The Flight Operations Monitoring System:
A Bundled Approach for Synergistic Safety Management

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Abstract

In this paper, we describe the new Airbus approach for integrated safety management. For any aircraft manufacturer safety is the single most important aspect of its business. Corporate shareholders, customers and employees depend on it for the success of its products and for continued allegiance to our brand. The most effective and strategic way to herald safety is to establish, maintain and develop a positive safety culture. (1) Several complementary programs and tools have been developed throughout the years, and separately presented to customer airlines. These tools pertain to the Line Oriented Monitoring System, to the Line Observation Assessment System and to the Aircrew Incident Reporting System. Their overall aim was to improve aircraft design, operations and procedures as well as training standards, both by means of quantitative and qualitative data.

Introduction

Simply put, an Aerospace Manufacturer must be responsible for the impact on safety of everything it does and always keep in mind risks of incidents and accidents. Since safety ultimately depends on the aircraft in the field, the best leverage to reduce risks is obtained from enhancing airline flight operations themselves. This indirect strategy is implemented by means of dedicated instruments for airline safety measurements as flight operations are inevitably being delegated to Airbus customers. The contemporary view of flight safety management is to take into account risk exposure and manage the risk portfolio by means of continuous measurements and comparisons by region, by period, by fleet, by routes and by safety issue.

The initial approach with individual tools was instrumental in fostering the Airbus safety culture: it created a "bottom-up" spirit whereby a subsequent "top down" management review helped generate an overall

Airbus policy. We have now decided to merge departmental efforts in order to present a powerful, overall policy for line operations monitoring and safety enhancement. This can be summarized around 2 axes:

- To provide airlines with a Flight Operations Monitoring package, including tools, methods and services to help enhancing their Flight Operations Standards and Safety level:
- Airbus Flight Operations monitoring tools,
  LOMS , LOAS and AIRS software,
- Handbooks to support Flight Operations methods and procedure,
- Additional services for assistance to implementation by operators.
- To implement ways and means for data and information sharing between Airbus and Airlines for:
- Improvement of AIRBUS aircraft,
- Continuous improvement of SOPs and training,
- Feedback to the Airlines on lessons- learned in Safety and Flight operations monitoring.

We can really state that a positive/safety culture is being instilled as this policy has received top management endorsement and commitment with regard to its implementation. Shared beliefs, practices and attitudes have effectively been bundled around this policy of measuring and improving flight operations quality. Whilst similar initiatives may have been taken at various institutional, governmental or regulatory levels (ICAO, FAA, JAA, FSF, IATA), Airbus Industrie can state that its measurement and data-driven approach is going to become an essential industry initiative to support risk assessment and management. An innovative approach was adopted through event risk assessment and safety management : this entails challenging existing safety strategies linked to event families and risk domains (flight operations, design, maintenance, loading, traffic) by revisiting their underlying beliefs and assumptions (qualitative approach by means of operational analysis in trade-oriented approach) and by veri-

fying the statistical distribution (quantitative approach by means of benchmarking in database-oriented approach) of their confirmations or negations. In so doing we will effectively delegate the instruments for measuring flight operations quality to the airline customers themselves yet support them throughout to best distribute and cascade efforts around.

Flight Operations Monitoring:
The Airbus Concept

The purpose of a Flight Operations Monitoring program is to implement a prevention system undertaking corrective actions to avoid flight operations incidents to reap lessons learned from any occurrences.

Quantitative Information from
Flight Data Analysis

This approach pertains to the routine collection and analysis of flight data to provide more information about, and greater insight to, the total flight operations environment. The aim is to provide a feedback for safety management, raising to the surface errors and operational deviations that can be considered as "precursors" of accidents or incidents but which are not always directly visible. This part of the Flight Operations Monitoring system is also called FOQA (Flight Operations Quality Assurance). FOQA is restricted to flight data analysis.

- Flight data analysis requires equipping aircraft with specialized devices (Quick Access Recorders, PCMCIA cards…) to **systematically** capture flight data collected on the aircraft's DFDR.

Data are processed in a centralized ground station, in order to qualify and quantify deviations from standard operating procedures and Company policies. These deviations are then compiled in a database as events and then statistically processed to produce reports performing trend analysis and identifying potential risks.

Qualitative Information from
Line Operations Assessment Surveys

In line operations surveys crew performance is rated by Check Captains, using standard evaluation sheets during Rolling Audits or line checks.

Evaluation sheets are compiled to produce statistical reports on crew performance in:

- Crew resource management,
- Communication,
- Application of SOPs,
- Etc…

Besides the coincidental spelling similarity, the LOAS approach is in essence very close to the LOSA initiatives currently being spurred in aviation safety circles. LOSA acquires direct, first-hand data on the successful recovery from errors by flight crews during normal line flights. It is aimed at collecting data on successful human performance; and this is indeed a first in our industry, since aviation has traditionally collected data on failed human performance, such as an accident or incident investigation. Crews must not be made to think that they are being given a check-ride. Observers are not to discipline or critique crews , they only collect data. LOSA data are confidential and de-identified to ensure anonymity.

Qualitative Information from
Aircrew Incident Reporting Systems

Crew reporting provides the individual crewmember or collective perception of the event occurrence and is an essential element to establish a diagnosis when looking for causes from symptoms. As technological advances have led to aviation product development, new advances in information management and decision support technologies have made possible improvements in aviation safety monitoring, analysis and alerting (2). Reportable occurrences are hence being systematically tracked either for their direct safety content, either for their value as precursors. A reportable occurrence is understood to be any incident, fault, malfunction, deviation or technical defect that endangers or could endanger the safe operation of the aircraft or its occupants or which could lead to an unsafe condition in the aircraft.

We have hereby to distinguish between mandatory and voluntary incident reporting. The mandatory channel is obligatory, reports have to be submitted in name of the whole cockpit crew and may be forwarded by the airline to the airworthiness authorities if safety has been significantly threatened. The voluntary channel is voluntary, reports may be submitted at the discretion of an individual crewmember and could become invaluable information if a safety hazard and/or safety precursor was encountered, and also helping to understand why an event happened if safety was imperiled.

Confidentiality and Blame

The potential apportionment of blame is linked with the cultural tendency to attribute guilt in the process of determining the cause of an event (3). Local events are hereby unveiled linked with direct acting responsibilities, but they hide systemic human factors that did set the stage behind the scene. Effective risk management systems can only operate successfully within an orga-

nizational culture, which endorses and promotes feedback and remediation. The key for an appropriate organizational safety climate is management cooperation and commitment to blame-free reporting. Voluntary disclosure should protect the organizations and individuals from outright punitive actions by promoting a just culture of accountability. Blame allocation by management on the other hand precludes any chance of seeing confidential safety reporting systems develop, as crew would simply abstain to divulge voluntary reports.

Risk Analysis and Decision-Making

A Flight Operations Monitoring System combines data with other sources and with operational experience to develop objective information to enhance:

- Training effectiveness,
- Operational procedures,
- Maintenance and engineering procedures,
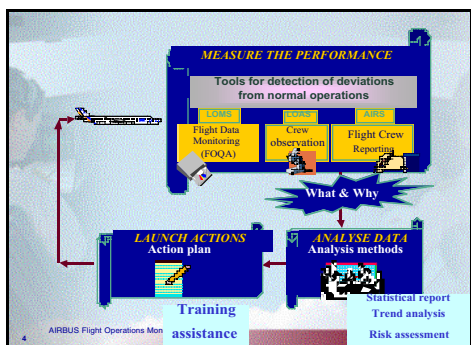- Air traffic control procedures.

Figure 1: The Flight Operations Monitoring Concept

The major and most critical step of a Flight Operations Monitoring program is to perform a pertinent interpretation of the results, and to decide upon the most appropriate and efficient actions. This implies the establishment of accurate risk assessment methods and guidelines for decisions based on detected risks.

Some basic keys toward success in the implementation phase are (4):

- Top management commitment in endorsing a candid pro-active safety culture, heralding accountability in cooperation with all organizational levels and in cooperation with relevant industrial associations (pilots, cabin staff, engineers, dispatchers, etc.),
- Crew cooperation is hereby fundamental and the program must actively demonstrate a non-punitive policy. The main objective of any Flight Operations Monitoring program is to improve safety by identifying trends, not by divulging individual acts,

- An accurate identification of potential risks requires the correlation by experts of results coming from the three types of tools,
- Only operational pilots experienced on the aircraft type being analyzed and training to risk assessment can accurately diagnose shortcomings under the form of safety precursors or threats,
- The FOQA department has to focus on monitoring fleet trends aggregated from numerous operations rather than pointing out specific events: the value of using aggregated FOQA data greatly exceeds that of a single flight assessment when trying to determine the root causes of systemic problems that need to be corrected,
- A well-structured de-identification system distributing confidential information to relevant departments but not sterilizing it to full anonymity,
- An efficient communication system is essential: while ensuring the confidentiality of data and the protection of the pilots, it shall timely inform the relevant people on risk assessment, allowing them to launch adequate preventive and/or corrective actions.

The Airbus Flight Operations Monitoring Package

This package now includes:

- The three types of Monitoring tools,
- Handbooks detailing Flight Operations Monitoring methods and techniques,
- Operational services for implementing Flight Operations Monitoring, tailored to Operator's needs.
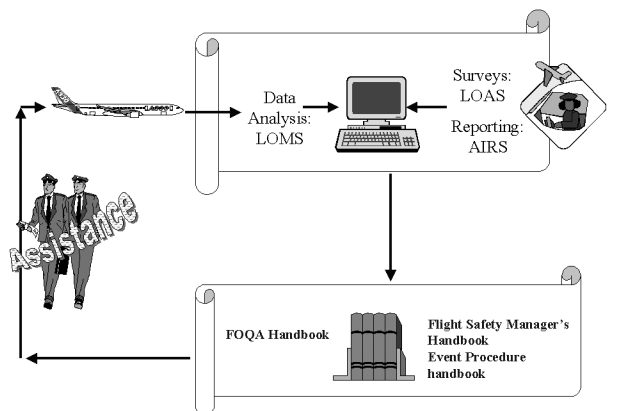

Figure 2: The integrated FOMS Package

Monitoring Tools

The Flight Data Analysis (FOQA) Tool:

- To record what happened during the flights.

- To process quantitative data extracted from the Flight data recorder to measure the deviations compared to standard flight path.
- To correlate data for trend analysis and fleet operation assessment.
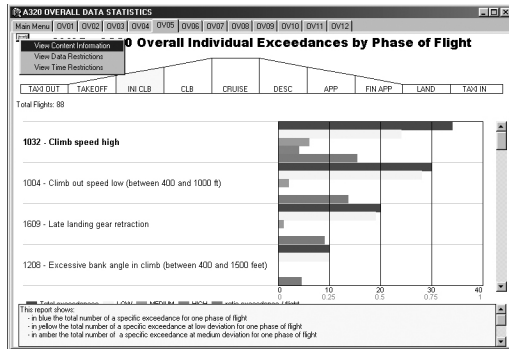

Figure 3: The Flight Operations Monitoring Concept Overall Individual Exceedances by Phase of Flight

The tool proposed here is the **LOMS** (Line Operations Monitoring System) which is an advanced computer program that uses the systematic routine download of Optical Quick Access Recorders to assist FOQA department in the daily monitoring of flight activity. This system provides statistical analysis with risk assessment demonstrated in recorded deviations from standard flight profiles. The output of LOMS processing is a flight path monitoring, aircraft handling assessment and risk analysis on the fleet level and its crew population as a group. This system covers the operations monitoring and feedback system in compliance with the promotion of risk awareness and the managed FOQA program specified in JAR-OPS 1.037. It is also compatible with the FAA requirements on flight data management and system integrity topics (5).

Figure 4: Flight Profile Visualisation

Because the accurate definition of the deviations from normal operations is a key element for a compre-

hensive flight data analysis, Airbus proposes its Flight Profile Specifications, to be integrated in any flight data monitoring system. A Flight profile is the set of references to which the flight data are compared in the flight data monitoring process. Each time the flight data deviates from a reference value, an event is triggered.

Flight Profile Data. Because the accurate definition of the deviations from normal operations is a key element for a comprehensive flight data analysis, Airbus proposes its Flight Profile Specifications, to be integrated in any flight data monitoring system. A Flight profile is the set of references to which the flight data are compared in the flight data monitoring process. Each time the flight data deviates from a reference value, an event is triggered.

The Flight Profile includes parameter filters, additional parameter computation, and event detection algorithms. On a scale of risk, deviations from the standard flight profile are classified into three severity levels allowing risk assessment of events and trends as a basis for remedial actions to be implemented:

- Low severity: yellow
- Medium severity: Amber
- High severity: red

The severity levels have been set to ensure compliance with the Flight Operations Regulations the aircraft limitations and the Airbus standard procedures. The events and deviations have been defined by operational and flight engineers and has been validated during specific flight tests. They are finalized and validated through thousands of flights in partnership with some Airbus operators. The events triggered could be single punctual events around 100 are monitored) as well as potential risk situations resulting of the combination of single events.

The following situations are currently monitored:

- Continuously Low during final
- Continuously Slow during final
- Continuously High during final
- Continuously Fast during final
- Continuously Steep during final
- Over Rotation at Take Off
- Under Rotation at Take Off
- Low Energy Take Off
- High Energy Take Off
- Tail Strike Risk at Take Off
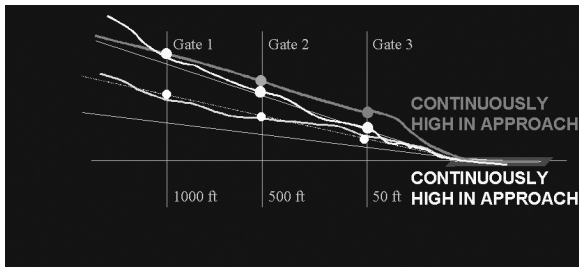- Low Energy Situation in Approach

Figure 5: Flight Profile Analysis

- High Energy Situation in Approach Late Offset in Short Final
- Poor Bracketing on Final
- Roll Oscillations prior to Flare
- Wing Strike Risk at Landing

The standard flight profiles are implemented and operational onLOMS. AIRBUS provides operators with the standard Flight profiles specifications related to all the configurations of Aircraft. Having the specifications available allows the Airlines to program them in their own flight data management system.

The Line Assessment Tool: The tool earmarked here is the LOAS (Line Operations Assessment System). The Line Operations Assessment System is a computer program dedicated to collect, analyze and archive the observations made by the Check Captains and Cabin Crew Auditors trained to use a system of crew behavior notation with a scoring method and key word descriptors. The resultant scores are used to evaluate patterns of group behavior as well as individual assessments appropriate to line check. LOAS compiles inspection and evaluations of line activity in an active analytical process. In an active mode, it provides the recommended rolling audit. The output is a cumulative series of scored evaluations of crew performance such as:

- CRM behavior
- Application of SOP's
- Cabin crew interface
- Operations support
- Route infrastructure

LOAS (Line Operation Assessment Survey) uses the University of Texas Data Collection Methodology called LOSA© (Line Operation Safety Audit) and is based on threat and error management as a most efficient means for risk precursor identification (6).
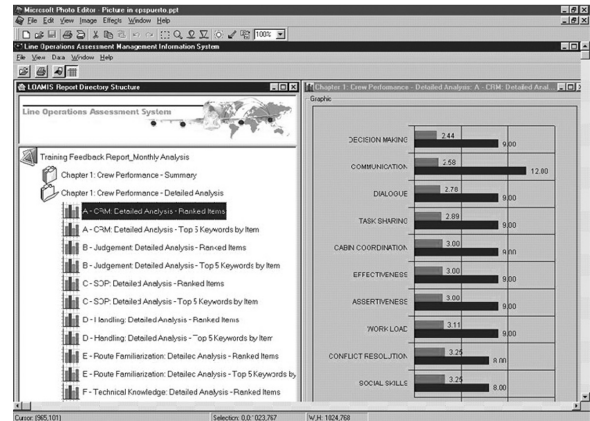

Figure 6: Statistical Reporting Analysis

The Aircrew Incident Reporting Tools: Before committing itself, Airbus Industrie critically reviewed eight operational reporting approaches:

- BASIS, British Airways Safety Information System,
- ICAO ADREP, ICAO's Accident/Incident Data Reporting System
- ECC-AIRS, a pilot study on the feasibility of an EC reporting system,
- MORS, the Mandatory Occurrence System of the UK CAA,
- OASIS and SIAM of the former Bureau of Air Safety Investigation in Australia, now ATSB,
- CHIRP, the Confidential Human Factors Incident Reporting Program in the UK,
- ASRS, the Aviation Safety Reporting System from NASA in the US,
- EUCARE, now extinct but formerly developed for the European Community at the TU-Berlin,

These systems were found to vary according to several dimensions:

- objectives of the system,
- definition of "relevant event",
- sophistication of the safety model,
- confidentiality,
- reporting format,
- coding and analysis systems,
- feedback and information transfer.
- The tool retained is the **AIRS** (Aircrew Incident Reporting System) part of the BASIS Safety Information System developed by British Airways. AIRS can interface with existing BASIS modules.

Initial AIRS Initially, AIRBUS INDUSTRIE convinced British Airways (7) to develop a human factors module in 1996 (HFR). The objective of the voluntary reporting process linked with HFR was to collect and analyze confidential data to understand the latent or systemic

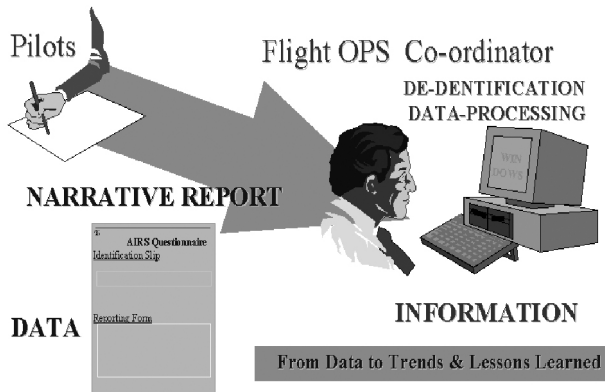conditions as well as the behavioral aspects behind operational events.

Figure 7: Process for Reporting Acknowledgment and Analysis

Developed in cooperation with British Airways, AIRS initially vowed to introduce voluntary confidential human factors reporting capability to better understand man-machine related events occurring in flight. The agreement enabled Airbus Industrie to distribute this module's software free of charge to subscribing airlines provided a license contract would be signed after course delivery in Toulouse.

The supporting Windows software of HFR allows:

- Storing of the completed questionnaires from flight & cabin in a standardized way,
- Translating the raw data into useful information for analyzing and updating,
- Human Factors filtering in order to identify trends.

AIRS does not have the trend analysis function built-in, but data could be treated with other tools. AIRS runs on any IBM compatible PC and Airbus offers assistance to administer the system through dedicated courses being run at its home base in Toulouse. The basic safety model of HFR is centered around the promise that any crew action and/or behavior is mediated by the following four influences:

- Organizational influences, under the responsibility of the organization,
- Informational influences, likewise
- Personal influences, under the responsibility of the individual(s) (him)(her)self/(themselves)
- Environmental, neither under control of the organization or of the persons involved.

The course aims to deliver a language of 64 keywords in association with software having the "look and feel" of the other BASIS modules. The course and software delivery does not commit airlines to have to send reports back to Airbus. If the option to do this is however taken, proper de-identification is recommended.

Lessons learned from initial AIRS Making an airline-oriented system available to customers induced a feedback flow of contextual reporting constituted of both Air Safety and Human Factors reports, mostly pertaining to mandatory ones (about 90 % ASR's) with a sizable chunk of voluntary ones (10 % HFR's).

Whereas we received 700 airline reports in several successive saccadic waves from 5 operators over the last 2 years, we received also over 5000 Safety Information Exchange reports for directed empirical analysis.

Clearly, the ability to ask intelligent questions from a data set is the key to time-efficient and meaningful incident analysis. This type of work cannot be carried out by a database analyst unless he or she is also an aviation expert or has guidance from an expert. Nor can it be carried out by aviation experts unless they are knowledgeable in database manipulation and at least basic statistics. Both types of expertise are needed at the manufacturer level to extract meaningful information from large data sets: complementary clinical and statistical analyses have to coexist to trigger action points as well as to enable filtering/sorting into main occurrence families.

As such, AIRS processing is promising but still resource-heavy:

- There is a need for pre-filtering to sort out relevant events and manage the flow ; this can be performed by the airline's Airbus field representative,
- There is a desire to reinforce the existing In Service Occurrence process (ISO) with AIRS reports, provided timely pre-filtering occurs, avoiding duplication, complementing with human factors information ; the ISO channel funneled by field representatives, is part of regular Line Oriented Follow Up (LOFU) and consists in the collection and analysis of in-service events (reported and potential events with a view towards traceable precursors) in order to perform operations, maintenance and engineering-oriented feedback,
- There is a requirement for keyword analyses to group SIE events into In Service Problem families to help correlate events and derive intelligent questions.

Evolved AIRS

With this experience in mind the objective is to have AIRS evolve into a system for better use of both air safety and human factors reports. This will hinge on an agreement with British Airways to include ASR's in the AIRS package hereby uniting both mandatory (ASR-part) and voluntary (HFR-part) channels. It will

also be important to include trending in the AIRS package and indications are that agreement will also be reached on this important point. But the biggest progress will reside in the possibility to send both ASR's and HFR's to Toulouse as e-mail attachments if airlines so choose and to give BASIS access to both the Resident Customer Support Representatives and to AI engineers. Provided a proper confidential and effective de-identification procedure is managed, this will result in less retyping by the Airbus representative and to a better visibility to airline safety reports. The BASIS system is very popular because of its wide distribution and overall user friendliness. Hence, Airbus Industrie is resolutely oriented towards the evolved Aircrew Incident Reporting System:

- For Airbus this will expand towards the possibility to consult the ARS's with the filtering and trending functions of BASIS,
- For airlines this will expand possibilities to get useful lessons learned not only from Airbus but also from operators themselves especially if a user community for ASR/HFR reporting already exists.
- As with regard to implementation, if the Resident Customer Support Manager is given the BASIS software:
- He/she will get a better visibility of operator's reports,
- He/she will use filtering/graphical functions,
- He/she will be able to efficiently download to Airbus headquarters for swift feedback action.

Conclusion

The Airbus Policy on a comprehensive Flight Operations Monitoring Package should pay a lasting contribution to breed safety cultures with its customers. The packaged approach makes more sense than the modular one as it adds value to potential risk management. It is well aligned with contemporary safety initiatives seen at ICAO, at the FSF, at CAST and JSIT/JSAT. It provides a federated approach to inject lessons learned:

- For both airline and manufacturer's return of experience,
- For risk assessment activities and safety performance metrics based on safety performance measurements and real operational performance data,
- Bridged across several safety package modules.

It is also well in line with IATA whose STEADES program is essentially airline-oriented, representing our customers and also relying on a curtailed version of BASIS, i.e. BASIS Lite. And it is well positioned to play a distinct and significant role in the deployment of a major world safety initiative, the Global Aviation Information Network, i.e. GAIN. GAIN promotes and facilitates voluntary collection and sharing of safety information by and among users in the international aviation community and amongst other accomplishments it will:

- Foster the use of existing analytical methods and tools and the development of new methods and tools.
- Promote and facilitate the development and implementation of systems to support the global sharing of aviation safety information.

Besides the promise for better return of experience in the safety arena (design, operations & training), another added benefit not mentioned to now, valid for both the airline customers and the manufacturer is a better protection against liability and legal exposure. With this packaged approach aiming to implement a positive safety culture, Airbus has put in place a unique approach to help its customers decrease risks of incidents and accidents.

As such the Flight Operations Monitoring System (FOMS) proposed by Airbus Industrie is fully in line with contemporary safety ideas which provide an invaluable contribution towards safety management by cross-linking safety information channels.

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