CRASH SITE
15 WING PLATING (502) APPROXIMATELY 2100' S E OF CRASH SITE
16 REAR SPAR PIECES (656 AND 651) DUNCAN FIELD AND ACROSS ROAD IN CREEK
17 FRONT SPAR (658) ON DUNCAN LAWN
18 SMOKE FLOW PATTERN
ORDER OF BREAK-UP
RUNWAY 32
FIRST EXPLOSION
SECOND EXPLOSION
THIRD EXPLOSION
TEARING OFF DURING DESCENT
CANADA
MINISTRY OF TRANSPORT
ACCIDENT INVESTIGATION DIVISION
RIGHT WING BREAK-UP OF DC8-63 CF-T.I.W.
Drawn by
Checked by
Approved by
Drawing Number
5002-B-0001/4

FIGURE 4

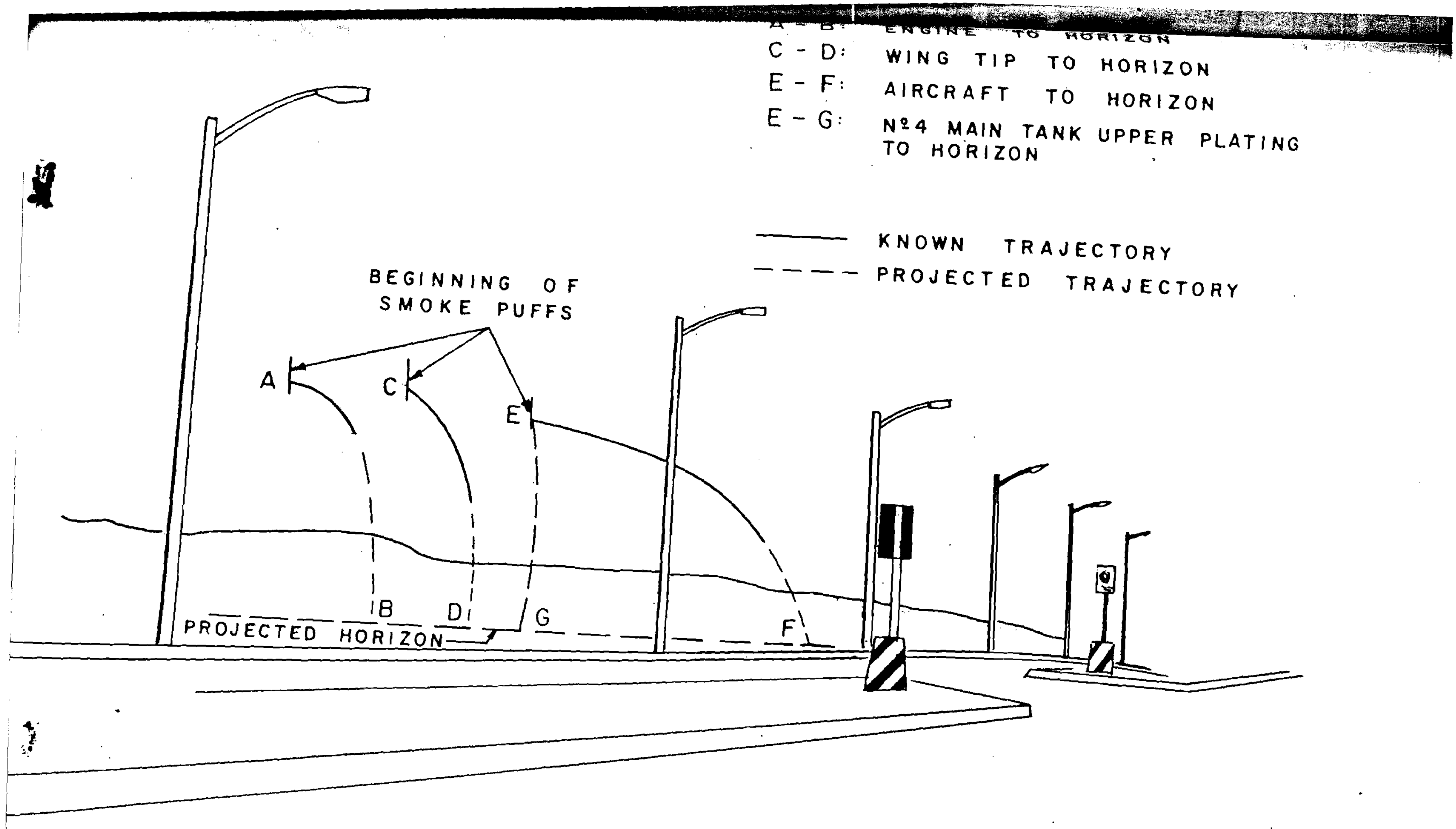


FIGURE 5

REVISED: 5 NOVEMBER 70

Dwg. Nº 5002-B-0001/5

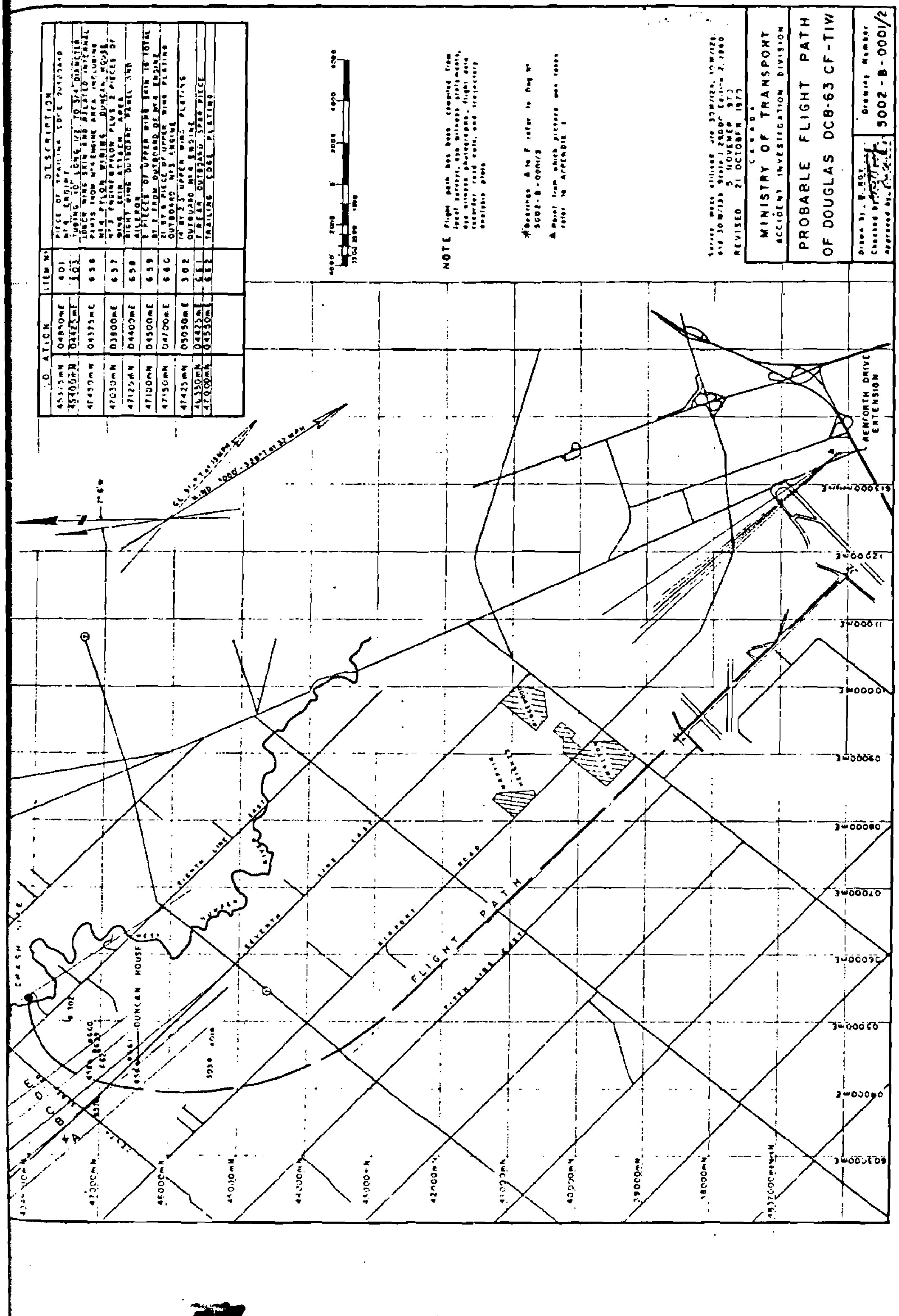
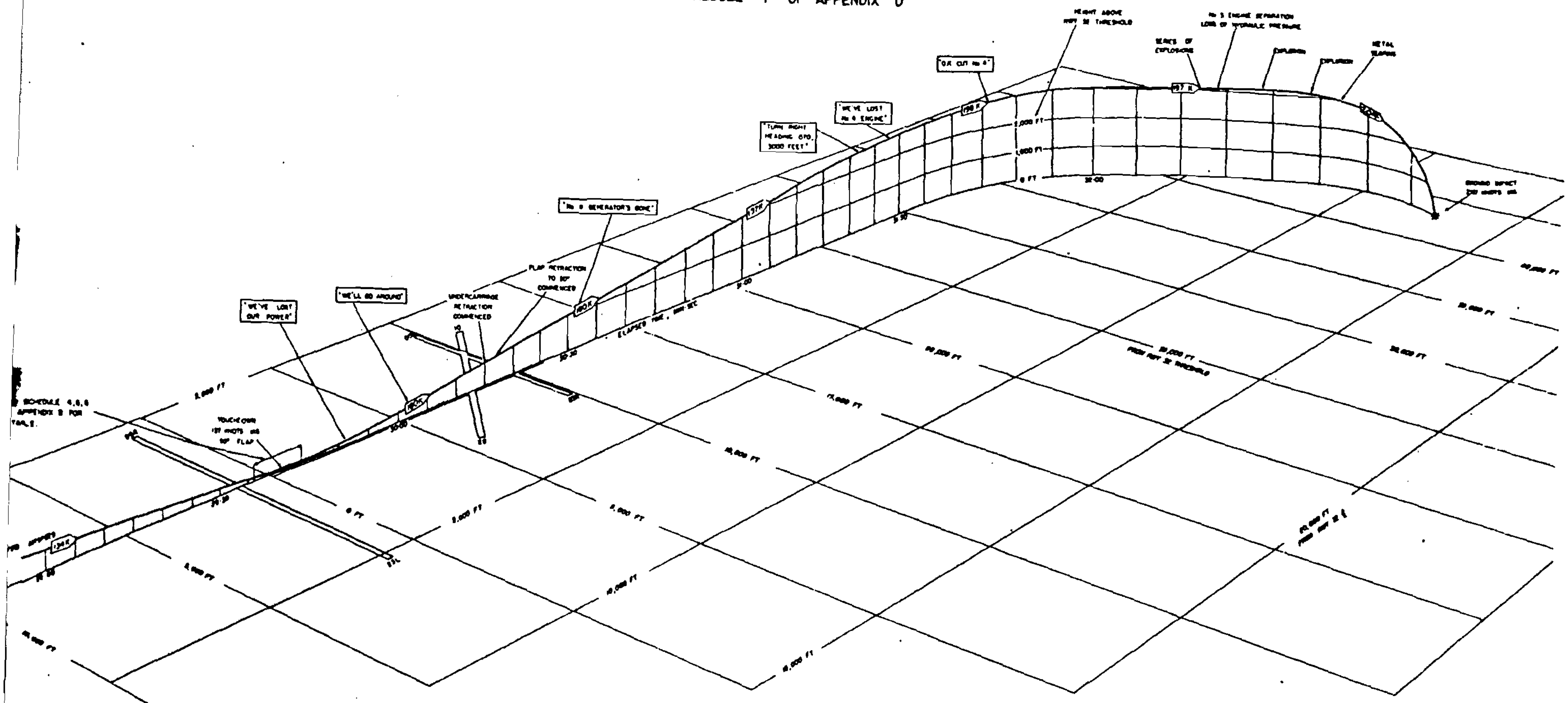

MINISTRY OF TRANSPORT
ACCIDENT INVESTIGATION DIVISION
PROBABLE FLIGHT PATH
OF DOUGLAS DC8-63 CF-TIW
5002-B-0001/2
FLIGHT PATH
RENFORTH DRIVE EXTENSION

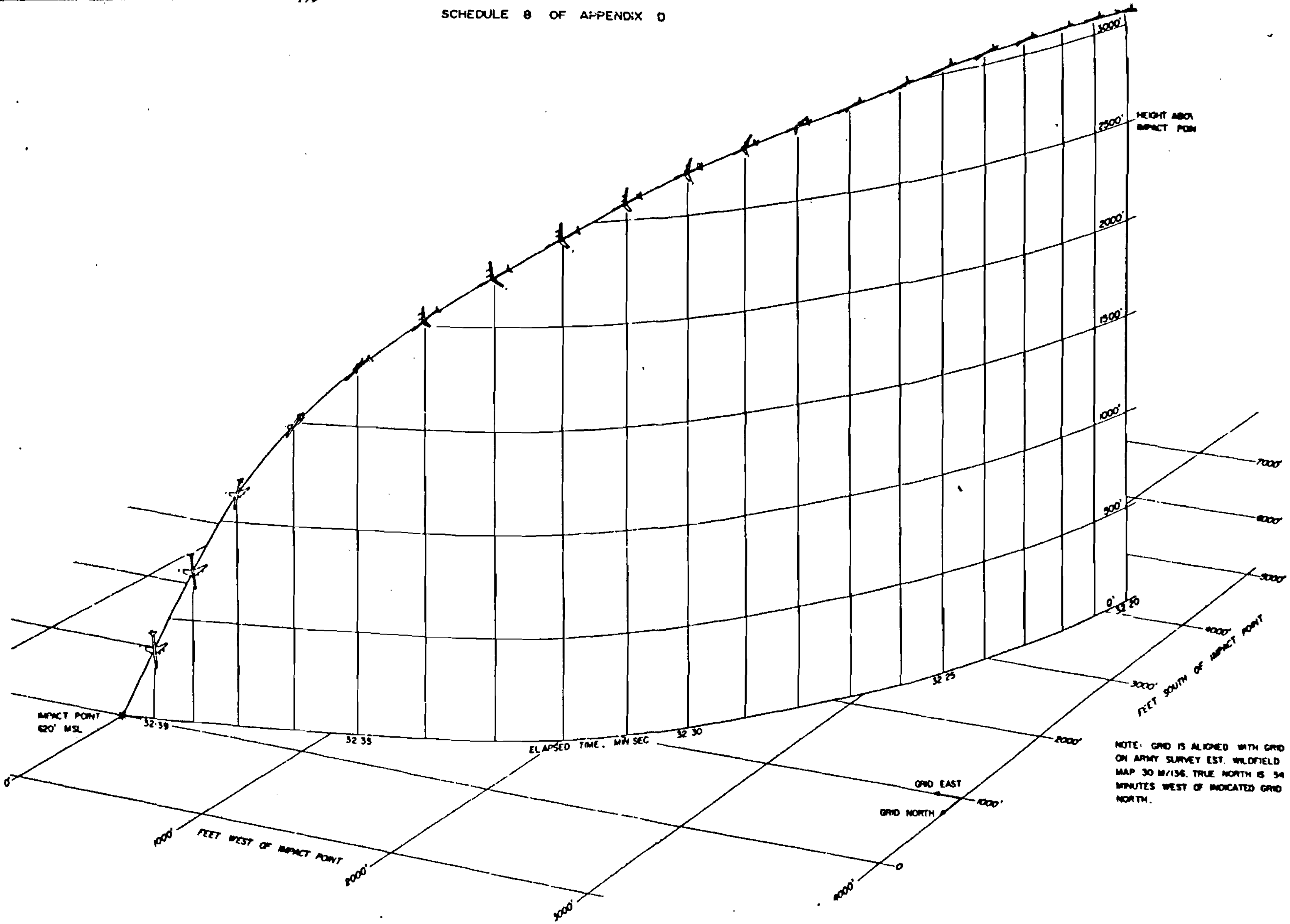
FIGURE 6

SCHEDULE 7 OF APPENDIX D



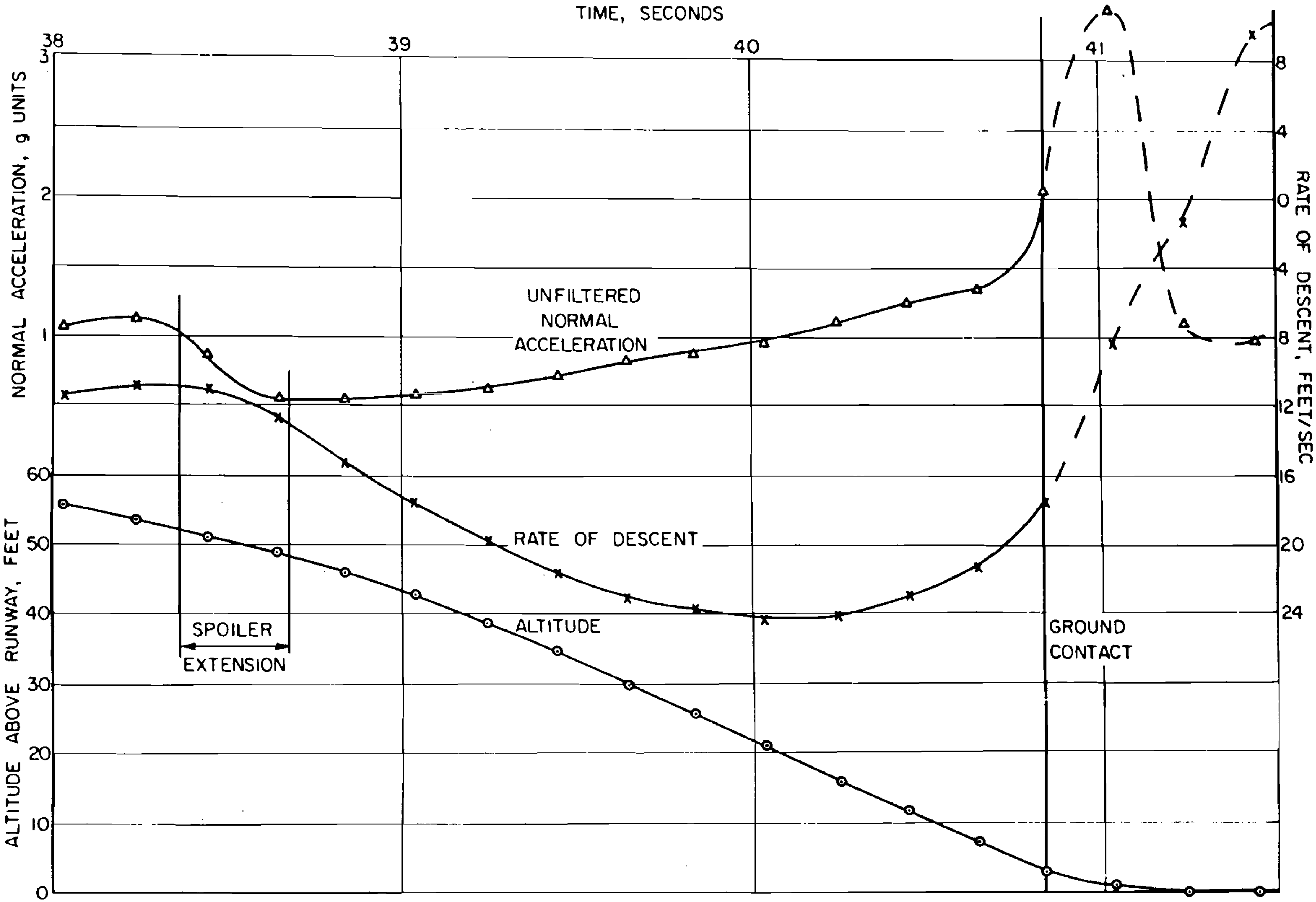
RECONSTRUCTION OF CF-TIW FLIGHT PATH AND EVENTS FROM THE FLIGHT RECORDER

FIGURE 7



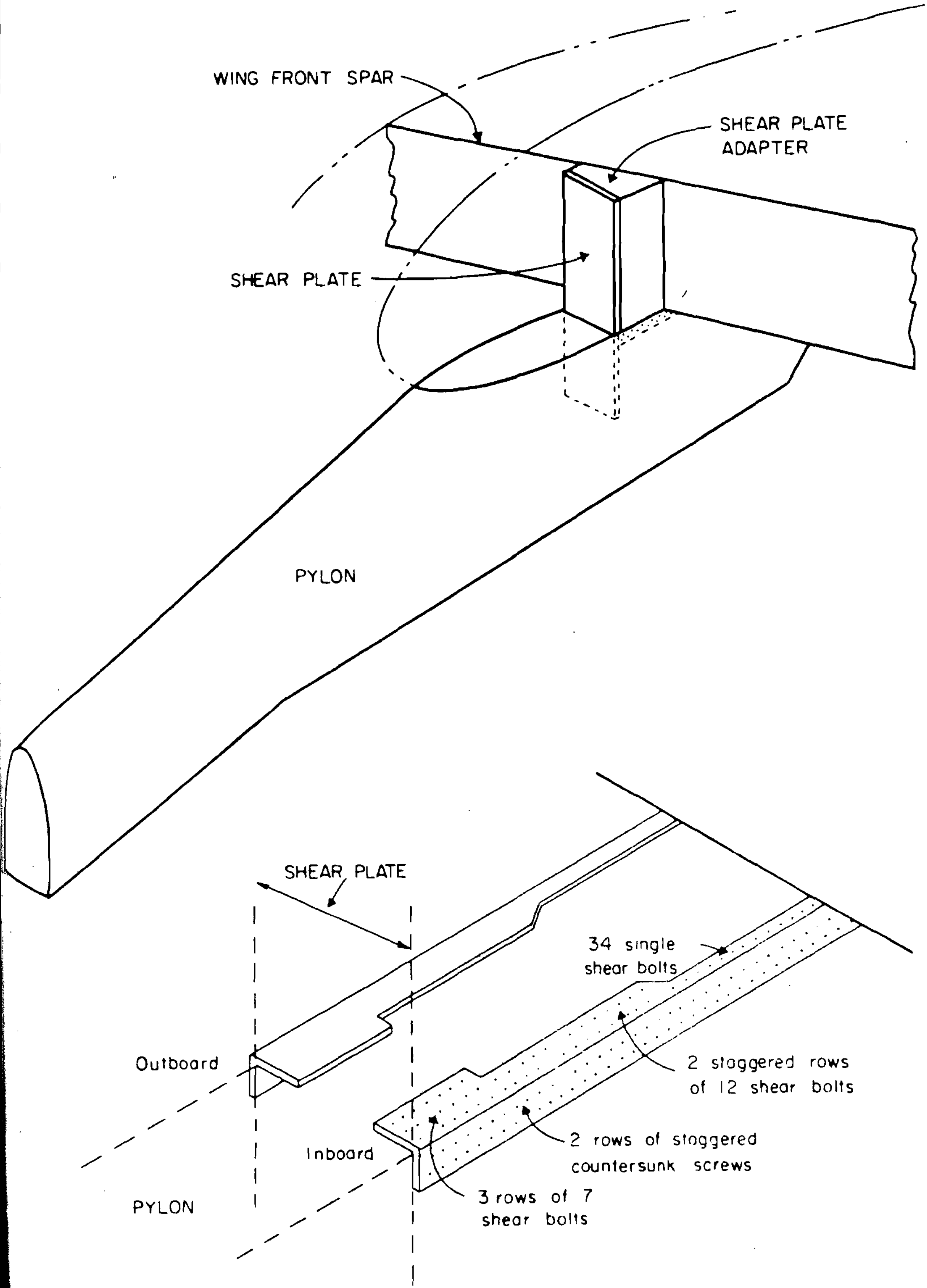
RECONSTRUCTION OF CF-TIW MOTION IN THE LAST 19 SECONDS BEFORE IMPACT

FIGURE 8



DETERMINATION OF RATE OF DESCENT AT TOUCHDOWN

FIGURE 9



ENLARGEMENT OF AREA UNDER SHEAR PLATE ADAPTER

THE INVESTIGATOR AND THE MEDIA

HAL FAWCETT
CHIEF, ACCIDENT INVESTIGATION DIVISION
MINISTRY OF TRANSPORT
OTTAWA, ONTARIO, CANADA

Ladies and gentlemen. I am pleased to have this opportunity to participate with you here today, especially in a seminar with the central theme of "Training". As indicated in the program, the subject for this afternoon is "The Investigator and the Media", which we will discuss the investigation of the operating media. I must admit I was a bit perplexed when I first saw the title of this afternoon's session. However, I managed to place my own interpretation upon this and if I stray too far from the subject, I hope you will forgive me.

Good investigators are born not made. If you consider all of the things that an investigator must be and do, it is surprising we have any good investigators at all. Some basic characteristics which a good investigator must display are: open-mindedness skepticism, insatible curiosity skepticism, persistence skepticism, diplomacy skepticism, to name a few. Some of these are characteristics which no training course will provide. Some are congenital characteristics which, I gather from the scientific types, reduces to a matter of genes. Some are the result of learning, not on a course, but long attendance in the school of hard knocks, or life, whichever way you wish to express it. It is especially true of the skepticism. Given the appropriate basic characteristics we have the raw material from which we can begin to develop an investigator. The question is: How to train him?

What can we teach these remarkable human beings we have selected, which will enable them to be better investigators. I believe it's a good idea to begin at the beginning, and so I think the first thing we must teach is the objective of investigation. On the surface this might appear extraordinarily simple, but experience has demonstrated it is far from that. Each investigative agency around the world seems to have expressed its objective in its own way. SASI is no exception to this. If you look on your membership card, you will find the sentence, "Promote that part of the aeronautical endeavour wherein lies the moral obligation of the air safety investigator to the public". Some agencies state simply that their investigation is carried out in the promotion of aviation safety. I favour the phrase, "Qualitative development of aviation". No matter how you express it, the objective of safety investigation must be to find the origin of accidents, hence understanding how they came about, and so arming yourself with the knowledge which is necessary if you are to improve the performance of civil aviation, which is an obligation we all have to the public. This is the beginning of our training scheme. Every investigator must know where he is going, the objective must become an inherent part of the investigative discipline.

Assuming we have successfully achieved the first part of our training program, what must we now teach the investigator? I believe we must develop in investigators, the conviction that they can function only in the specific kind of an atmosphere. I believe he must be made to understand that he can function effectively only if he is placed in a position in which he has but one master to serve, and that master can be no other than the objective that has already been set. He must learn if he is to be fully effective he cannot serve one or ten or a hundred persons, but all of the persons outside this room. Now this may sound as if I am suggesting that the investigator will have many masters but the interests of all of the public should be summed up in the objective.

If we now have an investigator who has a clear-eyed view of the ends which he is to serve, we have a man who is equipped to establish procedures for the conduct of an investigation. He will find the best way to respond to the need to proceed quickly to the accident scene to collect transient evidence; he will discover the best way to secure the accident scene, hence preserving all of the evidence that is available; he will find methods of proceeding with the investigation in such a way as to avoid interfering with the public obligations of officials of other jurisdictions; he will recognize that interested parties, next-of-kin, and others have interests which do not coincide with his own, and that he must have procedures which will permit him to avoid being influenced by such concerns. Similarly, this motivated, enlightened, investigator will be convinced of the need for procedures related to every aspect of his activities in order to ensure that he remains faithful to his objective.

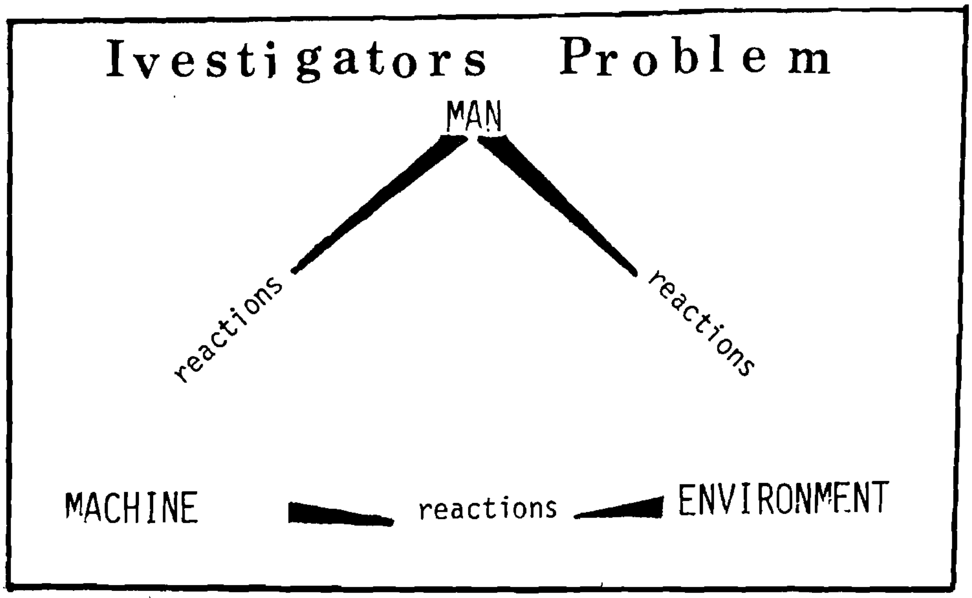
By now we have a man with the appropriate basic characteristics; disciplined in his approach to his job, and equipped with the procedures which will enable him to work with confidence. At this point we can now expose him to training in the techniques which will make him productive. Throughout this session, we have heard discussion of many techniques. This morning we heard of techniques related to investigation of the machine. I don't intend to become involved in a discussion of such specialist techniques, but rather, address myself to general techniques as they relate to the overall subject of accident investigation. Our investigator-in-training must first understand in simple terms the problems which he will be attempting to solve. This depiction demonstrates very simply what he is setting out to do. In any accident he will be attempting to determine the interactions which took place amongst the three basic elements: Man, Machine and Environment. Also he will be attempting to determine what the characteristics of each of those three basic elements were at the beginning of the accident sequence. For instance, how well equipped was the pilot to cope with the machine and the environment considering his personal and professional history; his physiological and psychological conditioning at the time of the occurrence? The same sort of examination must be applied to the machine and the environment. This simplified type of reasoning process is, I believe, essential if the investigator is going to be able to remain oriented with his objective. One of the most difficult tasks faced by the investigator, however, is not in amassing reams of data, but in determining relevancy of data.

The investigator would face an almost impossible task if he attempted to collect every document related to each of the three elements - man, machine and environment. How then can the investigator continue to keep his investigation within the confines of the circumstances of the accident. First, I think a standard view of an accident is imperative. Each accident has certain characteristics in common with all other accidents. If we study this graphic depiction, we will see it symbolizes the definition of an accident. On the left hand side the starting point is the point at which the first person embarks on board the airplane. The horizontal straight line to the right of that point indicates a period of normal operation, that is, the flight was going according to plan. To the right of this line is a series of links which symbolize the chain of individual circumstances which will be found in every accident. Each of these circumstances is an observable event and hence we refer to the series of links as the chain of events.

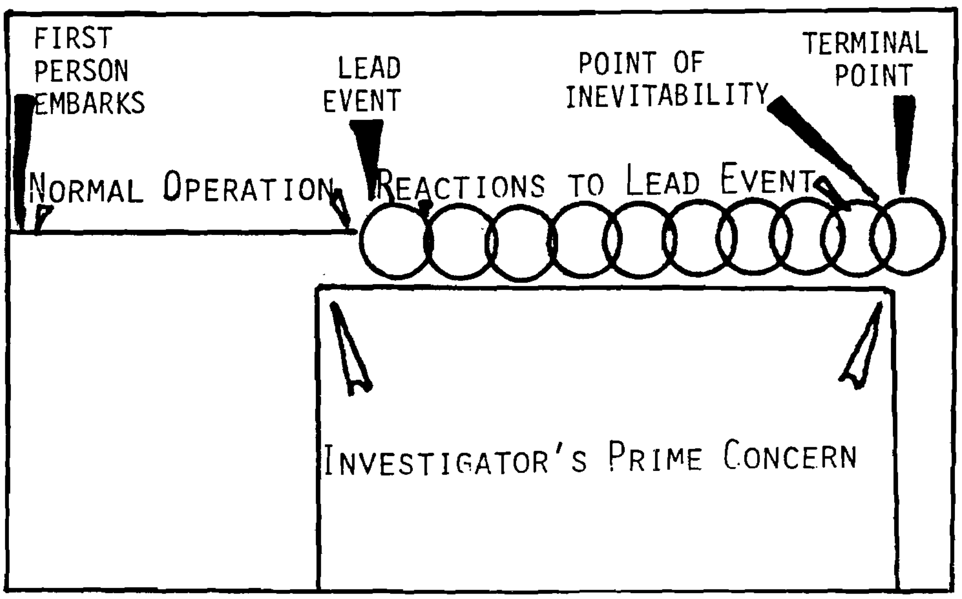
The first event, or lead event in the chain, is that occurrence during the flight which indicates that the flight is departing from the planned operation. The following links are simply pilot or aircraft reactions to the lead event. The last link of the chain is the terminal event, that is, what took place after the point at which crash or contact with the ground became inevitable. The depiction we have here is a reconstruction of the accident flight. It tells the investigator what took place. This information, however, is of little value from the prevention point of view. It will lead the investigator to understand the origin of the lead event and the origin and quality of the reactions. He is then armed with the knowledge which will enable him to eliminate the lead event or undesirable reactions, effectively severing the chain of circumstances in similar future potential accidents.

How can the investigator gain this knowledge? Simply by examining each of the events in the chain of circumstances by asking the question, why? For instance, in a simplified version of this - let us suppose the lead event in this single engine aircraft accident is a loss of power. The investigator pursues all the possibilities related to loss of power, and discovers that the fuel pump failed. He then traces the origin of the fuel pump failure through the process of elimination and discovers that the fuel pump drive failed. He repeats the process with this bit of information and discovers the wear on the shaft weakened it to the point where it was overstressed. He will then examine this knowledge and may eventually conclude that the drive shaft was under-designed or was poorly fabricated, or that the inspection cycles were inadequate. In this way, each of the events in the chain of circumstances can be investigated to its origin. This can be particularly important in the matter of an apparent pilot error. The pilot is the product of his inherent characteristics and his training and experience. An error on his part may not be a simple case of making a mistake. It is more likely to be a lack of knowledge or understanding, which in turn points up a deficiency in his training. By pursuing each of the events in the chain of circumstances, in this manner, the investigator eventually pin-points the deficiencies in the civil aviation system which are the origins of the accident. These facts when placed in the hands of licensing and regulatory authorities, owners, operators, engineers, all the members of the aviation community, provide them with the knowledge necessary to prevent future similar accidents.

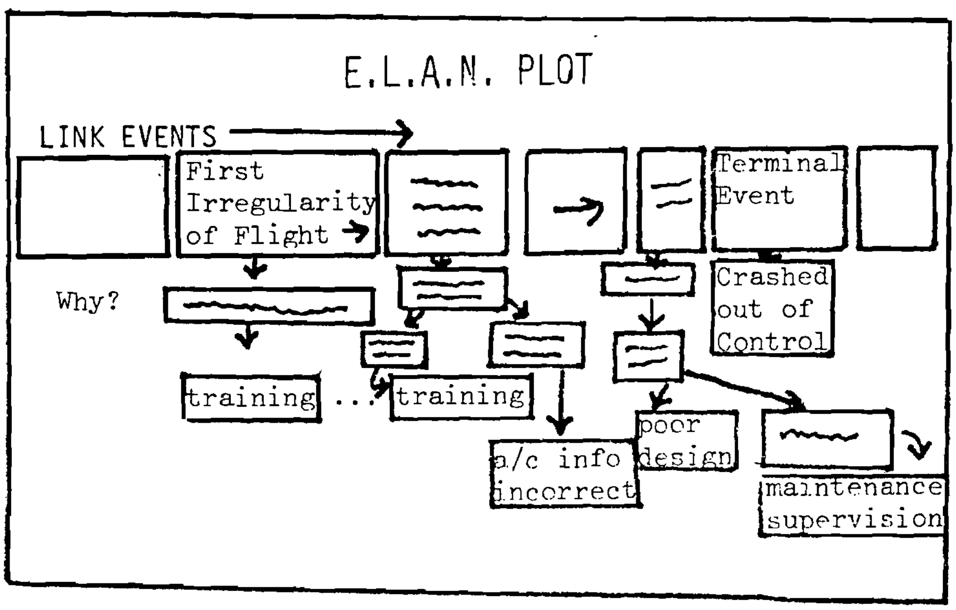
I think I have used up about all my allotted time here, but I would like to summarize by saying that in my view, any training scheme for investigators must include the three ingredients that I have covered. First being motivation, that is thorough understanding by the investigator of the objective of his activities. The second point is orientation, that is, how he is going to achieve his objective - what procedures will he use to achieve that objective. The third element of the training scheme must of course relate to techniques, and these breakdown into general techniques such as I have discussed here today, and specialists techniques, which we have heard about earlier and which we will be hearing about in the next few hours.


Ivestigators Problem
MAN
reactions
reactions
MACHINE
reactions
ENVIRONMENT

1


FIRST PERSON EMBARKS
LEAD EVENT
POINT OF INEVITABILITY
TERMINAL POINT
NORMAL OPERATION
REACTIONS TO LEAD EVENT
INVESTIGATOR'S PRIME CONCERN

2


E.L.A.N. PLOT
LINK EVENTS
First Irregularity of Flight
Terminal Event
Why?
Crashed out of Control
training
training
a/c info incorrect
poor design
maintenance supervision

3

BIRD STRIKES AND AIR SAFETY

VICTOR E. F. SOLMAN
CANADIAN WILDLIFE SERVICE
DEPARTMENT OF THE ENVIRONMENT
CHAIRMAN, ASSOCIATE COMMITTEE ON BIRD HAZARDS TO AIRCRAFT
NATIONAL RESEARCH COUNCIL, OTTAWA, ONTARIO.

In speaking to a group of people who are concerned with air safety and especially with the investigation of accidents involving aircraft, I think it proper to begin with an historical reference. Many countries claim to have originated powered flight and I am not about to get into the argument about who really did. In North America the Wright Brothers operated the first heavier than air, mechanically propelled aircraft in the autumn of 1903 at the foot of Killdevil Hill near Kittyhawk, North Carolina. I was always intrigued by the fact that if they had hit a gull on that flight or one of the subsequent ones, the history of aviation might have been different. I know that the North Carolina coast has the usual quota of gulls and I wondered how the Wright Brothers had managed to avoid a bird strike during their experimental flying. When I went down there to have a look, the answer became clear. I saw the model of their aircraft and the markers which indicated their first 128 foot flight. When I considered the speed involved, I realized that any agile gull could have easily gotten out of the way of the aircraft. The Wright Brothers' glider experiments had been carried out on the slope of a hill. Their power flights were made from the base of the same hill. They were inland in the sand dune country and not along the coast where the gulls were common.

Although they were fortunate, it wasn't long after their first flights that birds got into the act. In 1911, a promotional campaign for a soft drink called "Vin Fizz" involved the first transcontinental aircraft flight. The pilot, Cal Rodgers, planned his work carefully. He had a Wright model XE aircraft which I guess was about the Mark IV in the Wright Brothers' series. He also had a trainload of spare parts. He planned a route which would take him across the country with something like 30 landings, for refueling and repairs. He made the flight from the Atlantic coast of New York State to the Pacific coast of California, in forty-nine days. He made his 30 scheduled landings and, in addition, crashed 19 times. He used up a lot of the trainload of parts rebuilding the airplane but he survived as the first man to fly across North America. For several months he was a hero, and then he became distinguished in a totally unexpected way. He lost an argument with a gull in California, his plane crashed and he was killed. The first man to fly across North America was also the first man killed in a collision between a bird and an aircraft, in the spring of 1912.

Since 1912, birds and airplanes have contested their rights of way in the sky with both sides losing sometimes. During World War II and as far as I can tell, also a little bit during World War I, there were collisions resulting in damage and sometimes injury to persons. We don't seem to have a clear record of crashes. In the late 1950's the whole game changed. The introduction of turbine powered aircraft, did two things which gave the birds a great advantage. Aircraft began moving at speeds too fast for the birds to get out of the way, and so tended to hit more of them. Aircraft started using fragile turbine engines instead of robust piston engines. It didn't matter whether the turbine engines were driving propellors or not, although occasionally the propellor would knock a bird out of the way before it got into the turbine. Some of the early turbine engines, like the Rolls Royce Darts, were not axial flow engines but of a different design with more rugged components. They were put out of action by birds by being plugged with feathers, but not by broken components. When we moved into the axial flow engines like the Rolls Royce Conway and the Pratt and Whitney JT3D, we got spectacular damage. When you throw a pheasant into the front stage of a Conway on take-off, you sometimes stop the front half while the rear half rotates, the fan comes adrift and the whole thing breaks up. Airlines had experiences like that in the late 50's and early 60's and it really caught their attention. Nobody got hurt except the company finances.

When the breakage began, Air Canada and the Air Force, (the same thing was happening to military aircraft) came to the Canadian Wildlife Service of which I am a member, and said "Birds are causing us a lot of trouble - is there something we can do about it?" We said, "First we have to have a clearer idea of just what the problem is. You will have to get your people to start keeping track of what kinds of birds are being hit and under what circumstances. If we know what the birds are, and where they are, maybe we can figure out why they are there and do something about getting them out of the way". That seemed logical and so the operators began to collect statistics. From the beginning it was apparent that certain kinds of birds were more likely to be hit by airplanes than others. As we made those initial studies, it became obvious that we had to do some detailed studies on aerodromes and would have to carry out management to remove or reduce the bird hazards.

One of our colleagues in the Department of Transport who was involved in the discussions from about 1959 on, came up with the idea that he should write a letter for his Deputy Minister's signature to the National Research Council asking it to study the problem and recommend solutions. He did so, knowing of the National Research Council's flexible approach to research problems and its possible willingness to put some money into the work. The kinds of studies we needed would require money. We, in the Wildlife Service and the military, agreed. The letter was sent in 1962 and was passed to the Research Council's office of mechanical engineering, on the ground that a mechanical problem was involved. The head of the Mechanical Engineering Division referred the problem to his best trouble shooter, a man that many of you know. Mr. Malcolm S. Kuhring better known as Mac. Mac just doesn't recognize anything as being impossible. He has boundless enthusiasm for getting on with a job, regardless of obstacles. He had a lot of know-how about jet engines because he had done much testing on many of the big jets in the 50's and 60's. He had behind him the resources of the mechanical engineering division of National Research Council. But here he was confronted with a totally new kind of problem. He didn't know a lot about birds but he did know birds could break engine components if they got into them, just like any other kind of foreign object. He came to rely on the biologists of the Wildlife Service and other people with similar training to help him with the bird side of the question. He knew that you could never have too many sources of information and help if you are trying to solve a complicated problem. He set up an N.R.C. Associate Committee with himself as chairman and made sure he had appropriate representation from Transport and National Defence, from the Wildlife Service then in another department but now in the Department of the Environment, from the airlines, which were having the trouble, from the aero-engine manufacturers which repaired the broken machinery and from the Canadian Air Line Pilots Association whose members sat up there behind the relatively fragile windscreens. He had power to add to the committee experts in any other field that he might want.

His main concern was to reduce bird hazards to aircraft quickly - by whatever means seemed possible. No idea was too foolish to be considered at the beginning. Biological studies were made on airfields to find out why birds were there, and what could be done to keep them away. It was soon possible to make proposals to modify airfields to make them less attractive to the kinds of birds that caused problems. New airfields were designed to minimize birds attractions. A whole variety of things were set going almost simultaneously. By 1963, airfield modifications were being carried out right across Canada. A few years later it was possible to see the results. Air Canada's costs for parts to repair damage caused by birds averaged $238,000.00 a year from 1958 to 1963 inclusive. In the next 5 year period from 1964 to 1968, their fleet was expanding and was becoming more thoroughly jet powered but their parts cost dropped to an average of $125,000.00 a year. Since then it has remained near that level. All we did was make airfields less attractive to birds by removing, as far as possible, the food, cover and shelter which had formerly attracted the birds to the airfields.

Now all this is very easy to say but it took a lot of time and a lot of dollars to carry out. I won't bore you with the details of the wrangles we had with city councils trying to get them to move garbage dumps that attracted flights of birds across runways and flightways. I won't tell you of the costs to fill old borrow pits on existing airports that became lakes attractive to nesting ducks, or what it costs to cut down two miles of hedges or to relocate a complete market garden. We have gone through all those exercises at different airfields.

We not only reduced Air Canada's hardware breakage cost but, by attacking another side of the bird problem, we changed some military operations too. When we started our studies, civil airlines suffered about three quarters of the bird strikes close to the airfields and about one quarter on climb and descent. The military picture was almost the reverse. Military aircraft do a lot of low-level high-speed operations so three quarters of the bird strike damage occurred away from bases.

To get at the problem aloft we had to find out what the birds were doing up there, then figure out how to avoid them. We couldn't control birds in flight as we could birds on airfields. Bird migration has been known since the days of Aristotle. There is a 2,000 year record of observations of bird migration based on visual observations of birds in flight. Mark and recovery studies have gone on for hundreds of years, individually marked birds released at one point and recovered at another showed origin and destination of some migrations. There are many assumptions about migration that do not hold up to scrutiny. We didn't realize how bad some assumptions were until we started to use radar to look at mass bird migration across the whole North American Continent. We patched together a mix of military and civil radar stations across Canada, across the Caribbean and part of Europe as well before we got finished. We also worked out a technique to take time-lapse movies of the radar presentations so that when the bird migration had gone by we could study the film record at our leisure and develop correlations between bird migration and weather patterns.

After careful analysis of something like 200 miles of 16 millimeter film, we evolved a technique of forecasting bird migration hazards. You can say "well...so what, maybe that's no better than weather forecasting". And you would be right. It isn't any better than weather forecasting because it's based on weather forecasts. Birds have been flying weather patterns far longer than we have. So if you have a bad weather forecast, it's hard to base a good bird forecast on it. In spite of that, our bird forecasting is good enough that the loss rate in air force training programs was reduced. Before we started forecasting, one CF-104 was lost by bird damage a year. In the last three years during which the forecast system has been used none were lost although the training program wasn't changed throughout that period.

When you start making that kind of reduction in losses, word gets around and we were asked to put together a group to try to develop a similar system in Europe. We went to NATO's Scientific Affairs Division for money, seed money if you will, to get a number of European countries working together on a joint program. NATO likes to finance joint programs between member countries and began with $61,000.00 and seven NATO countries. To start them off I went to Europe as chairman of the committee and introduced them to the Canadian forecasting techniques in 1969. The countries are now enthusiastic and are developing techniques for their own use. Some are putting very large sums of money into the research that they wouldn't have done if we hadn't got the thing started with NATO's seed money. We've done another trick too and this is characteristics of the Canadian associate committee, which has always worked on a co-operative basis. We've even managed to get three non-NATO countries into the program. They can't receive grant money from NATO but they do co-operate. You may be surprised to learn that those three countries are Switzerland, Sweden and the U.S.S.R. The U.S.S.R. strike rate on aircraft is about the same as Air Canada's was at the beginning of our work. The Aeroflot annual strike count in 1968 was about 1,500. That's about what it should be if you look at the route mileage and number of aircraft compared to Air Canada's strike rate of about 200. The Russian delegate wasn't able to come to the recent meeting of Bird Strike Committee Europe in May so I don't have any reading on how much the U.S.S.R. rate has been reduced by modifying airfields. Dr. Yacoby, the man in charge of their work, is a good botanist and juggling plant cover is one of the airfield modifications that has turned out to be very appropriate in many countries. It is the major ground control modification that is being used in the United Kingdom and some other European countries.

You may say..."OK... so you've cut down the strike rate on birds - you've eliminated some of the losses of military aircraft and so on, but how many lives have you saved?" That's the old question that nobody can answer. In fact, I'm more worried about the bird problem now than 11 years ago when the Associate Committee started to function. Then we were dealing mainly with four engine jet aircraft. While there have been at least two cases of three engine wipe-outs by birds on approach - in each of these the aircraft was able to get down on the remaining engine and nobody got hurt. Lately we have been getting into another kind of ball game. We have been getting massive multi-engine damage on take-offs. One of the more spectacular ones was a DC-10 going out of Tulsa, Oklahoma last October 30th, that went through a flock of gulls at 200 feet and cleaned out the two underwing engines. The plane carried only 49 passengers and a crew of ten and was relatively lightly loaded with fuel so it was able to beat around the circuit and get back down in a few minutes on the center tail engine. This feat speaks very well for what you can do with one engine, if you have to, but it opens up a whole new can of worms. The European airbus which I saw at the Paris airshow in May, is a very pretty looking airplane. It uses the same engines as the DC-10 but only two of them to move a big airplane with a capacity of 260 people. If birds can wipe out two engines on a DC-10, they can do so on a European airbus. My European colleagues are pretty jumpy about that airbus though in a sense no more so than we are about things like 737's and DC-9's because there again a two engine wipe-out is possible. That it hasn't happened so far, doesn't tell us that it won't. I think airlines and aircraft manufacturing companies will have to pay attention to the bird problem when they design aircraft. It may be cheaper to build and operate two engine aircraft. If the public and governments decide they don't like the lack of safety in a massive bird strike with a two engine aircraft, three or four engines may become popular again.

The Associate Committee is having a book written on bird hazards to aircraft. Members of the Committee have already published scientific papers on the subject. We've produced movies, we've been on television and radio and we've given newspaper interviews. But a book is also needed. Many people concerned with all phases of airport operation, especially in other countries, are not fully aware of the problem or of what can be done about it. It's now time to publicize in simple language what we have learned from 11 years' experience in the field. The book should also be of interest to the public and particularly to air travellers who should know what more can be done to make their journeys safer. An informed public will press governments and other appropriate agencies for safety features at airports and in aircraft that will reduce the bird hazard. Our aim is a well written book on a technical subject which involves engineering, landscape management, bird watching, and many other things and puts them together to make life safer and more pleasant for people who travel by air. We are hoping for a publisher who can make it a best seller among air transport people and air travellers. More and more people travel and I think they should know that travel is becoming safer but can be safer still if everybody concerned will apply the bird management techniques that we have pioneered. I believe that's what we're really all after. Nobody likes investigating an accident, it is better to prevent it.

As I said earlier, the secret of the success of the Canadian Associate Committee on Bird Hazards to Aircraft has been complete flexibility and enormous co-operation. Anything we didn't have and couldn't buy, we scrounged. We had a group of active people on the Committee, so there was always somebody who knew where things could be borrowed or used at no cost. We even went so far as to borrow the use of radar stations from other countries. We began work in Europe to help protect our military forces and our civil airlines that operate through European bases. We passed on all our knowledge to our European colleagues and they applied it, found it useful, improved it and we are now importing back to Canada some of the techniques developed in Europe. The whole thing revolves around understanding, exchange of information and co-operation. I hope that is true of all accident investigation and safety research. I can't stress too much the experience of the Committee. Its method works, it gets results, it probably has saved lives, it certainly has saved millions of dollars and it can do a great deal more in saving lives and money. The Committee has solved some problems, its members are aware of others. There is probably no end to the kinds of things we can try. We've done all the easy things. We must now attack the harder problems, so now our progress will be slower. The solutions may be more difficult, more costly and take longer, but we'll persevere. We don't think there's anything more important than to carry out extremely interesting and challenging research to save human lives and property.

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THE HUMAN FACTOR IN CYCLIC AIRCRAFT ACCIDENT PATTERNS

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Recent evidence has indicated that in some aircraft operations, accidents tend to occur at highly specific times of the year and in regular cycles. While environmental factors are associated with these cycles, it has become increasingly obvious that human factors are more significant.

The objective of this project is:

(a) to identify and describe any patterns in the accident rates of CF-104's flying with the Canadian Forces, Europe -- particularly cyclic patterns;

(b) to identify the factors which produce such patterns with an emphasis on human factors; and

(c) to translate these findings into useful information and techniques that Commanders and Flight Safety Officers can employ to prevent aircraft accidents.

Consideration of preliminary data indicates that peaks in the accident rates of CF-104 operations in Europe exist and are periodic - occurring in January, April, July and October.

Many hypotheses as to human factors which might be implicated have been considered. Some are concrete; others are highly speculative. Some are easy to study; others, very difficult. Our investigations have concentrated on the following factors - leave periods, personnel rotations, and major exercises, as well as looking at environmental factors such as weather problems and bird migrations. Operational factors including sortie frequency have also been considered.

This paper discusses our results to date and our future investigations with an emphasis on the human factor.

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- Soesterberg, Netherlands, September 1973.

THE ASSOCIATION'S ROLE IN ACCIDENT PREVENTION

CAPTAIN R. D. NASSEY
CANADIAN AIR LINE PILOTS ASSOCIATION

Except for a few early dedicated pioneering individuals "a complete state of limbo" during the 1940's", can only describe the approach to safety and accident prevention practised by most aviation groups in Canada from Government to companies and including CALPA.

In the early 1950's with the airlines suffering a high accident rate trying desperately to sell aviation to a skeptical travelling public, a technical approach to flight safety emerged. The scarf, goggles and leather helmet approach to accident prevention was replaced by an assessment of safety in its total environment.

In 1951 the Department of Transport was approached to form a modern accident investigation bureau staffed with trained accident investigators including a working airline pilot.

During the mid 50's strenuous efforts were made to advance the Association from a period of non activity in Technical and Safety problems to an active participating organization. During the organizational period, another Comet 1 dragged its tail to catastrophic destruction at Karachi, and the cause was published as pilot error. The Canadian Air Line Pilots were incensed. Previous tail strikes had been recorded and more followed. Finally after eight years of persistent accident investigation by the British Air Line Pilots, the true Comet 1 story received official recognition and our pilots were vindicated.

In 1956 the Technical and Safety Division was formed composed of Aero-Medical, Fire Fighting & Rescue, ATC, Instrumentation Standardization, Airports and Radar and Operations. As the sciences of human factors, prolonged airframe testing, aviation psychology and pathology emerged, allied committees were formed to assess accident prevention and flight safety in its entirety.

Our first accident investigation was conducted in 1956. We found that the Viscount's propellers would go into ground fine pitch while in flight. This information was relayed to ALPA and assisted in finding the cause of the United Airlines accident in Chicago. The aircraft arrived unceremoniously from a height of 30 feet during its final landing phase. This was the first Viscount accident and an extremely bitter battle was fought over the propellers by Vickers, CAB, ALPA & CALPA. The point was proved and the pilot cleared. The same year we joined the Flight Safety Foundation and since have been active members.

At the opening of the FAA/ATC Research Center in Atlantic City, which at the same time hosted the 1958 FSF Forum, CALPA presented a paper introducing the use of separated dual VOR's at congested airports. ATC would use one installation for inbound aircraft and the other VOR for outbound traffic. Being a new concept the presentation received considerable attention from ATC authorities in Canada and the U.S.A. Today this air traffic pattern is utilized on most high density routes and terminals.

During 1959, our first qualified accident investigators graduated from the University of Southern California Accident Investigation Course. The knowledge gained in accident investigation by the first few was rapidly utilized in a comprehensive programme of accident prevention.

The late Captain Bill Rodgers, Air Canada, and Captain Cle Lamb (CP Air) formulated a system of confidential reporting of incidents affecting flight safety. The difficulty of communicating with a widely scattered membership has always been one of CALPA's greatest problems. A potential accident/incident would be identified in the Technical and Safety Digest, our effective safety tabloid since 1955, requesting responses on specific accident potentialities. For example - during poor atmospheric conditions, the glide slope on runway 10 at Toronto had a notorious fluctuation causing one accident and a very fortunate brush with trees by another aircraft all within a fifteen minute period. Pilot reports graphed on a simple 4 x 8 sheet of plywood proved that all pilots experienced an unacceptable downward deviation of the glide slope during specific atmospheric conditions. The pilot's career was terminated, however, the ILS was subsequently decommissioned.

Jet upset of catastrophic results was a regular occurrence in the early 1960's. Captain Paul Soderlind, Director Flight Operations, Northwest

Orient Airlines, identified the problem in a most comprehensive paper at the 1963 FSF Seminar. However, as Captain Soderlind identified the problem to a Seattle product, major carriers in Canada were having identical incidents with a Long Beach design. The CALPA accident prevention group in May, 1964, documented to the manufacturer incidents of near jet upset, reported through our confidential reporting system. Our condemnation of the stabilizer system specifically were and still are:

The inconspicuity of the stabilizer trim indicator for both day and night operation.

Insufficient warning that the stabilizer is in movement.

Lack of autopilot and yaw damper engaged indications on both instrument panels.

As the Ste Thérèse Accident Public Inquiry was currently evaluating positions of stabilizer jack screws, the manufacturer's representative was guardedly responsive. He noted from our presentation that "the installation of additional warning lights in the cockpit should not be considered as a replacement for proper crew techniques or coordination". "Gentlemen, as one of the original crew members qualified by the manufacturer's representative on this aircraft, I was not instructed at that time nor since by anyone on stabilizer mistrims catastrophic potentials - only jammed stabilizer landings. Reviewing some of the incidents noted in your letter (continued the writer) confirms our past concern of possible complacency in the cockpit. In January of this year a KNOW YOUR AIRPLANE was written and we enclose a copy for your file". Just six weeks later another letter was received by CALPA from the same source stating: "After extensive flight testing and engineering evaluation, the manufacturer is offering the following improvement items on future production airplanes". An IN MOTION audio warning of the stabilizer - now, if the manufacturer was consistent, a flashing blue light rather than a horn would be in psychological design compatibility as in other systems flashing blue lights denote motion and horns indicate misplacement of gear, flaps and spoilers - nothing under motion. Since all models have been modified to 1½ degrees less nose down trim capability not a single upset of this aircraft is recorded by our Safety Division.

Why did our Safety Division resort to confidential reports? - One of the first Associations to initiate this programme?

Pilots make errors and will always be prone to error as we are human beings - nothing can change that fact. The inherent guilt complexes and self incrimination made many pilots reluctant to give written reports of their experiences through normal channels. However, our confidential reporting system elevated the incident or error from coffee shop rumor to an analytical evaluation and frequency surveillance of the problem. In many cases contributing factors triggered the error. Radio aids, instrumentation layouts and lighting, lack of adequate company check lists, training procedures with multiples of simulated failures beyond aircraft and pilot capability of recovery - were producing "Pilot Error" evaluation to the self incriminating. An excellent case in point is the ground spoiler system on a popular jet transport. No other aircraft designed since the inception of the jet era has a single lever, which if misused, can produce such catastrophic consequences which to date has taken 170 lives, 2 complete hull loses, extensively damaged 2 aircraft and caused minor damage to two others - the major accidents were labelled as "Pilot Error". Until problems of this nature are recognized and suitable design improvements incorporated, further disasters are highly possible.

Association reports where action is indicated are always presented first to the Company involved. Usually with the report we enjoy today, the problem is expediently rectified, however, should an impasse prevail over an extended period such as we experienced with the lack of standby horizons, speed reductions below 10,000 feet, altitude alerting devices, emergency locator transmitters and even check lists, we then pursue the problem directly with the appropriate MOT authority where in these later years our presentations have received careful study.

In the early 1960's, the American Civil Aeronautics Administration recognized the value of line pilot participation in all groups of their accident investigation team. Although preferred, it was not a prerequisite that the pilot investigator have a qualified accident investigation certificate. His intimate knowledge of company operations, training procedures, current maintenance and aircraft problems if any, personal and professional problems if applicable of the crew, radio aids and navigational instrument intricacies are only a few of the many ways a line pilot investigator may assist as a recognized participant.

In 1962, a British made Canadian registered aircraft crashed attempting a three engine landing on American territory. The CAB welcomed the participation of the CALPA representative and even allowed three ALPA pilots to represent CALPA in all phases of the investigation. Meanwhile in our own country we were unofficially admitted in some accident groups and rejected from others. Although the CAB decided "Pilot Error" as the pilot lost control of the aircraft during the final landing flare", the CALPA group conclusively proved by evidence of wreckage distribution, ground scorch marks, witness statements and pictures taken at the scene, that the failure of the right fuel dump valve which had failed to close, causing a fuel imbalance with a resultant lateral control problem. Our documentation was fully supported by David Holliday, University Southern California, as the only reasonable prime cause factor. The CAB would not alter its conclusions. Three more incidents of fuel valve failures occurred in the same fleet after the accident. Now the Company convinced CALPA's findings were accurate, installed modifications to the dump mechanism, revised maintenance procedures and pilot check lists - no further problems were experienced. CALPA's role in accident prevention was steadily gaining the confidence of the industry.

In pursuit of our accident prevention policies we have lobbied diligently against slot machine insurance for air travellers. The State of Colorado was the first to recognize that no responsible traveller required any further insurance to travel in an airplane than his family needs dictate for travel through the concrete jungle. Excessive insurance and a love affair was reason enough for Albert Guay to blow up 28 people in a CPA DC-3 September, 1949, in Eastern Quebec. Guay was ultimately convicted and hanged as were his two accomplices who manufactured the bomb. Today our Federal Government, in their wisdom, have started another 5 year moritorium on the death sentence. In July 1965, another explosive disaster to a CPA aircraft, a DC-6B, 25 miles west of 100 Mile House, B.C., took the lives of 56 passengers and crew. Excessive flight insurance purchased shortly before departure was carried by a passenger of modest means. Because of indecisive accident investigative techniques at that time, it was not considered necessary to cover the sectional portions of the aft fuselage which were coated with explosive residue. Extremely soluable nitrates were washed down the drain by heavy rains during the controversial period. The RCMP crime lab required three months to eventually identify the explosive as Bulls Eye Gun Powder. Slot machine insurance was definitely not a proven factor in this accident but many cases of this nature have been proven in the United States. Our first brief against this type of flight insurance was presented to the DOT in June 1965. The Canadian Government were receiving revenue from the Insurance Vending Machine owner as rental, which compounded resolution of the problem. But today we are pleased to note these machines have been banned from Canadian airports.

As our Centennial year project another step forward in accident prevention and investigation was achieved. CALPA commissioned the University of Southern California Aerospace Accident Investigation group to conduct a course in Vancouver, B.C., 21 CALPA members participated, accompanied by invited Irish, British and Hong Kong pilots. Through this program CALPA has available 25 qualified accident investigators, and many are perpetually active in safety and technical committees, dedicated to accident prevention.

In 1962, the NRC formed an active Bird Hazard Committee and a CALPA representative was invited to join this unique NRC group. Dr. Vic Solman has already discussed the Committee's activities in his paper, therefore, I will not labour the point, other than to say my Association clearly recognizes the importance of their excellent achievements.

In 1969, a Canadian Civil Hercules aircraft crashed during a landing attempt at a strip in the Perusian Jungle. The pilot was suspended with a dismissal recommendation by the Company's accident team. During the bitter struggle in hearings which followed, the pilot was accused of having "a mental block in his black box against landing long". No basis of fact could be found to substantiate the Company's claim. In fact, the Company had neglected to medically examine the pilot after the accident. Our untiring Technical Director sent inquiries to all owners of Hercules aircraft and the military response was gratifying. Over 55 of the USAF Vietnam Hercules had center wing panel cracks and had to be modified. Wreckage distribution in the Peruvian accident definitely indicated wing structural failure, but local scavenging and hull slavage by a foreign Company made analysis impossible. The panel crack information was relayed to the Canadian Company who on inspection of a second Hercules found a severe center wing panel separation, and immediately grounded and modified the aircraft. Accident prevention through accident investigation, however the emotion of success dulled by the egg arriving ahead of the chicken. As the Company still held firm to a "mental block" case, CALPA after much deliberation enlisted the services of Chaytor Mason, Aviation Psychologist, USC, an unprecedented manoeuver by any pilots association. The pilot voluntarily subjected himself to lengthy psycho-analysis, passed with flying colors and reinstatement followed.

Not all accidents are pursued with such vigor to vindicate the pilot. Where pilot error is a proven fact or a degradation in a pilot's proficiency exists, CALPA will only ensure the pilot obtains fair hearings. I humbly submit we travel extensively as a passenger and this foremost in our minds while representing others. Our aim and policy, which was conceived during the emerging years still applies. Primarily it is to prevent accidents or incidents occurring, establish all factors involved and make certain all recommendations have been implemented to prevent similar accidents or incidents. As a professional Association we have a vested interest and recognize our responsibilities to the travelling public and the industry.

Thank you.

GEORGE B. PARKER

ASSOCIATE PROFESSOR OF SAFETY
HEAD, ACCIDENT PREVENTION/INVESTIGATION DEPARTMENT

THE SAFETY CENTER
UNIVERSITY OF SOUTHERN CALIFORNIA

The Safety Center is a major division of the Institute of Aerospace Safety and Management of the University of Southern California (USC). USC is a private university located in Los Angeles, California.

We have offered courses in aircraft accident investigation for over 21 years. Over 11,000 students have attended our courses, representing 56 countries.

Our interest in the Society of Air Safety Investigators was demonstrated when we co-sponsored the 1971 SASI International Seminar in Los Angeles.

The USC programs have always stressed the importance of education over training. This is based upon a philosophy that a safety specialist, graduating from an educational program, will have an understanding of his field that qualifies him to meet new and every changing criteria. Were he to rely on training to perform only certain tasks without the underlying theories and concepts his capability would be narrowly limited to prescribed conditions and standards.

The Safety Center programs include both military and civilian courses, ranging from one week short courses to full under-graduate and graduate degree programs. The emphasis in these courses is on accident prevention not accident investigation. Even in our program of accident investigation, the ultimate purpose is accident prevention. An accident investigation conducted to find cause, without effective preventive recommendations, is a costly and questionable concept.

The accidents that occur today are not the result of <u>new</u> cause factors. All of today's cause factors have already happened before. If we want to prevent accident recurrence, it is imperative that we determine not only how the accident occurred, but why. Gathering facts is only part of the solution --- determining the reason why accidents happen leads to accident prevention.

The mix of military and civilian students, from all phases of the aerospace industry, provides USC with a unique opportunity for an interchange of safety concepts, procedures, and ideas. Such an extensive student body brings to our programs a fund of safety information that we learn from, and pass on to our students. This interchange of information and experience is one of the principle advantages of having different safety programs at one place.

The Safety Center programs are all multidisciplinary. The Center is organized in the same manner, with four separate, yet coordinated, departments:

Accident Prevention & Investigation Department
Safety Technology Department
Human Factors Department
Safety Management Department

Each of these departments is staffed with full and part time faculty who are specialists in particular areas of safety.

We are proud of our reputation for faculty excellence. Men like John Stapp, Charles Barron, Harry Hurt, and Chaytor Mason are not only renown in the field of aircraft safety, but throughout the world in medicine, engineering, and psychology. Our students are the best judges about the quality of the faculty. Safety is a serious business and we find our students very demanding of quality in the classroom. If a member does not measure up, he won't last long at The Safety Center.

Safety Center courses of instruction that may be of interest to you include:

Aircraft Accident Investigation Course. A two week course given twice a year. It is tailored for civilian aviation. The attendees represent fixed-base operators, airlines, independent and company investigators, representatives from industry, attorneys, government and military investigators. The subject matter consists of accident investigation, aviation technology, human factors, and aviation law.

Aircraft Accident Prevention Course. This is a new two-week course providing civilian aviation with subject matter designed to prevent occurrence of accidents. It is oriented to accident prevention and the management of a prevention program.

Multidisciplinary Highway Collision Investigation Course. A new two-week course in motor vehicle accident investigation. Initially a course established for training of Multidisciplinary Accident Investigation Team members, under the jurisdiction of the National Highway Traffic Safety Administration. A non-contract version of this course will soon be offered on an open enrollment basis. This will be of interest to SASI members who are also involved with motor vehicle accident investigation.

System Safety Course. A three-week, 3 unit graduate course dealing with safety from the concept to the retirement of a system. This is a course of particular interest to government and industry safety specialists. (Mr. David Hall's paper provides further discussion of system safety).

Master of Science in Safety. A master's degree program designed to meet the needs of safety professionals in all areas of safety. Presented on campus at USC, this program includes the following 3 unit courses:

Required Courses

ASM 512	Philosophical Basis for Accident Prevention
ASM 514	Investigation of Accidents
ASM 532	Human Factors in Accident Causation
ASM 552	Quantitative Methods of Safety Analysis
ASM 652	Experimental Design and Safety Research

Safety Technology (electives)

ASM 580 Technical Aspects of Motor Vehicle Safety

ASM 582 Structural Safety and Failure Analysis

ASM 584 Technical Aspects of Flight Vehicle Safety

ASM 586 Safety of Chemicals and Propellants

Safety Management (electives)

ASM 572 Management of Accident Prevention Programs

ASM 576 Fundamentals of System Safety

ASM 670 Legal Aspects of Safety

Directed Research and Thesis (option)

ASM 590 Directed Research

ASM 594ab Thesis

The master's program requires 30 units of course work plus either a thesis or comprehensive examination. In addition to the five required courses, five of the seven electives must be taken. Prerequisites for the program are listed in available brochures, the Bulletin of the Graduate School of the University, or you may write to The Safety Center for information.

Special enrollment for the purpose of taking individual courses in the master's program may be arranged for those not applying for the degree program.

In addition to the courses already discussed, The Safety Center presents a BS/BA program in conjunction with our military safety courses. If you have attended any of our military programs and desire an undergraduate degree in safety you should contact the Center to discuss this opportunity.

The Safety Center's military programs include accident investigation, flying safety, advanced safety program management, system safety, and senior officer safety courses. Students come from the United States Air Force, United States Army, United States Coast Guard, and numerous foreign countries under the Mutual Assistance Program. Special courses are given from time to time on special request, such as Air Line Pilot's Association and Allied Pilot's Association aircraft accident investigation courses. Courses on industrial and occupational safety and health have been presented and are planned in the future. The success our students have achieved in aircraft accident prevention has challenged our faculty to apply the same philosophy and technology to other transportation and industry safety problems.

USC safety courses are all conducted in the English language. Class size averages 20-25 students. Tuition varies with the length of the course and is available on request.

The highest rewards in education come about when the faculty see their graduates achieve success in the real world. The faculty of The Safety Center sincerely hopes that we have been able to assist you in your dedicated efforts to reduce aircraft accidents and injuries.

Thank you.

AN ACOUSTIC BACKSCATTER RADAR SYSTEM FOR TRACKING AIRCRAFT TRAILING VORTICES

MARTIN BALSER, SENIOR VICE-PRESIDENT
CHARLES A. MCNARY, MANAGER, ACOUSTIC SENSING GROUP
ARTHUR E. NAGY, ASSISTANT MANAGER, ACOUSTIC SENSING GROUP
XONICS, INC., VAN NUYS, CALIFORNIA.

ABSTRACT

The safety hazard posed by potential encounters with invisible vortices from preceding aircraft imposes stringent limitations on aircraft spacing in the terminal area, hence on traffic-handling capacity. An acoustic backscatter radar system has been developed by Xonics, Inc. to detect and track such vortices, and thereby to provide the information for more advanced air traffic procedures that would eliminate the uncertainty and delay caused by vortices. The system is fully engineered and operates in real time. Examples of the real-time display and of vortex tracks from Boeing 747's landing at the Los Angeles International Airport are given in the paper.

The full paper will be published in the Journal of Aircraft shortly. Readers are asked to refer to the Journal for further details.

MR. ALASTAIR PATERSON, OBE, Q.C.

I was extremely flattered when your Committee asked me to speak to you at your annual banquet tonight. It is a great honour, but I confess I am still confused as to why your Committee should have picked on me. I have a distinctly uneasy feeling that by the time I sit down you will be as confused as I am as to why they should have asked me.

My connection with aircraft accidents started in 1934 when I joined the law firm of Beaumont & Son in London, England, as a young lawyer. With the exception of six and a half years during the last war, when I was otherwise engaged, my law practice has been extensively, but not exclusively, concerned with the legal consequences of aviation accidents of every type. It has included many major airline accidents and innumerable accidents relating to light aircraft, executive aircraft, helicopters and on four occasions to date hovercraft. Most of the time I have acted for the owner and operator of the aircraft, including many major airlines, or more correctly, I have acted for their passenger or third party legal liability insurers or their aircraft hull insurers. It is only on rare occasions that we have acted for plaintiffs, except we may act for the owner and operator and his hull insurer in claims against aircraft or component manufacturers when an accident is considered to have been caused by some defect in the aircraft or a component.

While I realize that the major thrust of your work is accident prevention, most of you also get involved in accident investigation and the results of your investigations are the raw material with which I have to work in dealing with civil liability claims that may arise from the accident. The investigation of accidents to aerodynes probably has a much longer history than most people might suppose. The earliest occasion that I have been able to turn up occurred in classical times in Greece following on the unhappy accident to Icarus. You may remember the story of Icarus. Icarus and his father, Daedalus, had been imprisoned in Crete. To enable them to escape from Crete, Daedalus made wings for himself and Icarus with feathers and wax. Before starting on their flight, Daedalus warned his son not to fly too low over the sea for fear his feathers would get wet and heavy nor should he fly too high lest the heat of the sun melt the wax holding the feathers. Having given this warning they took off to make the first crossing by air of the Icarian Sea. Daedalus, who was an old pilot, made the crossing successfully, but Icarus as the flight progressed was hugely enjoying the experience of flying and became infected with that euphoria that affects many pilots as they become over confident after they have their licences. He started to show off by seeing how high he could climb, got too near the sun, in consequence the wax in his wings melted and he crashed into the sea and drowned.

I had some research done in the archives in Athens and by an extraordinary piece of good fortune, I was able to come across the summary accident report that was issued by the Minister of Transport of the City State of Athens, which had the responsibility of investigating the accident. The format of the summary report bears a striking resemblance to the format used by the Canadian M.O.T. It is quite short, so I thought I might read it to you.

I am sorry, I thought you would all understand Attic Greek. I have here a translation, so I will read that instead:

Aircraft Make & Model	Registration	Date Time
Daedalus I (legs)	None	7068 BC 1420' Aegean Standard Time

Place	Latitude	Longitude
Icarian Sea off the Island of Icarus		

Locale

Over the Sea

Weather

CAVU winds light temperature 76°F

Description of Occurrence

While attempting a crossing of the Icarian Sea, the pilot exceeded the maximum height recommended for the aircraft - the wing bonding melted, the aircraft crashed into the sea and the pilot was drowned.

	Total	Fatalities
Crew	1	1

Assigned Cause

The pilot's presumption in exceeding the recommended maximum altitude for the type angered the Sun God - Apollo and he caused the pilot to come unstuck.

Recommendations

1. Feathers should be bonded with an approved bonding agent not with bees wax.
2. Flight plans must be rigidly adhered to at all times.
3. Suitable sacrifices should be made to Apollo before attempting a crossing of the Icarian Sea.

The changes that have occurred in the thirty-nine years during which I have been connected with the aircraft operating industry have produced change that is hardly less dramatic than that which occurred during the centuries between the crash of Icarus and 1934. In September 1934, when I first walked into my office at Beaumont & Son in the City of London, I found awaiting me on a side table a scale model of the wireless masts, as we called them in those days, at Ruyselede in Belgium.

In 1933, the Apollo, an Argosy aircraft owned and operated by Imperial Airways, the predecessor of B.O.A.C., had flown into these wireless or radio masts while flying on the regular scheduled service from Antwerp to London. In those days, even in passenger airline operation, navigation was by visual reference to the ground plus a compass with an occasional wireless bearing. The route between Brussels and London normally involved flying parallel to and keeping in sight a canal and a railway line, to the north of which at Ruyselede were these wireless masts - if my memory serves me correct there were two rows of four or five masts or pylons parallel with the canal. At the Antwerp end there were no wires while at the opposite end was the wireless or radio hut and with various wires coming down from the masts. The masts; I think, were over 1,000 feet high and were connected at the top by wires and each of the masts had guy wires to support them. In conditions of very poor visibility, the Apollo had flown into the open end and was trapped inside like a bird in a soft fruit cage. The captain suddenly saw something ahead, probably wires, banked steeply to port, the starboard wingtip was sheared by the wires at the top, then the port wing hit one of the guy wires and the aircraft crashed near the foot of another tower. Belgians working in the adjoining potato fields rushed to help and probably as a result of one of them pulling live wires to try and get at the bodies of the passengers, the wreckage took fire quite an appreciable time after the crash and one of the rescuers was badly burned.

My first introduction to Air Law, therefore, as a solicitor was to assist in preparing the defence for Imperial Airways and its insurers in respect of the claims by the dependants of the passengers killed in the accident and the claim in the Courts of Belgium by the rescuer.

It was the first case to be litigated in England and indeed, I think, in the World after the Warsaw Convention of 1928 had come into force between certain countries. At that time, the United Kingdom was party to that Convention, but Belgium was not. One of the deceased passengers was a man called Grein and the action that was tried in the High Court in England was Grein vs. Imperial Airways. Mr. Grein was travelling on a return ticket from London to Antwerp and back to London. If the Warsaw Convention applied, then Imperial Airways' liability was limited; if it did not apply, then it was not limited. Counsel for the Grein family argued that a return ticket really constituted two separate contracts of carriage; one from London to Antwerp and one from Antwerp to London. If this were so, then neither contract was affected by the Warsaw Convention, as Brussels was not a party to that Convention. On behalf of Imperial Airways it was argued that the place of departure was London, the place of destination was London and that Brussels was just an agreed stopping place and therefore the Convention did apply.

We lost in the Court of First Instance, won by two judges to one in the Court of Appeal and decided that, that was a favourable decision which we should do everything possible to retain, so we made it our business to settle Mr. Grein's case, so that the judgment in the Court of Appeal stands to this day and is the authority for saying that a return ticket from a High Contracting country is subject to the Convention. While the decision is less important today, when so many more countries have become High Contracting parties, in the first twenty or twenty-five years after that decision it saved airlines and their insurers a great deal of money, as it brought within the Convention carriage which might not otherwise have been governed by it.

In the decade before the last war, Imperial Airways were using that remarkable warhorse, the Handley Page Hannibal. While it was noisy, the basket seats were very comfortable while one streaked through the air at 90 mph from London to Paris. That decade also saw the birth of the conception of the Empire Mail Scheme, whereby within the British Empire all first class mail was carried by air without surcharge. This came about contemporaneously with the introduction of flying boats.

The introduction of the "C" class flying boats required a massive conversion training programme converting long-time old land pilots to pilots of flying boats.

In the five years prior to the last war, although never an employee of Imperial Airways, but being a partner in Beaumont & Son who were their solicitors, I presided over a three-man internal court of inquiry into every accident or incident, assisted by a senior captain and a senior engineer. One of the early "C" class flying boat accidents we had to enquire into was a taking-off accident. The Captain called for quarter flap, the flap motor was operated by a simple on-off switch, the First Officer switched the flap motor on, became distracted and forgot to switch it off when the flap was one-quarter extended, so that the flap continued to come out during the take-off. In consequence, violent porpoising resulted and on the third porpoise the aircraft nose-dived into the sea and was wrecked. I do not recall there was any loss of life.

That was my first experience of what has so often seemed to me to be a failure in human engineering by manufacturers of aircraft. They seem to lack any understanding or imagination as to the human failings that may beset all of us. They seem to design for supermen who are always on their toes, are clear eyed and bushy tailed and never feel tired or out of sorts or have quarrelled with their wives that morning. I sometimes think that every manufacturer should be compelled to have among his test pilots the civil aviation equivalent of the R.A.F.'s Pilot Officer Prune.

The flap switch problem was of course quickly corrected by modifying the switches, but one would have thought that the manufacturer should not have had to wait for an accident in order either to install a position switch or a spring-loaded switch.

In this respect, I really do not think that there has been any great improvement and that in the 1960's it should not have been difficult to design a spoiler operating lever in a DC8 which would be proof against the careless or the inattentive First Officer.

The conversion to flying boats suffered the usual problems of converting long-time land pilots to flying boats. Inevitably there was a captain, who after flying the Mediterranean from Alexandria to Mirabella in Crete failed to realize that he was faced with a glassy water landing and made what would have been a perfect landing if the water had been ten feet deep, but unfortunately for him it was thirty feet deep. As a result of lack of escape hatches, lives were lost.

It was also in this decade that we had the experimental Mayo composite aircraft; that was substantially a "C" class flying boat on the top of which and connected with it was perched an aircraft that was very like a Supermarine Spitfire. The composite aircraft took off on the power of the lower component, which climbed to the operating height of the upper component, at which time the engine of the upper component was started and by a very ingenious device the aircraft separated and the upper component then flew non-stop across the Atlantic.

An Australian, Captain D.C.T. Bennett (Don Bennett), who was afterwards Air Vice Marshall in charge of the Pathfinders, was the Captain of the upper component. He was a magnificent navigator and pilot, crossing the Atlantic of course he used stellar navigation.

About the last case in which I was concerned before I left the Law for the Army was a good illustration of the difficulties of persuading old-timers to use new methods. The northbound "C" class flying boat from Cape Town to London via Durban had reached Lake Victoria, Nyansa, and was to continue north to land on the Nile at Khartoum. The radio officer of the northbound flying boat had been having some trouble with the radio reception for his ADF. As he expected to use it on the leg from Lake Victoria, Nyansa, north to Khartoum, he exchanged the sealed radio component with the southbound, but contrary to the required drill omitted to test his ADF either on the water before take-off or in the air shortly after take-off. As they flew they experienced sandstorm conditions, which are much the same as white-out conditions in our North; you have some limited visibility directly below the aircraft, but the reflection of the sun on the particles of sand in the air prevents you from seeing in any other direction.

The Captain was an old-timer of the days of flying by visual reference to the ground and he had the profoundest distrust for his new fangled gadget called an ADF. His radio officer was young and enthusiastic and believed implicitly in science.

As the ETA came up, the Captain reluctantly agreed that the radio officer might get him some headings to fly by using the ADF. The ETA came and went, five minutes passed, ten minutes passed, twenty minutes passed and still the enthusiastic radio officer was giving the Captain headings to fly and the Captain's grumbling was increasing. Neither of them thought to turn ninety degrees and then take three consecutive bearings; had they done so, they would have found that they were stationary and it was the ground station that was moving. Eventually, far too late, they decided that they must be 180° out of phase and turned back and then realized that they did not have enough fuel to make their destination. As they had recently passed over some water where it appeared possible to make a landing, they turned around again and brought off a remarkable landing in a very confined stretch of water, which turned out afterwards to be some of the head waters of the Congo. They had landed right in Pigmy country and it took ten days or more to take the passengers out via the west coast of Africa over land.

The aircraft was undamaged, but there was insufficient water to fly it out. The late Captain Lamplugh, the Chief Underwriter and Surveyor of The British Aviation Insurance Company, that was the leading insurer, said simply "Captain X put it in there - Captain X can fly it out", so armies of pigmies were set to work to raise the level of the water, but just as the aircraft was on the step and was about to unstick, it hit a submerged rock, by that time I had been in the Army for some six or eight weeks and I really do not know how they got it out in the end, as for the next six years I was concerned with trying to shoot down enemy aircraft, which was a reversal of my previous role in civil life.

I have one true anecdote of my six and a half years in the Army which I will inflict on you. At the time, I was Adjutant of 3rd Battalion The London Scottish, which on the outbreak of war had become a H.A.A. Regiment. We were stationed on the west coast of Wales at Aberporth. My C.O. thought it would be a nice gesture to the villagers if we had our pipe band play on the village green on the following Saturday afternoon. So I laid it on accordingly.

At lunch on the Saturday, the C.O. said "Come on Pat lets walk down to the village and see how the pipe band is getting on". When we got to the village green, the band was marching and countermarching with pipes skirling watched by some groups of villagers. We walked over to one group and the C.O. asked an old man how he was enjoying the pipes. The old man thought for a moment or two - spat and replied in that sing-song English which the Welsh use when speaking English: "Dhu, mun, it is lucky they do not make a smell as well!"

When civil aviation was revived after the war, understandably things were in some confusion, particularly in a country that had been occupied for many years by an enemy power. Such was the situation in France. During the occupation, all air traffic control was of course German and after the liberation was a combination of RAF and United States Air Force. French traffic controllers had to be trained from scratch and towards the end of 1946, although not really ready to take on the task, national pride personified by De Gaulle insisted that the French should resume control of civil aviation within France. B.O.A.C. and B.E.A. pilots flying into France had no confidence in the traffic controllers and indeed they relied as much as possible on England to provide them with information. The high powered station at Gloucester was used by B.O.A.C. pilots right down to the Mediterranean and beyond. It was in this climate that a B.O.A.C. flight to West Africa via Bordeaux left London; on arrival over Bordeaux, it was barely within limits with very low cloud. They were given number one to land on an instrument approach, but before they had broken cloud they were told by the French control to break off their approach and go round again. This was due to a U.S. Liberator that had declared an emergency, but because the military frequency was different to the civil aircraft frequency, the crew of the B.O.A.C. aircraft did not know why they had been told to go round again nor did French Traffic Control enlighten them. They were again told they were number one to land and almost at the same point of their instrument approach, they were again told to break off and go round again. Unknown to them, the Liberator had turned round and was back tracking the runway. Because of the basic lack of confidence and perhaps also in a fit of pique, the Captain advised Gloucester that he was going to return to London and they started to fly back to England. After about half an hour, they advised Gloucester that they had decided to divert to Paris and asked Gloucester to advise Paris control that they were coming.

Unknown to them, the French control were having difficulties in the adverse weather conditions prevailing and, due to their lack of experience and training, the controllers at Paris were not taking aircraft from the bottom of a holding stack until the previous aircraft had actually landed, so that they were only landing about five to six aircraft an hour. The satellite landing fields were also jammed up. On entering the Paris control area, the B.O.A.C. aircraft was given a frequency to call, which was that of a satellite airfield, but communications available to the controllers there were such that they could only operate one aircraft at a time. An air ambulance coming up from Switzerland had declared an emergency due to lack of fuel, so that the controllers were busy trying to get it in. The B.O.A.C. aircraft hung around, calling and calling and calling without reply and eventually when it was too late decided to head for home where they could find competent help. By the time the French had landed the ambulance and called B.O.A.C., it was too late for them to return. Why they did not attempt to land at somewhere like Le Touquet or an airfield in the north of France, I do not know. They knew they had not got sufficient fuel to get back to London, but they hoped to make it to Manston, Kent. They crossed the Channel, but at Stowting they ran out of fuel and crashed. There were some survivors, but the crew and some of the people were killed.

There were two accidents affecting British South American Airways in short succession. The first was the loss of Star Tiger, a Tudor aircraft, between the Azores and Bermuda which involved flying that distance at a planned altitude of 2,000 feet to avoid high headwinds. An operation that would have been acceptable in war, but was hardly acceptable for civil operation in peace time. No trace of the aircraft or any wreckage was ever found. It was the subject of a lengthy public inquiry in Westminster Hall presided over by a very famous judge, Lord MacMillan. Among the spectators was a young officer who had been given special leave from the British Army in Germany to attend the Inquiry as his sister has been one of the stewardesses lost in the accident. It was a coincidence that fourteen years later I met this same young officer who was on the staff of the British High Commission in Ottawa and two years after that he married our daughter at St. James Cathedral here in Toronto and is the father of our two grandsons.

A BEA Viking accident pointed up the fact that it may be undesirable for the first officer to move into the lefthand seat when flying the aircraft. A BEA Viking taking off at Northolt had an engine failure on the starboard engine, at the vital point of take-off the Captain in the right hand seat took over before in his capacity as First Officer he had raised the undercarriage and they continued to fly in a semi-stalled condition oblivious of the fact that the undercarriage was still down. Due to poor visibility and to their making a wide sweep to go round again, they were not visible from the control tower, so after dodging round Harrow Church they eventually hit trees and crashed.

As a result of the accident to a Stretched Tudor at Llandough in Wales, I have a rooted dislike for stretched aircraft; they always strike me as being abortions. This was the first trip of a Stretched Tudor with newly approved seating, which provided five seats to a row. This stretching of the Tudor had reduced the permitted limits of the centre of gravity to a very narrow limit and with a full load of passengers five abreast, substantial weight in the nose freight compartment was essential. The charter was to take supporters from Wales to Ireland for the Wales/Ireland Rugby Football Match. It was to pick up the passengers on a Friday night and bring them back on a Sunday night. The operators anticipated that the passengers would have sufficient overnight bags to provide the necessary weight, but they overlooked the fact that in Wales, unlike the South of England, rugby football is a very democratic sport and its principal supporters are to be found amongst the Welsh miners, who if they go away for a weekend are unlikely to bother to take any night clothes or even a change of shirt - a toothbrush and a comb and possibly a razor shoved in the pocket is about all. Special arrangements had been made to use the RAF airfield at Llandough and there was no ballast available. The pilot took off from Llandough alright and successfully landed in Belfast. On the return journey, he trimmed out the excessive tail heaviness and in making a very cautious approach to land, as the runway available was only just long enough, he had occasion to boost his throttles to maintain flying speed, the thrust of the engines on the Tudor tended to push the nose upwards and the aircraft rotated on its axis, stood on its tail and then turned over and went in nose first.

Everyone was killed except for the men in the last row, the telescoping of the fuselage as it went in nose first reduced the g in the tail of the aircraft to tolerable limits. For years after this accident, I always made sure that I got a seat right at the rear. Soon after I came to Canada, as was my custom, I stood at the head of the queue waiting for the flight to be called. Next to me was a man of equal bulk who started off at a brisk walk - we matched each other stride for stride across the tarmac and arrived at the foot of the ramp simultaneously - puffed up the ramp and each collapsed into the last row of seats. On recovering his breath, the man turned to me and said "I see, Sir, you have travelled by air before".

Then there was the collision between Scandinavian Airlines DC6 and an RAF transport plane bringing on Churchill's specific instructions the Governor and Commander-in-Chief of Malaya from Singapore for urgent conferences at Downing Street, There was some remarkable detective work by the accident investigators in that case, they were able to establish that the altimeter of the RAF aircraft was set 10 millibars wrong, traffic control had made an error of one millibar in passing the setting to the Swedes and at that time despite protests from the British Airline Pilots Association and others, the vertical separation permitted was only 500 feet. Right there, 330 feet out of 500 was accounted for, add another 50 feet for lag and 50 feet plus or minus for normal manufacturing limits plus say 100 to 150 feet plus or minus if you are trying to fly a DC6 in a holding pattern of a figure of eight and the whole 500 feet of vertical separation is accounted for. The RAF crew of the aircraft, which had been diverted from its normal destination in Wiltshire on Churchill's specific orders, had no previous experience or briefing in procedures in a highly controlled zone such as London and thought that "orbit" meant that they were free to orbit the airfield and blundered right into the holding pattern of the Swede. Without litigation I succeeded in recovering from the Crown the full value of the DC6 and an indemnity for SAS for the passengers and an admission of liability for the deaths of the crew. Understandably underwriters were delighted as was SAS, but the trouble has been that ever since the underwriters have expected me always to produce such a successful result.

In 1953, I made the transition to Canada and since my arrival in Canada I have been concerned with the Maritime Central Airways crash at Issoudun, Quebec, C.P. Air Cold Bay, T.C.A. Mount Slessey, CP Air Honolulu, CP Air detonated high explosive at a Hundred Mile House, Air Canada Ste. Thérèse, Air Canada Malton, the recent loss of the Air Canada DC8 by fire and the like.

It will perhaps not surprise you to know that although I am approaching the age at which most public companies would require retirement, I find life far too challenging and interesting even to contemplate it; happily in my profession we are permitted to fade away and I am very gratetul to my energetic young men, such as Eric Lane and Bruce MacDougall, that they still need me around and that there is plenty of work for us all.

This has been a highly personal account of one man's exposure to the consequences of aircraft accidents; apart from my prejudices against stretched aircraft, I think the thing that strikes me most is that despite the giant strides that aviation has taken since 1934, it still seems to me that the manufacturers of aircraft consider that all pilots of their products are going to behave like supermen under all weather and all conditions and that there is still too little thought given to designing switches, levers, what have you, so as to reduce the dangers of the inattentive, the tired, the sick operating them without being forced to realize that they are doing so.

FRIDAY, 31 AUGUST 1973

CHAIRMAN OF THE DAY:	Mr. M.R. McCubbin
9:00 A.M.	"THE SOCIETY'S ROLE IN ACCIDENT INVESTIGATION TRAINING" Panel Chairman: Mr. E.F. Harvie Air Accidents Investigation Division Ministry of Transport Wellington, New Zealand
	INTRODUCTION OF SESSION Mr. E.F. Harvie
	PANEL DISCUSSION 1. Mr. D.E. Kemp 2. Mr. Tom Collins 3. Mr. R.M. (Bill) Kidd 4. Dr. R.R. Shaw 5. Dr. W.J. McArthur
	DISCUSSION OF SOCIETY'S ROLE
	SEMINAR SUMMATION Mr. D.E. Kemp
	CONCLUDING REMARKS Dr. W.J. McArthur
12 NOON	LUNCH
1:00 P.M.	BUS TO ONTARIO PLACE
	CANADIAN INTERNATIONAL AIRSHOW

THE SOCIETY'S ROLE IN ACCIDENT INVESTIGATION TRAINING

E. F. HARVIE
CHIEF INSPECTOR OF AIR ACCIDENTS
NEW ZEALAND

This morning we are fortunate in having a distinguished panel of speakers so well known that they need no formal introduction. I am sure they will contribute more to this discussion that anything I myself may be able to offer. But before asking each member to make his presentation I would like to make one or two observations and I hope you will forgive me if I begin on a rather personal note. My excuse is that it has a direct bearing on a suggestion I want to offer shortly for SASI's Board of Directors to consider at an appropriate time - one which I believe will be supported by our other international members in particular.

At international gatherings like those of ICAO, the Flight Safety Foundation and SASI; during study and familiarization visits to various aviation organizations abroad; through participation in classes at the National Aircraft Accident Investigation School and USC; and in on-the-spot discussions with bodies like the NTSB and FAA, one gets to know a good many people in the accident investigation field. Again, in New Zealand, for instance, we have had visits from such SASI members as Mike Bates of Douglas; David Hall of Garrett AiResearch and USC; Mack Eastburn of American Airlines' Safety Department; Bill McArthur, President of our Society's Canadian Chapter; and that effervescent exemplar of FDR/CVR expertise, Bob Rudich - all of whom have helped us a great deal when we have needed the benefit of their courteously-given professional knowledge and advice.

The point I am trying to make is that much more that would otherwise be the case can be achieved when cooperation through good international realtionships is available. Take, for instance, the very simplest case: You will all know how helpful it is, when faced with some problem or looking for particular information, to be able to write personally to someone you know overseas from whom you can get a worthwhile answer quickly, and how different that is from information derived from lengthy exchanges of formal correspondence conducted on an impersonal basis and which seldom give you the kind of answer you are looking for. The development of good international relationships is therefore very important to us all.

Absent from our midst today is Bobbie R. Allen, former Director of the NTSB's Bureau of Aviation Safety and a SASI charter member whose untimely death I heard about only a week or two ago. I first met him at the ICAO AIG III Meeting in Montreal in 1965 and had the privilege of working closely with the U.S. Delegation which he headed and which included Bob Froman, Bill Halnon and Don Madole, all SASI members. And like other "foreigners" (from the U.S. standpoint) I soon came to appreciate, from the vast help that he was able to arrange for the U.S. to give us, how great an internationalist he was. It is certainly true to say that accident prevention and investigation work in a good many countries as well as the United States has reached a high standard through the assistance he was able to give them.

I think, then, that I will have the support of the other international members of SASI in recommending that our Society's Board of Directors consider this suggestion. It would be improper and seem almost ungrateful if Bobbie Allen's work in promoting international goodwill and cooperation were to be allowed to be forgotten. Accordingly, I make the suggestion to the Board that they consider the establishment of what might, for instance, be called the Bobbie R. Allen Memorial Award or, alternatively, some continuing project named in his memory, to act as an inspiration to others to advance the cause for which in life he strove so well and successfully. Adoption of this suggestion would, I feel, pay some tribute to the great worth of his efforts and to one who was, as a man, a hard bargainer, one with whom one could not always agree all of the time but who was always ready to respect another's viewpoint and to admit it if he were to be proven wrong; above all else, a human being at heart, a worthy son of the red soil of his native Texas and an essentially humble and gentle man.

And now to this morning's discussion. I don't profess to know the answers to the question, how can we improve the Society's role in accident investigation training, but one or two things may be worth thinking about.

In SASI's overall membership, perhaps the most important group comprises the professional air safety investigators themselves - for they are the ones responsible for leading or most closely following the leader of the formal investigation and responsible for accident cause determinations. The rest are concerned with particular aspects of the inquiry and are in a slightly different category.

The more developed countries have statutorily constituted accident investigation authorities staffed by people of wide aviation experience and qualifications and who have undergone specialized training provided by specialist schools such as the National Aircraft Accident Investigation School and the Institute of Aerospace Safety and Management at the University of Southern California, institutions probably regarded as being the best of their kind anywhere. The kinds of things taught there form the basis of ICAO's Manual of Aircraft Accident Investigation and it is hard to see how investigative practice can suffer or be deficient if procedures are faithfully followed.

The work done by those schools, the vast amount of research and development in which they have shown themselves both innovative and practically capable, and the human and material resources they are able to call upon place them in a category of excellence that would be hard to find anywhere else. They need the encouragement and support of us all. Few can claim that they are not doing an acceptable job.

Perhaps the greatest service our Society could render to the public would be in the field of education - making the layman and even the participant in the occasional investigation more aware of the true purposes of the exercise, more often than not completely misunderstood by such people as those representing the news media, the hungry or suspicious attorney or greedy litigant intent on getting his own pound of flesh no matter who may be hurt in the process, or those seeking some sort of revenge.

Should SASI not concentrate some of its efforts in educating such people to a proper understanding of what the professional investigator is intent on doing? Only through education will we be able to counter the criticisms of those who, through insufficient or a total lack of knowledge, think they are just a little smarter than we are ourselves.

Members of this panel, though, may have other ideas and we must now hear what they have to say.

THE SOCIETY'S ROLE IN ACCIDENT INVESTIGATION TRAINING

THOMAS J. COLLINS
DIRECTOR, SASI

The dictionary gives, among others, the following definitions: The verb "to train" - to form by instruction, drill, discipline, etc. - to educate. The noun "training" - the course followed by one who trains or submits to being trained. - Discipline - Education. Of these, the verb "to educate" and the noun "education" are the definitions most appropriate to our discussion today.

The founding members of SASI clearly had in mind education as the purpose of the Society. The original SASI Constitution, drafted in 1964 and filed with our Articles of Incorporation, attests to the importance attached to education.

Quoting from Article II, Aims and Objectives:
"To promote education of members, of those directly associated with aeronautical problems, and of the general public concerning those problems peculiar to the work of the Air Safety Investigators".

"To promote air safety by the exchange of ideas, experiences and information regarding aircraft accident investigations and to otherwise aid in the advancement of flight safety".

"To promote technical advancement by providing for professional education through lectures, displays, etc.".

When the Constitution was revised, about four years ago, these words were changed, but, the importance of education is clearly in evidence in the current document.

In my view, education, or "Training" if you will, is the name of the game for SASI. For a few moments, let us review SASI's past efforts in the area of training and then look to what might be done in the future.

At this point let me say that the Program Committee selected an excellent spot on the agenda for this panel. It was just nine years ago today, on August 31, 1964, that SASI was founded.

From this milestone in our history, let us review the past nine years.

In SASI's infancy, training was confined to talks by guest speakers at infrequent luncheons of the Washington Headquarters Chapter. Some two years later, Sam Parsons, an active Chapter member and prolific writer, began publishing an excellent series of newsletters titled "PDQ". This series eventually evolved into our official publication FORUM which made its debut January 1968, with Parsons as Editor. Since then, SASI has published twelve more editions of FORUM, the latest being published this month.

FORUM has been a vehicle for the exchange of ideas among our members. It has carried articles and papers relating to accident investigation techniques and the problems of the investigator. It has also presented information concerning new aeronautical products with which the investigator should be acquainted.

Thus FORUM became an additional device for achieving our educational objective. Its introduction also provided the first educational mode for members residing outside the Washington, D.C. area. This is still the case today for many of our members and is, in fact, their only link with headquarters and fellow members. (That is, if we discount the receipt each year of an annual dues statement).

On April 5, 1968, we entered a new phase in our development when the Los Angeles Regional Chapter held its first meeting under the guidance of Dessel Erickson and Robert Shaw.

At last, more of our members could enjoy the benefits of regular meetings with fellow investigators, where ideas could be exchanged and guest speakers could be heard.

In 1969, the New York City Chapter began operations and a trend was started with the Oklahoma City Chapter approved in 1970, the Dallas/Fort Worth Chapter in 1972 and the Canadian Chapter in 1973.

During this period of Chapter growth, SASI took what must be considered a giant step in its education commitment by introducing, in 1970, the Annual International Seminar. Here the member is exposed to the best brains in the business, in surroundings and atmosphere far superior to the limited environment of a luncheon or dinner meeting.

We can all be proud of this and past seminars! So much for the past! What of tomorrow? I foresee the following:

First - a continuation of Chapter development until the benefits of Chapter membership are available to members worldwide.

Secondly - I see SASI providing, from within its membership, a pool of lecturers, recognized experts in their areas of investigative specialization, who will be made available to schools offering formal training in accident investigation.

Thirdly - there will be a Central Program Committee that will identify outstanding topics and speakers and will schedule such speakers to address all Chapters.

Finally - I foresee a SASI Aircraft Accident Investigation Library where the best of reports, analyses, films, video tapes, etc., will be available to members and training institutions.

When will these things come to pass?

With certainty I can predict only that the development of Chapters will continue at the rate of one new Chapter every year or two years. Beyond that it is impossible to predict, for it depends upon how well we meet the most pressing problem of SASI at this point in our growth.

I am speaking of the problem of managing the day to day operation of an organization which has grown in nine short years from 143 Charter Members to an approximate 1000 members.

Operating as we are, with volunteer workers, we can no longer continue our expansion without employing a permanent headquarters staff. Such a step involves expenses that require increased revenues, whether these be from increased dues or from other sources.

Our dues have been kept to the lowest possible level. This is proper for a non-profit organization which must show that all its income is expended to the benefit of its members in accordance with the specified aims of the organization.

It is true that we have a modest amount in our treasury, however, lest you be lulled into a false sense of well being, this is because we have failed to keep our commitment to publish FORUM on a quarterly basis.

I have recently became editor of FORUM and have resolved to publish it on schedule. With the increase in printing, mailing and related costs, I can safely say that the Society is now programmed to self-destruct in about two years.

We must not let that happen!

IN SUMMARY

SASI has, in the past, fulfilled its educational or, if you prefer, training objective, through luncheon and dinner meetings at the Chapter level and, through encouraging the growth of Chapters. It has printed the FORUM and it has given us the Annual International Seminar.

In the future, I predict the continuing development of Chapters, the establishment of a speakers' bureau, a Central Program Committee to provide speakers for Chapter meetings and, finally, a library for its members and for training institutions.

The time to implement these programs cannot be assessed until we have successfully negotiated the next big turn in the road, formation of a permanent headquarters organization.

Let us, therefore, give this task our utmost attention!

THE SOCIETY'S ROLE IN ACCIDENT INVESTIGATION TRAINING

R. M. KIDD
DIRECTOR, TECHNICAL & SAFETY DIVISION
CANADIAN AIR LINE PILOTS ASSOCIATION

The question - what is the value of the Society and its role in accident investigation training to my Association - caused me to take a deep look at the past, present and future of flight safety and accident prevention. Let us go back to the 1960 CALPA Convention, the delegates approved the handbook of CALPA Air Safety activities, the contents were compiled as a result of dedicated safety activities by individuals who had been quietly sponsoring flight safety since the Association was formed in 1937.

Let us consider how SASI can be valuable, here I will briefly discuss areas which I trust will identify the need for close cooperation and understanding of all concerned.

Gentlemen - in the last issue of Forum, Bob Rudich wrote an article "Beware the Whistler or Complacency Strikes Again". He stated, "if one applies pure logic to the solution of the riddle of causation, he often arrives at the inescapable conclusion that, logically, the accident could not have occurred, or stated another way, no pilot (and for pilot one may substitute mechanic, dispatcher, air traffic controller, etc.) would logically have performed a specific act of omission or commission which occurred in the chain of causation". This statement in itself really states the need of today's aviation for development and understanding of modern accident prevention programs.

Do we learn from accidents and incidents? Gentlemen - we contend that we don't. Lets examine a couple of specific cases:

(1) Deployment of spoilers in flight, two major accidents - one incident since preventative action was recommended as a result of a public enquiry. Why aren't the results of any accident investigation available to all pilots? Gentlemen - here I contend that certain accident and incident reports must be included in recurrent training syllabuses and/or demonstrated

during simulator practice. This may be difficult, but when we have recurring accidents, a fresh look must be taken by everybody to establish what must be done to give the pilots the knowledge of the unfortunate experiences of others.

(2) There are many times when CVR and FDR tapes have been of extreme importance during an investigation. How many times have they been misread and misinterpreted by misinformed parties. We have all recently been following a National bugging episode, which I am sure has indirectly affected many of us in this room. But still the airline pilot prefers and desires to have CVR's and FDR's available to assist in incident investigations. How many of the airline representatives here today have an organizational system whereby tapes can be immediately removed at any station stop when requested by the pilot, very few! Without these tapes the recent tragic L-1011 accident would have been extremely difficult to solve. The Trident accident report was excellent, but conspicuous by its absence was the CVR which unfortunately was not yet a mandatory requirement for the aircraft concerned. Currently, we in Canada are investigating an accident where the recorders were all unserviceable. We need better maintenance standards and a better understanding of the pilots' problems. How can this be achieved? By the introduction of an intensified accident prevention programme.

I feel a few words regarding the development of the Technical and Safety Division in my Association will indicate the pilots point of view and the necessity for an organization such as SASI to achieve improvements in the necessary areas.

Originally, we had difficulty in being accepted into the field of flight safety. In the 50's a member was fired because of his dedicated activities in Safety. Our Association had him reinstated, and this individual is still extremely active in safety matters. The Association joined FSF in 1956 as a corporate member. In many instances other Canadian

Aviation Organizations felt it was not necessary to join and contribute to this organization for many years.

We have been an active member of NFPA Fire Fighting and Rescue Committee since 1959. Incidentally during the recent DC-8 fire in Toronto, our NFPA representative coincidentally was transiting during this period and his observations have been invaluable to the investigation.

We joined CASI in 1966 as a sustaining member, and Aero Space Medical Association since the early 60's.

We have been an active member of the National Research Council Associate Committee on Bird Hazards to Aircraft since 1963.

To date we have 25 trained accident/incident investigators, three were trained in 1959 and 22 as the Association's Centennial project in 1967. You must realize that the Association membership at that time was approximately 1700. We are planning to have three more members trained this Fall.

Our Founders Flight Safety Award was formally introduced in 1966.

We were one of the original Associations who assisted in the founding of IFALPA in 1948. IFALPA now represents 65 Associations and approximately 70,000 airline pilots, incidentally they also include USSR overseas pilots. This dedication to the advancement of flight safety and accident prevention knows no political boundaries, particularly when one is gathering information of similar experiences to those that may have been involved in a major accident or incident.

Why do the airline pilots devote so much of their time voluntarily to safety and also pay from their dues for the training of accident investigators, etc.? Gentlemen - there are still many individuals within the industry who are living in the past and are only too willing to slam the book shut with the comment "Pilot Error". We therefore contend there is a need for a better understanding of all problems associated to the safe operation of aircraft and therefore if SASI is to be of value to the industry, it must dedicate itself in achieving this understanding by education and a free interchange of accident/incident information to prevent the chain reaction type of accident and incident from occurring. This must be done at the earliest possible time during an incident investigation, by means of an active accident prevention program.

We receive the pilots' incident reports but do we say, that can wait until tomorrow or is the response treated as immediate action, or do we say we can't afford this modification - Gentlemen - can we afford similar accidents and still have a healthy industry. We believe a SASI sponsored accident prevention program, using information from other experiences, will assist in achieving our goal - zero accidents.

DR. R. R. SHAW
INTERNATIONAL AIR TRANSPORT ASSOCIATION

I am somewhat at a loss to address myself directly to the title of this session -- primarily because I do not really know what machinery this Society has available for training of investigators. I do, however, have a few thoughts related to the attitude of air safety investigators which might well be inculcated through the Society.

Let me first say that the airlines have no interest whatsoever in accident investigation as an end in itself. This statement may startle you but it is literally true. Our interest is in accident prevention. Although accident investigation is an essential part of accident prevention, I feel that it sometimes falls short of doing the job it should because the ultimate aim of prevention is not always kept clearly in sight.

In matters related to accident prevention, the airlines can never rest on their laurels. We concern ourselves with rates of accidents per million flying hours or per hundred thousand flights. Our problem is that as traffic grows so does the total number of flying hours and flights per year. If our unit rate of accidents do not improve more than proportionately, then the absolute number of accidents every year must steadily increase to unacceptable levels.

In 1968, Mr. M.W. Eastburn, Director of Safety for American Airlines, made a prediction based on the assumption that the then prevailing accident unit rates did not improve. On this prediction, the airlines could expect to be having a fatal jet accident every week in the year 1977. By the end of the century this could become more than one fatal jet accident every day. Clearly this must not be.

Actually we have done better than this. Mr. Eastburn predicted on this basis that from end-1968 to end-1972, there would be 74 fatal jet accidents; in fact we had 52 (70%). So our unit rates have improved. But we cannot stop, we must improve still further.

The principal point I want to make today is that accident investigators must now go more deeply into the causes of accidents. There is, I fear, a tendency which derives from centuries of legal tradition, to look primarily at the question of "fault" in determining the cause of accidents. To the lawyer, once the bank robbers are identified, arrested, prosecuted and convicted, the case is closed. In aircraft accidents this approach does not go far enough. It is not enough for the investigation to find that the cause of the accident was the pilot actuating a control at the wrong time, or the mechanic or Air Traffic Controller making a specific mistake in their work. This establishes "fault" and opens delightful vistas of liability litigation, but it does not answer the question of "why". Why did the pilot actuate the control at the wrong moment? Why did the mechanic put the bolt in upside down? Why did the Air Traffic Controller fail to watch the radar screen? Until we answer these questions, we have not established the basic cause of the accident and we have not taken the critical step towards preventing a recurrence.

As we have become more expert at preventing disastrous mechanical failures in aircraft so the residual number of accidents involving some degree of "human factors" has become increasingly important. I believe that the "human factors" part of accident investigation is at present only in its infancy and we are unlikely to continue to make significant progress in reducing our rate of accidents until we become a great deal more sophisticated in analyzing this aspect of the problem. We must concern ourselves with man/machine interfaces, workload, normal and abnormal behavioural patterns, management, discipline, procedures, and so on. That this is difficult I do not deny. But it must be done if we are to continue to make progress in the real task of accident prevention.

SEMINAR SUMMATION

DONALD E. KEMP

Ladies and Gentlemen. Before I proceed with the Seminar Summation, I would like to offer a gift on behalf of the Society in appreciation to the two ladies responsible for organizing and conducting the ladies' program. Would my wife, Lynn McArthur and Pat Winship please come to the podium. I will let my wife make the presentation since she created these beautiful floral centerpieces. We all thank you Lynn and Pat, but since I am the President of this Society, I have the privilege of kissing the lovely ladies in showing my appreciation. Thanks again.

I would like also to say to all the members and wives of the Canadian Chapter that the success of this seminar is a result of your entiring effort and the hospitality of all the people in Toronto will be hard to match.

The only good thing about being asked to do the Seminar Summation is that I can stand up here and make all the statement that I like without any fear of a rebuttal on your part. In doing the summation, I will not make any attempt to discuss items based on order of importance.

The first item I would like to discuss is the PRESS. During this seminar we had a press article which one of our speakers charged that he was misquoted - to which the reporter counters this charge. I do not want to discuss this case, but let me explain that everyone has a job to do during an aircraft accident investigation - you to determine the facts of the accident - and the press to report the facts to the public. I urge full cooperation with the press, but I think you must realize that normally a reporter assigned to cover an aircraft accident does not have an aviation background and it is your responsibility to explain to him or her in detail if you expect to get an accurate accounting in the newspaper. Let me relate an actual occurrence to illustrate my point. In recent takeoff collision accident of a DC-9 and a CV-880 at Chicago, Illinois, a young reporter named Mrs. Jones (her true name) asked me "Was the ASDE (Aircraft Surface Detection Equipment) radar working? - Oh, you probably won't tell me either like

Board (National Transportation Safety Board) man". I told her that to my knowledge it was working, but I like the Board man could not state that factually since neither of us had examined the records. I then asked if she had the tower chief's phone number - to which she said "yes" - so I said why don't you call him and ask him if you could look at the records. She was quite surprised and said, "Do you think he'll let me in?" I told her that I knew of no reason why he wouldn't. Well the next morning she brought me a copy of her newspaper and her article was the first that gave a factual report the ASDE was operating.

I agree with your various descriptive adjectives that the desired qualities a good aircraft accident investigator should have are: open-minded, skeptical, curious, persistent, etc. These are essential to a complete accident report. We believe that a good investigation can help to prevent future accidents.

On subject of prevention - I hope that someone will be able to teach us how we can modify human behaviour. Over the years, there has been many approach and landing accidents. Now that we have the cockpit voice recorder, we know that correct procedures and discipline were not followed. No one can explain why this happens - but somehow we must learn how to modify human behaviour if we are going to be able to eliminate this type of accident.

I believe this was one of the most important seminars that we have ever held. It is the first time that the available programs for aircraft accident investigation training were discussed in a single meeting. The importance of this is that it permitted effective comparisons and created an atmosphere of better understanding.

At this time, I would like to turn the podium over to our host chapter president, Dr. McArthur.

Thank you.

MAJOR BILL MCARTHUR, M.D.
DCIEM, TORONTO, ONTARIO

During the Seminar we have heard many excellent presentations regarding accident investigation. Now, we have come to the critical point in the meeting where we must ask vital questions regarding the Society's role in Air Safety Investigation Training. Having done this, we must then attempt to develop effective and practical long term goals. I would like to give you my personal views on this subject and I have three major points to make.

First of all the Society is a professional organization. We are a group of individuals who collectively have an amazing array of experience, knowledge and skills. When I was writing this, I looked up Webster's definition of professional and found that "a professional is an individual who participates for gain or livelihood in an activity or field of endeavor often engaged in by amateurs". SASI is a Society of professionals and we must conduct ourselves accordingly.

My second major point is that many of us, myself included, frequently fail to identify the real problem and as Dick Shaw has said, the real problem in air accidents is human failure. Those who are familiar with problem solving techniques are aware that frequently in life individuals and organizations leap to conclusions and initiate corrective action before the problems have been identified, and the pertinent factors and potential courses have been examined. In the worst situation, this is referred to as crisis management, but more commonly it goes unrecognized and falls under the heading of bad management.

At the risk of being accused of being a purist, I wish to suggest to you in all sincerity that every aircraft accident is caused by human failure. Human failure covers a broad spectrum. At one extreme we have the accident caused by a well-documented gross error of judgment in the cockpit. No rational human would ever deny that this type of accident is caused by human failure. At the other end of the spectrum, I am often reminded of a very close friend of mine who was killed when the wing fell off his aircraft approximately 100 feet above the ground. The primary cause factor assigned to this accident was structural failure. I cannot argue with the fact that the main spar fractured but I object strongly to the primary cause factor assigned. The operation of aircraft can be reasonably divided into three phases - namely design, maintenance and operations. The critical limiting factors in all these phases are human and the failure of that main spar was, I believe, due to inadequate performance by the human designers of the aircraft.

I have never written a letter to an aircraft, although I must admit to having spoken harshly to a few in times of particular stress. This did not seem to modify the performance of the aircraft to any measurable degree. Whenever I have had difficulty with the operation or maintenance of an aircraft, I have always found it was necessary to modify human behavior to rectify the situation. As a pilot I have become accustomed to modifying my own behavior and the behavior of those around me in order to change operating and maintenance procedures. As an air safety investigator I have similarly recommended that operating and maintenance procedures be changed and also on occasion have found it necessary to recommend design modifications.

In short, my experience indicates that the only way to prevent incidents and accidents is to modify human behavior and thereby minimize human failure. We as investigators and as a Society must be much more cognizant of this fact.

My third major point is that the time has come for the Society to shoulder a larger and more effective role in the aviation industry. Last night there was a headline in the Toronto Star which suggested that most aircraft accident investigators were amateurs. I disagree. You will remember that Webster defined a professional as one "participating for gain or livelihood in an activity or field of endeavor often engaged in by amateurs". It is easy to suggest that we are amateurs and thereby infer that we are not responsible for our conduct. Unfortunately that also implies that this is a social organization and not a professional society. In this room we have members from 20 countries who make their living directly or indirectly in aircraft accident prevention. By definition we are professionals and like it or not we are the experts no matter how shaky or insecure our individual knowledge may be at any one time. If everyone in this room died at this instant, the aviation industry would suffer a catastrophic setback.

We must accept our responsibility remembering of course that as a Society, we are educators and advisors but not enforcers. It is my opinion that the time has come right here and now at this seminar to accept the fact that the Society must become organized so that it can give well-founded authoritative practical advice to the industry. We must be prepared to respond to requests from government, the airlines, the manufacturers, the military and general aviation, and we must be able to do this as a professional Society, avoiding at all times parochial or partisan stances. This is a challenge but it is possible and we are the only ones who can do it.

Gentlemen, I suggest to you that the time has come as a society to appoint a professional advice committee charged with the responsibility of examining the ways and means in which SASI can and should prepare itself to assume its proper professional place in the most exciting and challenging industrial environment in which we live.