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FLIGHT DATA MONITORING
STATUS REPORT, MARCH 1999

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FLIGHT DATA MONITORING STATUS REPORT, MARCH 1999

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Flight Data Monitoring Status Report, March 1999

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16. Abstract

This report details the objectives and activities of the Flight Data Monitoring (FDM) project. FDM refers to the task of acquiring, transcribing, processing and routinely analysing flight data, from initial engine startup to landing and final taxi. FDM also includes the means for presenting results of the analysis and drawing cause-effect relationships from flight data.

A generic FDM system consists of the following components: airborne data collection, data transfer, ground data processing and analysis, flight animation, statistical trend analysis and reporting.

The costs of implementing an FDM program are largely driven by the required data recording equipment on the aircraft and the ground station used to store, analyse and present the data. These costs vary depending on fleet sizes and existing aircraft configurations.

The benefits of an FDM program are wide-ranging, with potential improvements in training, flight safety, efficiency of operations, reduced insurance costs and system reliability.

The potential safety improvements, including reduced accidents, dictate that all carriers implement FDM programs.

The web site, *http://fdm.sofkin.ca*, developed during the project, is a source of information on FDM.

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16. Résumé

Ce rapport explique en détail les buts et les activités du projet de suivi des données de vol (SDV). Le SDV est la tâche de recueillir, de transcrire, de traiter et d'analyser les données de vol, à partir de l'allumage des moteurs jusqu'à l'atterrissage et l'immobilisation de l'aéronef. Le SDV se rapporte aussi aux moyens mis en oeuvre pour présenter les résultats des analyses et pour établir des liens de cause à effet à partir des données de vol.

Un système de SDV comprend les étapes suivantes : recueil des données en vol, transfert des données, traitement et analyse des données au sol, animation du vol, analyse statistique des tendances et établissement de rapports.

Les coûts de la mise en oeuvre d'un programme de SDV sont surtout dictés par l'équipement embarqué d'enregistrement des données et par la station au sol qui procède au stockage, à l'analyse et à la présentation des données. Les coûts varient selon la taille de la flotte et la configuration des aéronefs.

L'étendue du programme de SDV comporte une vaste gamme d'avantages et laisse place à l'amélioration sur les plans de la formation, de la sécurité des vols, de l'efficacité des opérations, des frais d'assurance et de la fiabilité du système.

Les améliorations potentielles de la sécurité, y compris la réduction du nombre d'accidents, commandent que tous les transporteurs mettent en oeuvre un programme de SDV.

Le site Web (*http://fdm.sofkin.ca)* conçu au cours du projet est une source d'information sur le SDV.

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Air Canada
Transport Canada
- Transportation Development Centre
- Aircraft Services
- Civil Aviation
- Safety and Security
- Air Carrier Standards and Operations

Environment Canada Atmospheric Environment Service
Association Québecois des Transporteurs Aérien
Air Transport Association of Canada
NAV CANADA
Air Canada Pilots Association

EXECUTIVE SUMMARY

The principal objective of the Flight Data Monitoring (FDM) project is to increase flight safety and provide a basis for improvements to many aspects of flight crew performance, carrier operations and the national air transportation system. FDM refers to the task of acquiring, transcribing, processing and routinely analysing flight data, from initial engine startup to landing and final taxi. FDM also includes the means for presenting results of the analysis and drawing cause-effect relationships from flight data. For most operators, the cost savings of an FDM program can justify the startup and life-cycle costs.

A generic concept for an FDM system consists of airborne data collection, data transfer, ground data processing and analysis, flight animation, statistical trend analysis and reporting components. Software Kinetics' Flight Animator was developed to demonstrate the flight animation component in a prototype FDM system.

A suggested approach for carriers starting FDM programs consists of the following:

- Management
- Fleet selection
- Technical feasibility study
- Equipment installation and configuration
- Trial program
- System refinement and configuration
- Ongoing FDM activities in closed-loop system
- System enhancements and additions

It is recommended that carriers cooperate with Transport Canada using FDM data for specific studies, as well as for reporting on the system's effectiveness and safety benefits. These studies and reports would use analysed aggregate data. In this way, airlines would not be providing raw data, thus alleviating their concerns regarding data security.

Air Canada, Canada 3000, First Air and Transport Canada Aircraft Services Directorate participated in the FDM project.

SOMMAIRE

L'objectif principal du projet de suivi des données de vol (SDV) est d'accroître la sécurité des vols et de fournir un outil susceptible d'améliorer divers aspects de la performance de l'équipage de conduite, des opérations des transporteurs aériens, et du réseau national d'aviation civile. Le SDV est la tâche de recueillir, de transcrire, de traiter et d'analyser les données de vols, à partir de l'allumage des moteurs jusqu'à l'atterrissage et l'immobilisation de l'aéronef. Le SDV se rapporte aussi aux moyens mis en oeuvre pour présenter les résultats des analyses et pour établir des liens de cause à effet à partir des données de vol. Pour la plupart des exploitants, les économies réalisées grâce à la mise en oeuvre d'un programme de SDV justifient les coûts de mise en service et du cycle de vie du matériel.

Un système de SDV comprend les étapes suivantes : recueil des données en vol, transfert des données, traitement et analyse des données au sol, animation du vol, analyse statistique des tendances et établissement de rapports. Le logiciel d'animation de vol de Software Kinetics a été conçu pour faire la démonstration d'un outil d'animation de vol dans un prototype de système de SDV.

L'approche recommandée pour les transporteurs amorçant un programme de SDV est la suivante :

- Gestion;
- Choix des aéronefs;
- Étude de faisabilité technique;
- Installation et configuration de l'équipement;
- Programme d'essais;
- Mise au point et configuration du système;
- Activités continues de SDV en circuit fermé;
- Améliorations et ajouts au système.

Il est recommandé que les transporteurs travaillent en collaboration avec Transports Canada en utilisant les données de SDV pour des études spécifiques ainsi que pour l'établissement de rapports sur l'efficacité du système et sur les avantages pour la sécurité. Ces études et rapports reposeraient sur des données globales analysées. Ainsi, les compagnies aériennes ne fourniraient pas des données brutes, ce qui réduirait leurs inquiétudes quant à la sécurité des données.

Air Canada, Canada 3000, First Air et la direction générale des Services des aéronefs de Transports Canada ont pris part au projet de SDV.

CONTENTS

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GLOSSARY

ACPA	Air Canada Pilots Association
AIDS	Aircraft Integrated Data Systems
AIMS	Aircraft Integrated Monitoring Systems
AQTA	Association Québécois des Transporteurs Aérien
ATAC	Air Transport Association of Canada
ATC	Air Traffic Control
BASIS	British Airways Safety Information System
CD-ROM	Compact Disk-Read-Only Memory
DFDMU	Digital Flight Data Management Unit
DFDR	Digital Flight Data Recorder
EC/AES	Environment Canada Atmospheric Environment Service
ECAM	Electronic Centralized Aircraft Monitor
ECM	Engine Condition Monitoring
EFIS	Electronic Flight Instrument System
FDAU	Flight Data Acquisition Unit
FDM	Flight Data Monitoring
FDR	Flight Data Recorder
FRCS	Flight Recorder Configuration Standard
GAIN	Global Analysis and Information Network
GDRAS	Ground Data Replay and Analysis Station
GPS	Global Positioning System
HSI	Horizontal Situation Indicator
ISASI	International Society of Air Safety Investigators
N_1	Rotation speed of Engine Low Speed Compressor
PCMCIA	Personal Computer Memory Card International Association
PERD	Program for Energy Research and Development
PFD	Primary Flight Display
QAR	Quick-Access Recorder
SDRAM	Synchronous Dynamic Random Access Memory
SOP	Standard Operating Procedure
SSFDR	Solid-State Flight Data Recorder
TCASD	Transport Canada Aircraft Services Directorate
TDC	Transportation Development Centre
URL	Uniform Resource Locator
VCR	Video Cassette Recorder
VHS	Video Home System
WAAS	Wide Area Augmentation System

1. INTRODUCTION

Transport Canada's Safety and Security Group (Transportation Development Centre (TDC) has been conducting a Flight Data Monitoring (FDM) research and development project with Canadian carriers and Software Kinetics Ltd. since 1995. Natural Resources Canada's Program for Energy Research and Development (PERD) also provided support for this contract. This report describes the objectives, activities, results, conclusions and recommendations of the Flight Data Monitoring project.

The objectives of the Project were to:

- determine the best means of obtaining and analysing in-flight data;
- develop a concept for an FDM system based on a review of international safety procedures, systems and programs;
- design and develop a cost-effective prototype FDM system;
- develop voluntary FDM programs, in cooperation with Canadian commercial air carriers; and
- initiate and promote FDM programs in the Canadian aviation community.

1.1 Flight Data Monitoring

FDM refers to the task of acquiring, transcribing, processing and routinely analysing flight data, from initial engine startup to completion of taxi. FDM also includes the means for presenting results of the analysis and drawing cause-effect relationships from flight data.

The overall purpose of FDM is to use the information derived from ongoing FDM programs to increase flight safety and provide a basis for improvements to many aspects of flight crew performance, carrier operations and the National Air Transportation System.

There are many potential applications and end-users of FDM systems. Some examples of possible users of FDM systems include:

- Airline flight safety;
- Equipment manufacturers;
- Pilot/airline organizations;
- Flight training schools;
- Accident investigation boards;
- Regulators; and
- Aircraft/airport designers.

Some examples of application areas that may benefit from a FDM program are:

- Improved efficiency and significant cost savings in:
  - Maintenance operations,
  - Aircraft performance,
  - Fuel consumption,
  - Flight profile planning,
  - Operational procedures, and
  - Training programs;
- Crew self-assessment;
- Improvements to aircraft/airport designs;
- Safety through incident/accident prevention; and
- Identification of human factors problems.

1.2 History of FDM

A form of FDM has been used ever since the first instruments were installed in early aircraft. Through the years, FDM has evolved to encompass an increasing number of parameters.

The initial purpose of Flight Data Recorders (FDRs), up until the 1960s, was to use the data in accident/incident investigations and in-flight aircraft structures performance assessment. In the 1970s the installation of FDRs became mandatory on most commercial aircraft. The introduction of digital FDRs (DFDRs) prompted airlines to augment their aircraft monitoring operations.

Digital recording systems were used in Aircraft Integrated Data Systems (AIDS) to monitor aircraft systems for the purpose of improving maintenance procedures. Eventually AIDS were replaced with Aircraft Integrated Monitoring Systems (AIMS), a more complex system that combined flight performance evaluation and maintenance assessments. In 1991, British Airways Safety Information System (BASIS) was created to analyse air safety reports more efficiently.

In recent years, Flight Operational Quality Assurance (FOQA) and Flight Data Monitoring programs have emerged worldwide. These programs are deemed necessary at a time when projected increases in air traffic demand continuous improvements in aviation safety.

The successful implementation of these programs relies on data protection issues being resolved. It has been recognized (particularly in North America) that the participants in FDM/FOQA Programs must be free from concerns about inappropriate use of the data/information that might work to the detriment of the pilot, the pilot association or the airline involved. The concerns that have been identified are: use by the carrier to discipline a pilot, misuse through public access, use in courts against the carrier and/or pilots, and use by the regulator for enforcement purposes.

1.3 Document Overview

This report outlines the goals of FDM and provides an overview of the project activities. The contents of this report are organized in the following sections:

Section 1	Introduction – Describes the purpose of the report and provides an overview of the FDM project.
Section 2	System Concept and Definition – A synopsis of the operational concept, system design and development.
Section 3	Guidelines for Starting an FDM Program– A suggested approach for carriers starting FDM programs and an overview of the cost and benefits.
Section 4	FDM Project Activities – A summary of the activities undertaken with an FDM program the participating airlines, data security issues, Software Kinetics' 'Flight Animator' product, Flight Recorder Configuration Standard and web sites. A summary of the FDM promotional activities undertaken throughout the project.
Section 5	Conclusions – Conclusions based on the evaluation of the project results are presented.
Section 6	Recommendations – Recommendations for future developments related to the FDM project are presented.

2. FDM SYSTEM CONCEPT AND DEFINITION

The concept for a generic FDM system, which was developed following a review of existing international initiatives and technologies, is presented in the following sections.

Figure 1 illustrates the data flow for a generic FDM system. Recorded flight data from multiple aircraft types may be downloaded and then processed with a Ground Data Replay and Analysis Station (GDRAS). The output of the GDRAS may then be fed to an animation system and animations of flight segments of interest created. Subsequently, a statistical analysis of the frequency of specific occurrences and parameter distributions may be conducted to predict the occurrence of exceedances through routine FDM.

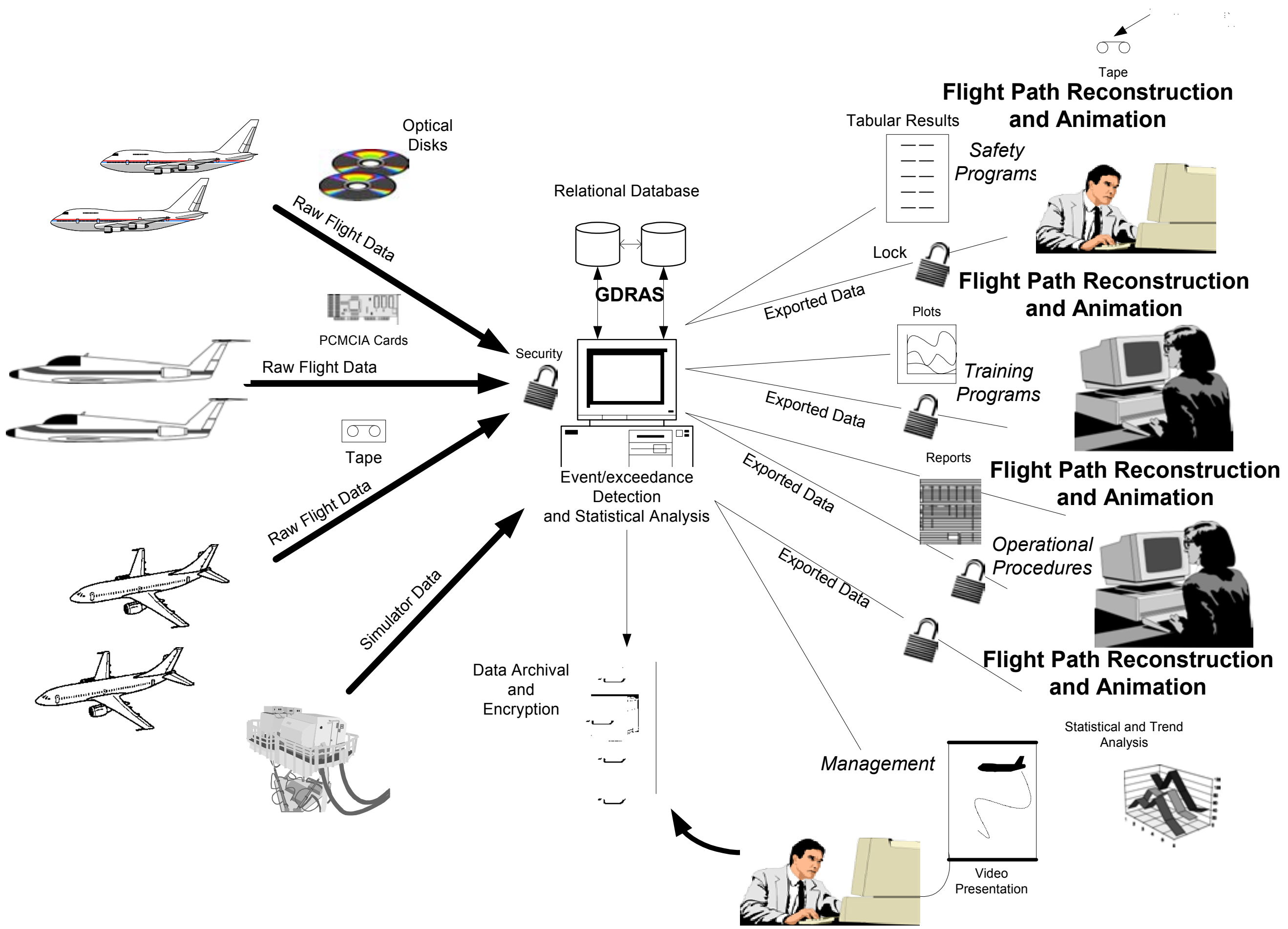

Figure 1 FDM Data Flow

The components of a generic FDM system are airborne data collection, data transfer, ground data processing and analysis, flight animation, statistical trend analysis and reporting. They are described below.

2.1 Airborne Data Collection

Some examples of types of data recording devices for acquiring flight data include Quick-Access Recorders (QARs), FDRs and Digital Flight Data Management Units (DFDMUs).

2.2 Data Transfer

Raw and processed flight data may be transferred from the aircraft to the ground-based facility via wireless data transfer, optical disk, solid-state memory or tape.

2.3 Ground Data Processing and Analysis

Analysis at the ground-based data processing station consists of data transcription, event and exceedance detection, flagging flight data segments suitable for in-depth analysis and flight animation, database update and report generation. Event/exceedance definitions may be implemented for several detection criteria ranging from information to safety critical levels. Event detection conditions may depend on several factors including:

- Recorded parameter states/values;
- Derived parameter states/values;
- Flight modes;
- Fleet-specific constraints; and
- Airline-specific requirements.

Some examples of events/exeedances for different flight modes are:

- Pitch attitude high on takeoff;
- Late flap extension;
- High vertical acceleration on ground;
- Climb speed high;
- Maximum operating altitude exceedance;
- Gear down late;
- Rotation speed of engine low speed compressor (N_1) overspeed;
- Excessive roll rate; and
- Unstabilized approaches.

At this stage the raw data may be encrypted and stored for future analysis.

2.4 Flight Animation

The animation capability provides a realistic, quantitative, 3-D reconstruction of selected flight segments. The aircraft animation is typically replayed with data-driven, synchronized custom cockpit instrumentation. The graphical display of data-driven instrumentation is a means of relaying the recorded flight data in a manner similar to what the pilot may have observed in the cockpit.

2.4.1 Cockpit Instrumentation

The choice of instruments that may be displayed in an animation is dependent on the set of parameters recorded. Some examples of generic instruments and glass cockpit instrumentation include:

- Indicator lamps (for example: air/ground, gear position);
- Horizontal situation indicator (HSI);
- Airspeed indicator;
- Altimeter;
- Flap/slat position indicator;
- Rudder position indicator;
- Electronic Flight Instrument System (EFIS) Primary Flight Display (PFD); and
- Electronic Centralized Aircraft Monitor (ECAM).

The user can customize instrument characteristics and their layout in an instrument panel, as well as create new instruments. The animated cockpit instrumentation does not constitute a simulation of the processing done by the instrument. Figure 2 is a snapshot of an aircraft animation with instrument panel.

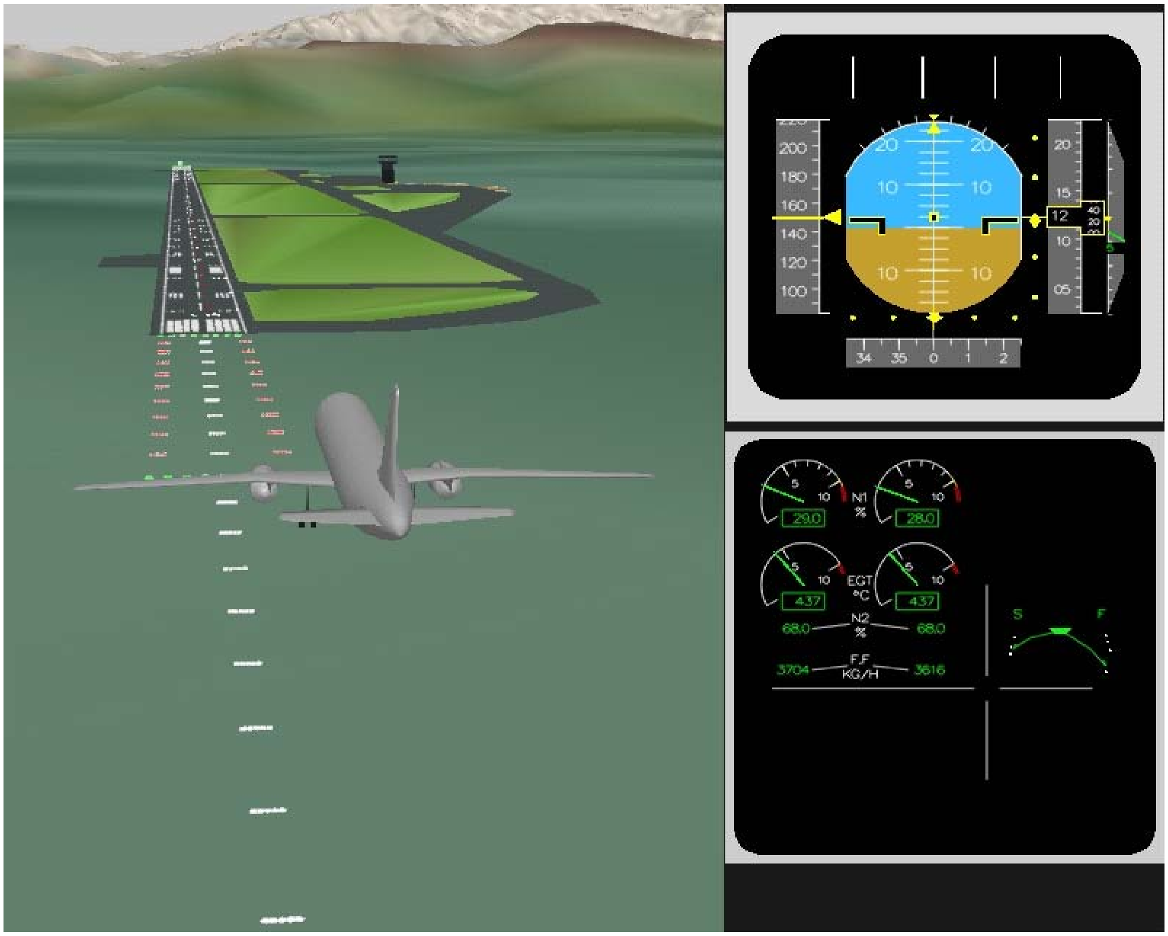

Figure 2 Aircraft Animation with Instrument Panel [1]

2.4.2 Scenario Data

To further augment understanding of a particular event, environmental factors such as visibility, cloud layers and daylight illumination may be depicted. Terrain elevation data, runways, towers, modeled navigational aids, ground vehicles and buildings are other examples of cultural features that may be rendered. External references such as digital map data, weather reports and detailed approach plates are required to ensure that the information is represented correctly.

2.4.3 Animation Features

Some key system characteristics include camera view control (chase, chase ground, cockpit and fixed ground), time control (playback speed and direction), time-based subtitling, scripted playback and camera position control (radial, horizontal and vertical distances).

These assist the analyst with the interpretation of a flight segment. Unlike videotape, which was more commonly used in the past, direct access to desktop animation systems allows the end-user to interact with the system.

2.4.4 Flight Path Reconstruction

Flight path reconstruction consists of using recorded flight data to derive the aircraft's instantaneous position and orientation relative to an orthogonal, right-handed Cartesian frame of reference that is fixed to the earth.

Several algorithms are used for calculating an aircraft's flight path, which require different sets of parameters. The total set of parameters includes airspeed, pressure altitude, radio altitude, ground speed, drift angle, roll attitude, pitch attitude, heading (true or magnetic), glideslope deviation, localizer deviation, magnetic variation, wind speed, wind direction, temperature and station pressure [2].

The process of choosing an algorithm for reconstructing an aircraft's flight path must take into consideration the accuracy, sampling rate and resolution of the recorded parameter data, as well as the input data source. Figure 3 is an example that depicts the aircraft's flight path.

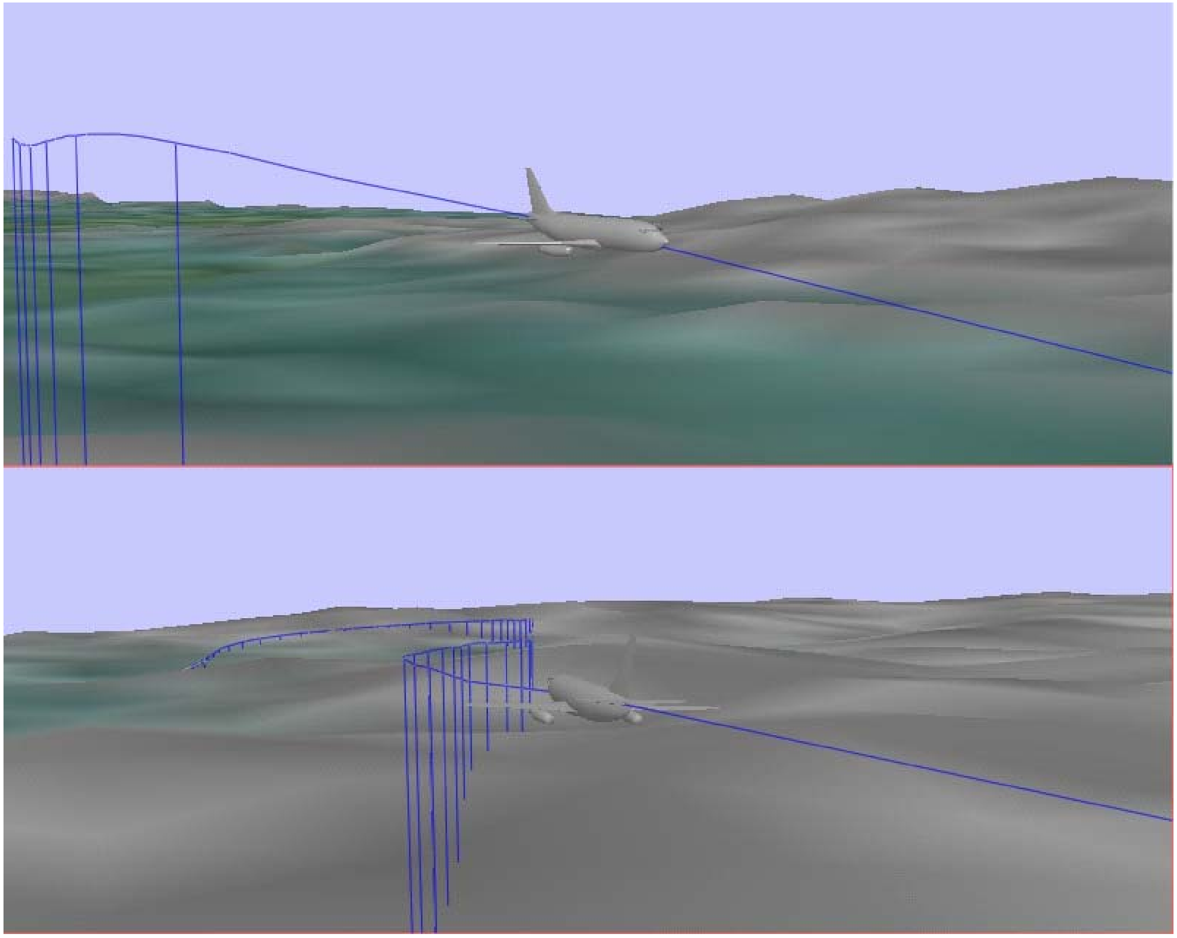

Figure 3 Flight Path and View Perspectives [1]

2.5 Statistical Trend Analysis

Statistical analysis of the frequency of specific occurrences and a comparison of flight parameter values with pre-established baselines may help predict the occurrence of events and exceedances and identify causal patterns. Trend analysis involves monitoring special events, as well as seemingly routine normal events.

2.6 Reporting

Tabular, graphical and text reports are used to convey the results of the analyses.

3. GUIDELINES FOR STARTING AN FDM PROGRAM

This section suggests a general approach for starting an FDM program at an airline and outlines the cost factors and types of benefits achievable.

3.1 Suggested Approach

A suggested approach for carriers starting FDM programs is as follows:

1. Management

An FDM program must be based on trust at the personal and organizational level. It is therefore important that all interested parties be included in the planning and implementation of the program. The program should include a formal agreement with the pilots and detailed procedures describing how the program will be operated and how the data will be used for its intended purpose and protected from misuse.

2. Fleet Selection

Taking into consideration such factors as existing recording capabilities, fleet sizes, flight profiles and anticipated benefits, the aircraft to be included in the FDM program should be selected.

3. Technical Feasibility Study

A technical feasibility study should be conducted to select the onboard recording equipment, data transfer mechanism, flight data analysis and animation systems and data security components. The percentage of the fleet to be monitored, degree of coverage for the data analysis tasks and frequency of the analysis should be determined.

4. Equipment Installation and Configuration

The selected onboard recording equipment should be installed on the aircraft and analysis systems configured for the airline’s specific requirements.

5. Trial Program

During the trial program, data download, transfer and analysis processes should be tested and automated for the planned future analysis requirements.

6. System Refinement and Configuration

Once the system is operational, a reasonable set of data should be collected to refine and validate the event/exceedance definitions. Further customization of the flight animation system should be undertaken.

7. Ongoing FDM Activities in Closed-Loop System

The interpretation and dissemination of information derived from the FDM program should be tested in order to obtain the full benefits from the program.

8. System Enhancements and Additions

Future system enhancements and additions may include such things as: adding other fleets to the program, adding a statistical and trend analysis component and increasing the quantity of data collected.

3.2 Cost Factors

The cost factors associated with starting and maintaining an FDM program can be divided into recurring and non-recurring costs. The fleet size, configuration and routing affect the choice and quantity of equipment required, thereby affecting the system costs. Non-recurring cost factors associated with implementing an FDM program include:

- Data acquisition equipment
  - On-board data recorders (QAR, Solid-State FDR (SSFDR...),
  - Flight Data Acquisition Units (FDAU), and
  - Additional sensors;

- Data retrieval and transfer equipment
  - Data download units, and
  - Wireless data transfer technology;

- Flight data analysis and animation
  - GDRAS (software and hardware), and
  - Animation system (software and hardware).

Typical Hardware Requirements are:

- Windows NT 4.0 workstation;
- 450 Megahertz Pentium processor with 512 Kilobytes cache;
- 256 Megabyte Synchronous Dynamic Random Access Memory (SDRAM);
- 9.1 Gigabyte hard disk drive;

- Graphics accelerator card (for animation);
- 17" Super Video Graphics Adapter (SVGA) Monitor;
- 1.44 Megabyte floppy drive;
- 32x Compact Disk-Read-Only Memory (CD-ROM);
- Keyboard;
- 2-button mouse; and
- Optional support equipment.
  - Video cassette recorder (VCR);
  - Network card;
  - Card reader; and
  - Printer.

- Optional additional components
  - Data security and encryption software; and
  - Video capture and editing software.

The recurring cost factors associated with operating a FDM Program comprise:

- Performing routine data downloads;
- Performing routine flight data analysis and animation; and
- Support materials;
  - Video Home System (VHS) tapes; and
  - Data storage media (Personal Computer Memory Card International Association (PCMCIA) memory cards, optical disks)

3.3 Benefits

In addition to safety benefits, FDM programs have been found to yield substantial cost benefits in many areas including maintenance, fuel efficiency/usage and engines. The benefits have been found to be more than sufficient to justify the implementation and operational costs associated with an FDM program.

3.3.1 Benefits to Carriers

Carriers that have started FDM programs are continuing and expanding their efforts. They have recognized that FDM programs provide benefits in several areas of their operation, particularly safety and maintenance. For example:

- Engine Condition Monitoring (ECM)

  Through monitoring of engine parameters, engine on-wing life may be extended and maintenance intervals may be increased [3].

- Fuel Management

  Detection of out of trim conditions may yield fuel savings. Monitoring of fuel flows and capacities may improve fuel efficiency and usage [4].

- Component Warranties

  Information gathered through FDM may be used in warranty administration programs [4].

- Brake Savings

  The replacement cycle on brakes may be extended through monitoring of brake usage [4].

- Inspection Savings

  The number of hard landing inspections may be reduced through analysis of recorded flight data [4].

- Safety Savings

  The risk of a tailstrike may be reduced through improved training and/or procedural changes identified through FDM. Routine monitoring of accident cause factors may help identify potential problems and help reduce or prevent accidents. Routine monitoring of flight data may also provide a means of verifying the condition of equipment [4].

- Insurance Savings

  There are potential insurance rate reductions with evidence of an FDM program.

- Training Programs

  Flight data may be used to supplement and optimize training sessions.

- Increased Aircraft Availability

  Losses incurred from unscheduled maintenance resulting in aircraft being unavailable may be reduced or averted [5].

- Improved Procedures

  Problems with Standard Operating Procedures (SOPs) and Air Traffic Control (ATC) procedures for specific airports may be identified and resolved.

3.3.2 Benefits to Transport Canada

The FDM project has the potential to benefit several directorates within Transport Canada including Safety Programs, Strategies and Co-ordination, Civil Aviation and Aircraft Services. These benefits include:

- promoting proactive safety programs that are administered by the airlines;
- improving feedback from airlines to Transport Canada;
- receiving reports from participating carriers on the safety improvements derived from their FDM programs;
- receiving recommendations from participating carriers for improvements to all elements of the National Air Transportation System;
- receiving information from participating carriers to support specific Transport Canada studies; and
- participating in an international effort to promote aviation safety.

4. FDM PROJECT ACTIVITIES

The activities undertaken during the FDM project are described in this section.

4.1 Activities with the Airlines

First Air, Canada 3000, Air Canada and Transport Canada Aircraft Services Directorate participated in the FDM project. Their involvement is summarized below:

- First Air

  First Air selected their fleet of Hawker-Siddeley 748 and one Boeing 727 aircraft for trial use in an FDM program. During the trial program, the primary objective was to process flight data from these aircraft types. Data collection logistics and parameter availability were investigated. As part of investigating the uses for FDM data in such areas as training, a method for exporting data from the GDRAS to the Software Kinetics Flight Animator was developed.

- Canada 3000

  A trial prototype FDM system was configured to process data from one of Canada 3000's Boeing 757 aircraft. Runway braking events were defined for providing a reference of nominal braking performance during routine landings with contaminated runway conditions for Boeing 757 aircraft at Pearson International Airport. The runway braking event has not yet been tested in a routine data collection and analysis program. A 3-D aircraft animation with synchronized cockpit instrumentation, of an event of interest to Canada 3000, was produced.

- Air Canada

  An Operational Concept Document (OCD) was formulated that describes the issues with starting and maintaining an FDM program including data acquisition, transcription, processing, analysis, presentation and dissemination. A cost benefit analysis (CBA) was produced that considers the initial implementation and recurring costs of an FDM program and identifies the types of benefits achievable. Air Canada provided valuable information based on their practical experience in the aviation industry to assist in the development of the OCD and CBA. The concept and cost analysis were refined to specifically address Air Canada's requirements and aircraft fleet configuration. Data from Air Canada's Airbus A319/A320 aircraft and CL-65 Regional Jets was processed.

- Transport Canada Aircraft Services Directorate (TCASD)

  A technical feasibility study addressing the costs associated with an FDM program for TCASD's fleet of Cessna Citations, targeted to their operation, the types of benefits achievable through routine monitoring and a proposed strategy for implementing and maintaining an FDM program was conducted. The feasibility study assessed the existing recording and data acquisition equipment and investigated the options for upgrading the equipment, as well as data download, transfer and analysis issues.

4.2 Data Security

Discussions were held to address the data security concerns of airlines and pilots participating in the FDM program. On December 11, 1997, a meeting was held in Ottawa, Ontario, with participants from Transport Canada, Air Canada, Canada 3000, Airline Pilots Association, NAV CANADA, Transportation Safety Board and Software Kinetics Ltd. to discuss the contents of the draft Transport Canada Civil Aviation policy. Data security issues relating to access to information, regulatory enforcement action, civil litigation and data use by the airline operator to judge a pilot's performance were the focus of the agreement.

4.3 Software Kinetics Ltd. 'Flight Animator'

Software Kinetics Ltd. developed a three-dimensional animation system, one of the components of an FDM system. The 'Flight Animator' runs on low-cost personal computers equipped with graphics-accelerator cards, thereby making it more affordable to multiple individuals at airlines than the high-end computer workstations used in the past. The animation is a means of presenting the recorded flight information and drawing cause-effect relationships in a meaningful manner, consisting of an aircraft's flight profile, cockpit instrumentation, terrain and scenario data.

Some of the key features of the 'Flight Animator' include:

- Time-based subtitling for overlaying text from ATC or Cockpit Voice Recording Transcripts;
- Generic and custom cockpit instrument panels;
- Data interpolation and smoothing;
- Configurable representation of environmental factors such as visibility, cloud layers and daylight illumination;
- Scenery elements such as cultural features and airport layouts;
- Real-time playback of events; and
- User-interactive control of the camera view (chase, cockpit, chase ground, fixed ground), camera position and time steps.

Some support tools provided with the 'Flight Animator' include:

- Flight Path Reconstructor

  A utility that computes the aircraft's instantaneous position and orientation using different flight path reconstruction techniques and recorded flight data as the inputs.

- Runway Editor

  A utility for generating runways that conform to regulatory standards.

- Explorer

  A utility for quickly and easily configuring the main components of an animation, namely the instrument panel, data-driven aircraft model and terrain features based on a set of pre-configured standard profiles.

4.4 Flight Recorder Configuration Standard

Currently, the processes for extracting and transcribing flight data are both time-consuming and prone to errors in accuracy. Thus, a standardized format and content for documenting the data recorded by Flight Data Recorder Systems was developed by Software Kinetics Ltd. Member organizations that contributed to the development of the standard include the Transportation Development Centre, the Transportation Safety Board of Canada, Transport Canada Civil Aviation, the U.S. National Transportation Safety Board, the National Research Council of Canada, the U.S. Federal Aviation Administration and Bombardier/Canadair.

The proposed international standard (Flight Recorder Configuration Standard (FRCS)) for documenting the format and arrangement of flight data is intended to facilitate the process of extracting and transcribing flight data. A FRCS Editor tool for creating and maintaining FRCS-compliant electronic files was also developed during the project. It is anticipated that adoption of the FRCS as an international standard would be beneficial to air safety investigators, airlines and manufacturers, whether it be for analysing flight data after an occurrence or for analysing flight data on a routine basis, as is required in Flight Data Monitoring Programs.

For more information on the FRCS, refer to the document Flight Recorder Configuration Standard Version 1.0 [6].

4.5 Web Sites

Web sites were designed and developed, containing information to be updated on a periodic basis on FDM, the FRCS and the Software Kinetics' 'Flight Animator'. The Uniform Resource Locator (URL) addresses for each of the previously mentioned sites are:

- http://frcs.sofkin.ca
- http://fdm.sofkin.ca
- http://flightanimator.sofkin.ca

4.6 Promotional Activities

In order to promote the widest possible use of FDM and to accelerate the implementation and acceptance of FDM by the aviation industry, the Software Kinetics Team and Transport Canada participated in several activities to promote FDM. Representatives of TDC and Software Kinetics attended and/or gave presentations on the FDM project on the following occasions:

- Teledyne User's Conference, fall of 1995;
- International Society of Air Safety Investigators (ISASI) Conference, April 1996;
- Teledyne User's Conference, fall of 1996;
- Canadian Aviation Safety Seminar (CASS) 97 , 1997;
- Canadian FDM Meeting at Transport Canada, January 1997;
- Canada 3000, February 1997;
- International Conference on FDM at Transport Canada, March 11-12, 1997;
- FOQA Symposium, fall of 1997;
- ISASI Flight Recorder Working Group/Transport Canada 2nd International FDM Meeting, June 1998;
- Canadian Forces Directorate of Flight Safety Education Seminar, September 22, 1998;
- Third Global Analysis and Information Network (GAIN) Conference, November 3-5, 1998.

The combined international audience at these presentations and demonstrations comprised experts from government and industry in the following areas:

- Air navigation;
- Aircraft services;
- Aviation and air safety;
- Aviation standards and procedures;
- Crew training;
- Flight data monitoring;
- Flight data recorders;
- Flight operations;

- Human factors;
- Meteorology;
- Pilot and line operations; and
- Regulations.

5. CONCLUSIONS

Flight Data Monitoring is continuing to gain international acceptance as one of the most cost-effective methods of improving aviation safety and operational efficiency. Numerous cost, operational and safety benefits can be derived from an FDM system that processes all the available raw flight data on a continuous basis. The motivating factors for implementing an FDM program are improvements in aviation safety and anticipated performance enhancements in a diversity of areas such as maintenance, flight planning, training and operational procedures. Nonetheless, resolution of the data security issues with the airlines remains an impediment to wide-ranged implementation of FDM programs and data sharing.

For most operators, the cost savings of an FDM program can justify the start-up and life-cycle costs. The benefits achievable from such programs encompass areas throughout the aviation industry. The potential safety improvements, including reduced accidents, dictate that all carriers implement FDM programs.

The increasing number of airlines participating and interested in FDM are evidence of the progress that has been made in the area of FDM in Canada. Furthermore, as more quantifiable evidence of the benefits achievable from FDM become available, it has become increasingly apparent that there may be negative repercussions from not conducting FDM. Thus, Transport Canada needs to continue to work with industry to promote FDM within Canada and continue improving aviation safety.

6. RECOMMENDATIONS

Some recommendations for the Flight Data Monitoring project are as follows:

- Airline Support

  Continuing support for airlines starting and maintaining FDM programs should be provided by Transport Canada. This could include providing assistance with technical feasibility studies and analysis, as well as custom system development and system integration activities.

- Focused Studies

  A focused study, such as the runway braking study should be conducted to demonstrate some of the immediate benefits from FDM to the Canadian aviation industry.

- Provision of FDM Services

  The provision of FDM services as an alternative means of lowering costs and/or increasing commercial benefits should be considered. Due to the high cost of many commercial FDM products, the systems are not always affordable for smaller carriers. Nonetheless, given the larger number of small carriers as compared to large carriers, and the potential for deriving the same benefits from FDM, there is a need to provide an affordable service geared towards the requirements of smaller carriers.

- Enhancements to Existing Tools

  The provision of additional tools to be used in conjunction with the Flight Animation System such as an instrument designer and scenery builder would be useful. The implementation of filtering techniques for combining the outputs from different flight path reconstruction algorithms to obtain a more accurate flight path would be beneficial.

- Desktop Simulation

  Training is one of the main feedback mechanisms that links detected events to corrective actions. In addition to producing animations of selected events, the incorporation of desktop simulation to depict the effect of alternate courses of action or occurrences should be investigated.

- Statistical Trend Analysis

  In conjunction with routine FDM, data and information should be recorded and stored for the purpose of identifying statistical trends and results over the long term. For instance, data collection relating to aircraft braking performance at a Canadian airport over several years and throughout different seasons could be used to build a useful database of landing performance at a specific airport and monitor brake usage.

- Resolution of Data Use and Protection Issues

  Litigation issues and means for preventing the misuse of data and information from FDM systems still need to be resolved to obtain the maximum benefits from FDM. These could be addressed by: continuing the discussions regarding the draft Transport Canada Civil Aviation Policy, creating forums for addressing the concerns in the aviation sector and using technology to address data security and access issues.

- Guidelines for Submitting Information to Transport Canada

  One of the objectives of the FDM project is for Canadian carriers to provide information obtained from FDM programs to Transport Canada. The type of information that is of most interest to Transport Canada falls in two main categories, namely:

  - Information for Focused Studies

    The large quantity of data from the multitude of sensors onboard aircraft contains information that would be useful to many research initiatives in the aviation industry. By providing raw data sets or executing algorithms that require raw flight data inputs at an airline's data analysis facility, verification and validation of these algorithms would be possible. Some examples of research areas that could benefit from an analysis of the raw flight data are: wake vortex prediction, runway braking coefficient determination, turbulence measurements, improved SOPs and Global Positioning System (GPS) Wide Area Augmentation System (WAAS) navigation system verification.

  - Information Relating to Safety Benefits from FDM

    Evidence of safety benefits from FDM would be useful in promoting wider adoption of FDM programs nation-wide. Furthermore, sharing of safety information would yield safety improvements throughout the National Air Transportation System. With increased factual knowledge relating to safety issues, Transport Canada would be better able to assist with the necessary safety improvements.

    To obtain these types of information, Transport Canada does not require the raw flight data. Thus, some of the airline's concerns with data security issues are alleviated.

- Promotion

  Activities to promote FDM programs within the Canadian aviation community should be continued, as well as participation in international efforts to increase aviation safety.

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