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AERONAUTICAL CIRCULAR
CIVIL AVIATION AUTHORITY – MACAO, CHINA

SUBJECT: ***Flight Data Analysis Programme***

EFFECTIVE DATE:

1 January 2020

CANCELLATION:

Nil.

GENERAL:

The President of Civil Aviation Authority – Macao, China, in exercise of his power under Paragraph 89 of the Air Navigation Regulation of Macao (ANRM) and Article 35 of the Statutes of Civil Aviation Authority, approved by the Decree-Law 10/91/M, established this Aeronautical Circular (AC).

1. Introduction

ANRM Part I Paragraph 2 defines that flight data analysis is a process of analysing recorded flight data in order to improve the safety of flight operations.

ANRM Part V Paragraph 26 (7) specifies that an operator of an aircraft of maximum certificated take-off mass in excess of 27,000 kg shall establish and maintain a flight data analysis programme as part of its safety management system, and the flight data analysis programme shall be non-punitive and contain adequate safeguards to protect the source(s) of the data.

Aeronautical Circular AC/GEN/005 Paragraph 7.1.2 specifies that a service provider shall develop and maintain safety data collection and processing systems that provide for identification of hazards and the analysis, assessment and mitigation of safety risks.

The purpose of this Aeronautical Circular is to establish the requirements for flight data analysis programme.

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2. Applicability

This AC is applicable to operators of Macao registered aircraft flying for the purpose of commercial air transport with aircraft of maximum certificated take-off mass in excess of 27,000 kg.

3. Flight Data Analysis Programme (FDAP)

3.1 Operator shall identify and document in its Operations Manual the accountabilities, responsibilities and authorities of:

a) the Safety Manager, who is responsible for the identification, assessment and transmission of issues from the FDAP;

b) the manager(s) responsible for taking appropriate and practicable safety action within a reasonable period of time that reflects the severity of the issue; and

c) other personnel that involve in the FDAP.

3.2 The Flight Data Analysis Programme shall allow an operator to:

a) identify areas of operational risk and quantify current safety margins;

b) identify and quantify operational risks by highlighting occurrences of non-standard, unusual or unsafe circumstances;

c) use the FDAP information on the frequency of such occurrences, combined with an estimation of the level of severity, to assess the safety risks and to determine which may become unacceptable if the discovered trend continues;

d) put in place appropriate procedures for remedial action once an unacceptable risk, either actually present or predicted by trending, has been identified; and

e) confirm the effectiveness of any remedial action by continued monitoring.

3.3 Flight Data Analysis techniques shall comprise the following:

a) Exceedance detection: searching for deviations from aircraft flight manual limits and standard operating procedures. A set of core events should be selected to cover the main areas of interest to the operator. A sample list is provided in appendix 1 to this AC. The event detection limits shall be continuously reviewed to reflect the operator's current operating procedures.

b) All flights measurement: a system defining what is normal practice. This may be accomplished by retaining various snapshots of information from each flight.

c) Statistics – a series of data collected to support the analysis process: this technique shall include the number of flights flown per aircraft and sector details sufficient to generate rate and trend information.

3.4 The Flight Data Analysis Programme shall cover analysis, assessment and process control tools. The effective assessment of information obtained from digital flight data should be dependent on the provision of appropriate information technology tool sets.

3.5 The Flight Data Analysis Programme shall incorporate education and publication. Sharing safety information shall be a fundamental principle of aviation safety in helping to reduce accident rates. The operator shall pass on the lessons learnt to all relevant personnel and, where appropriate, industry.

3.6 Every pilot shall be responsible for reporting events. Significant risk-bearing incidents detected by the FDAP shall therefore normally be the subject of mandatory occurrence reporting by the pilot. If this is not the case, the pilot shall submit a retrospective report that should be included under the normal process for reporting and analyzing hazards, incidents and accidents.

3.7 The data recovery strategy shall ensure a sufficiently representative capture of flight information to maintain an overview of operations. Data analysis shall be performed sufficiently frequently to enable action to be taken on significant safety issues.

3.8 The data retention strategy shall aim at providing the greatest safety benefits practicable from the available data. A full data set shall be retained until the action and review processes are complete; thereafter, a reduced data set relating to closed issues could be maintained for longer-term trend analysis. Operator may wish to retain samples of de-identified full-flight data for various safety purposes (detailed analysis, training, benchmarking, etc.).

3.9 The data access and security policy shall restrict information access to authorised persons. Operator shall ensure that its policy is compliant with applicable legislation, in particular, Law no. 2/2013 - *Civil Aviation Accident and Incident Investigation and Safety Data Protection Law* and Law no. 8/2005 – *Personal Data Protection Law.* A procedure shall be in place to prevent disclosure of crew identity.

3.10 The above policy shall be signed by the Accountable Manager and communicated, with visible endorsement, throughout the organization.

3.11 The procedures to prevent disclosure of crew identity shall be documented and, as a minimum, define:

a) the aim of the FDAP;

b) a data access and security policy that shall restrict access to information to specifically authorized persons identified by their position;

c) the method to obtain de-identified crew feedback on those occasions that require specific flight follow-up for contextual information;

d) the data retention policy and accountability, including the measures taken to ensure the security of the data;

e) the conditions under which advisory briefing or remedial training take place; this shall always be carried out in a constructive and non-punitive manner;

f) the conditions under which the confidentiality may be withdrawn for reasons of gross negligence or significant continuing safety concern;

h) the policy for publishing the findings resulting from FDAP.

3.12 Airborne systems and equipment used to obtain FDAP data could range from an already installed full quick access recorder (QAR), in a modern aircraft with digital systems, to a basic crash-protected recorder in an older or less sophisticated aircraft. The analysis potential of the reduced data set available in the latter case may reduce the safety benefits obtainable. The operator shall ensure that FDAP use does not adversely affect the serviceability of equipment required for accident investigation.

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Appendix 1 – Table of FDAP Events

The following table provides examples of FDAP events that may be further developed using operator and aeroplane specific limits. The table is considered illustrative and not exhaustive.

Event Group	Description
Rejected take-off	High speed rejected take-off
Take-off pitch	Pitch rate high on take-off
	Pitch attitude high during take-off
Unstick speeds	Unstick speed high
	Unstick speed low
Height loss in climb-out	Initial climb height loss 20ft above ground level (AGL) to 400 ft above aerodrome level (AAL)
	Initial climb height loss 400 ft to 1500 ft AAL
Slow climb-out	Excessive time to 1000 ft AAL after take-off
Climb-out speeds	Climb-out speed high below 400 ft AAL
	Climb-out speed high 400 ft AAL to 1000 ft AAL
	Climb-out speed low 35 ft AGL to 400 ft AAL
	Climb-out speed low 400 ft AAL to 1500 ft AAL
High rate of descent	High rate of descent below 2000 ft AGL
Missed approach	Missed approach below 1000 ft AAL
	Missed approach above 1000 ft AAL
Low approach	Low on approach
Glideslope	Deviation under glideslope
	Deviation above glideslope (below 600 ft AGL)
Approach power	Low power on approach
Approach speeds	Approach speed high within 90 seconds of touchdown
	Approach speed high below 500 ft AAL
	Approach speed high below 50 ft AGL
	Approach speed low within 2 minutes of touchdown
Landing flap	Late land flap (not in position below 500 ft AAL)
	Reduced flap landing
	Flap load relief system operation
Landing pitch	Pitch attitude high on landing
	Pitch attitude low on landing
Bank angles	Excessive bank below 100 ft AGL
	Excessive bank 100 ft AGL to 500 ft AAL
	Excessive bank above 500 ft AGL
	Excessive bank near ground (below 20 ft AGL)

Appendix 1 – Table of FDAP Events

Event Group	Description
Normal acceleration	High normal acceleration on ground
	High normal acceleration in flight flaps up (+/- increment)
	High normal acceleration in flight flaps down (+/- increment)
	High normal acceleration at landing
Abnormal configuration	Take-off configuration warning
	Early configuration change after take-off (flap)
	Speed brake with flap
	Speed brake on approach below 800 ft AAL
	Speed brake not armed below 800 ft AAL
Ground proximity warning	Ground proximity warning system (GPWS) operation – hard warning
	GPWS operation – soft warning
	GPWS operation – windshear warning
	GPWS operation – false warning
Airborne collision avoidance system (ACAS II) warning	ACAS operation – resolution advisory
Margin to stall/buffet	Stick shake
	False stick shake
	Reduced lift margin except near ground
	Reduced lift margin at take-off
	Low buffet margin (above 20000 ft)
Aircraft flight manual limitations	Maximum operating speed limit (VMO) exceedance
	Maximum operating speed limit (MMO) exceedance
	Flap placard speed exceedance
	Gear down speed exceedance
	Gear selection up/down speed exceedance
	Flap/slat altitude exceedance
	Maximum operating altitude exceedance

<u>Appendix 2 – Guidance Material</u>

1. FDAP Analysis Techniques

1.1 Exceedance detection

1.1.1 FDAP are used for detecting exceedances, such as deviations from flight manual limits, standard operating procedures (SOPs), or good airmanship. Typically, a set of core events establishes the main areas of interest to operators.

Examples: high lift-off rotation rate, stall warning, ground proximity warning system (GPWS) warning, flap limit speed exceedance, fast approach, high/low on glideslope, and heavy landing.

1.1.2 Trigger logic expressions may be simple exceedances such as redline values. The majority, however, are composites that define a certain flight mode, aircraft configuration or payload-related condition. Analysis software can also assign different sets of rules dependent on airport or geography. For example, noise sensitive airports may use higher than normal glideslopes on approach paths over populated areas. In addition, it might be valuable to define several levels of exceedance severity (such as low, medium and high).

1.1.3 Exceedance detection provides useful information, which can complement that provided in crew reports.

Examples: reduced flap landing, emergency descent, engine failure, rejected takeoff, go-around, airborne collision avoidance system (ACAS) or GPWS warning, and system malfunctions.

1.1.4 The operator may also modify the standard set of core events to account for unique situations they regularly experience, or the SOPs they use.

Example: to avoid nuisance exceedance reports from a non-standard instrument departure.

1.1.5 The operator may also define new events to address specific problem areas.

Example: restrictions on the use of certain flap settings to increase component life.

1.2 All-flights measurements

FDAP data are retained from all flights, not just the ones producing significant events. A selection of parameters is retained that is sufficient to characterise each flight and allow a comparative analysis of a wide range of operational variability. Emerging trends and tendencies may be identified and monitored before the trigger levels associated with exceedances are reached.

Examples of parameters monitored: take-off weight, flap setting, temperature, rotation and lift-off speeds versus scheduled speeds, maximum pitch rate and attitude during rotation, and gear retraction speeds, heights and times.

Examples of comparative analyses: pitch rates from high versus low take-off weights, good versus bad weather approaches, and touchdowns on short versus long runways.

1.3 Statistics

Series of data are collected to support the analysis process: these usually include the numbers of flights flown per aircraft and sector details sufficient to generate rate and trend information.

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1.4 Investigation of incidents flight data

Recorded flight data provide valuable information for follow-up to incidents and other technical reports. They are useful in adding to the impressions and information recalled by the flight crew. They also provide an accurate indication of system status and performance, which may help in determining cause and effect relationships.

Examples of incidents where recorded data could be useful:

– high cockpit workload conditions as corroborated by such indicators as late descent, late localizer and/or glideslope interception, late landing configuration;
– unstabilised and rushed approaches, glide path excursions, etc.;
– exceedances of prescribed operating limitations (such as flap limit speeds, engine overtemperatures); and
– wake vortex encounters, turbulence encounters or other vertical accelerations.

It should be noted that recorded flight data have limitations, e.g. not all the information displayed to the flight crew is recorded, the source of recorded data may be different from the source used by a flight instrument, the sampling rate or the recording resolution of a parameter may be insufficient to capture accurate information.

1.5 Continuing airworthiness

Data of all-flight measurements and exceedance detections can be utilised to assist the continuing airworthiness function. For example, engine-monitoring programmes look at measures of engine performance to determine operating efficiency and predict impending failures.

Examples of continuing airworthiness uses: engine thrust level and airframe drag measurements, avionics and other system performance monitoring, flying control performance, and brake and landing gear usage.

2. FDAP Equipment

2.1 General

FDAP generally involve systems that capture flight data, transform the data into an appropriate format for analysis, and generate reports and visualisation to assist in assessing the data. Typically, the following equipment capabilities are needed for effective FDAP:

2.1.1 an on-board device to capture and record data on a wide range of in-flight parameters;

2.1.2 a means to transfer the data recorded on board the aircraft to a ground-based processing station;

2.1.3 a ground-based computer system to analyse the data, identify deviations from expected performance, generate reports to assist in interpreting the read-outs, etc.; and

2.1.4 optional software for a flight animation capability to integrate all data, presenting them as a simulation of in-flight conditions, thereby facilitating visualisation of actual events.

2.2 Airborne Equipment

2.2.1 The flight parameters and recording capacity required for flight data recorders (FDR) to support accident investigations may be insufficient to support an effective FDAP. Other technical solutions are available, including the following:

(A) Quick access recorders (QARs). QARs are installed in the aircraft and record flight data onto a low-cost removable medium.

(B) Some systems automatically download the recorded information via secure wireless systems when the aircraft is in the vicinity of the gate. There are also systems that enable the recorded data to be analysed on board while the aircraft is airborne.

2.2.2 Fleet composition, route structure and cost considerations will determine the most cost-effective method of removing the data from the aircraft.

2.3 Ground replay and analysis equipment

2.3.1 Data are downloaded from the aircraft recording device into a ground-based processing station, where the data are held securely to protect this sensitive information.

2.3.2 FDAP generate large amounts of data requiring specialised analysis software.

2.3.3 The analysis software checks the downloaded flight data for abnormalities.

2.3.4 The analysis software may include: annotated data trace displays, engineering unit listings, visualisation for the most significant incidents, access to interpretative material, links to other safety information and statistical presentations.

3. FDAP in Practice

3.1 FDAP Process

Typically, operators follow a closed-loop process in applying an FDAP, for example:

3.1.1 Establish a baseline: initially, operators establish a baseline of operational parameters against which changes can be detected and measured.

Examples: rate of unstable approaches or hard landings.

3.1.2 Highlight unusual or unsafe circumstances: the user determines when non-standard, unusual or basically unsafe circumstances occur; by comparing them to the baseline margins of safety, the changes can be quantified.

Example: increases in unstable approaches (or other unsafe events) at particular locations.

3.1.3 Identify unsafe trends: based on the frequency and severity of occurrence, trends are identified. Combined with an estimation of the level of severity, the risks are assessed to determine which may become unacceptable if the trend continues.

Example: a new procedure has resulted in high rates of descent that are nearly triggering GPWS warnings.

3.1.4 Mitigate risks: once an unacceptable risk has been identified, appropriate risk mitigation actions are decided on and implemented.

Example: having found high rates of descent, the SOPs are changed to improve aircraft control for optimum/maximum rates of descent.

3.1.5 Monitor effectiveness: once a remedial action has been put in place, its effectiveness is monitored, confirming that it has reduced the identified risk and that the risk has not been transferred elsewhere.

Example: confirm that other safety measures at the aerodrome with high rates of descent do not change for the worse after changes in approach procedures.

3.2 Analysis and Follow-up

3.2.1 FDAP data are typically compiled every month or at shorter intervals. The data are then reviewed to identify specific exceedances and emerging undesirable trends and to disseminate the information to flight crews.

3.2.2 If deficiencies in pilot handling technique are evident, the information is usually de-identified in order to protect the identity of the flight crew. The information on specific exceedances is passed to a person assigned by the operator for confidential discussion with the pilot. The person assigned by the operator provides the necessary contact with the pilot in order to clarify the circumstances, obtain feedback and give advice and recommendations for appropriate action. Such appropriate action could include re-training for the pilot (carried out in a constructive and non-punitive way), revisions to manuals, changes to ATC and airport operating procedures.

3.2.3 Follow-up monitoring enables the effectiveness of any corrective actions to be assessed. Flight crew feedback is essential for the identification and resolution of safety problems and could be collected through interviews, for example by asking the following:

(A) Are the desired results being achieved soon enough?

(B) Have the problems really been corrected, or just relocated to another part of the system?

(C) Have new problems been introduced?

3.2.4 All events are usually archived in a database. The database is used to sort, validate and display the data in easy-to-understand management reports. Over time, this archived data can provide a picture of emerging trends and hazards that would otherwise go unnoticed.

3.2.5 The data retention strategy should aim at providing the greatest safety benefits practicable from the available data. A full dataset should be retained until the action and review processes are complete; thereafter, a reduced dataset relating to closed issues should be maintained for longer-term trend analysis. Operator may wish to retain samples of de-identified full-flight data for various safety purposes (detailed analysis, training, benchmarking, etc.)

3.2.6 Sharing safety information should be a fundamental principle of aviation safety in helping to reduce accident rates. The operator should pass on the lessons learnt to all relevant personnel and, where appropriate, industry. Lessons learnt from the FDAP may warrant inclusion in the operator's safety promotion programmes. Safety promotion media may include newsletters, flight safety magazines, highlighting examples in training and simulator exercises, periodic reports to industry and the competent authority. Care is required, however, to ensure that any information acquired through FDAP is de-identified before using it in any training or promotional initiative.

3.2.7 All successes and failures are recorded, comparing planned programme objectives with expected results. This provides a basis for review of the FDAP and the foundation for future programme development.

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4. Preconditions for an effective FDAP

4.1 Protection of FDAP data

The integrity of FDAP rests upon protection of the FDAP data. Any disclosure for purposes other than safety management can compromise the voluntary provision of safety data, thereby compromising flight safety.

4.2 Essential trust

The trust established between management and flight crew is the foundation for a successful FDAP. This trust can be facilitated by:

(A) the operator strictly limiting data access to selected individuals;

(B) maintaining tight control to ensure that identifying data is kept securely; and

(C) ensuring that operational problems are promptly addressed by management.

4.3 Requisite safety culture

Indicators of an effective safety culture typically include:

4.3.1 top management's demonstrated commitment to promoting a proactive safety culture;

4.3.2 a non-punitive operator policy that covers the FDAP;

4.3.3 FDAP management by dedicated staff under the authority of the safety manager, with a high degree of specialisation and logistical support;

4.3.4 involvement of persons with appropriate expertise when identifying and assessing the risks (for example, pilots experienced on the aircraft type being analysed);

4.3.5 monitoring fleet trends aggregated from numerous operations, not focusing only on specific events;

4.3.6 a well-structured system to protect the confidentiality of the data; and

4.3.7 an efficient communication system for disseminating hazard information (and subsequent risk assessments) internally and to other organisations to permit timely safety action.

5. Implementing an FDAP

5.1 General considerations

5.1.1 Typically, the following steps are necessary to implement an FDAP:

(A) establishment and verification of operational and security procedures;

(B) installation of equipment;

(C) selection and training of dedicated and experienced staff to operate the programme; and

(D) commencement of data analysis and validation.

5.1.2 An operator with no FDAP experience may need a year to achieve an effective FDAP. Another year may be necessary before any safety and cost benefits appear. Improvements in the analysis software, or the use of outside specialist service providers, may shorten these time frames.

5.2 Aims and objectives of an FDAP

5.2.1 As with any project there is a need to define the direction and objectives of the work. A phased approach is recommended so that the foundations are in place for possible subsequent expansion into other areas. Using a building block approach will allow expansion, diversification and evolution through experience.

Example: with a modular system, begin by looking at basic safety-related issues only. Add engine health monitoring, etc. in the second phase. Ensure compatibility with other systems.

5.2.2 A staged set of objectives starting from the first week's replay and moving through early production reports into regular routine analysis will contribute to a sense of achievement as milestones are met.

Examples of short-term, medium-term and long-term goals:

(A) Short-term goals:
— establish data download procedures, test replay software and identify aircraft defects;
— validate and investigate exceedance data; and
— establish a user-acceptable routine report format to highlight individual exceedances and facilitate the acquisition of relevant statistics.

(B) Medium-term goals:
— produce an annual report — include key performance indicators;
— add other modules to the analysis (e.g. continuing airworthiness); and
— plan for the next fleet to be added to programme.

(C) Long-term goals:
— network FDAP information across all of the operator's safety information systems;
— ensure FDAP provision for any proposed alternative training and qualification programme (ATQP); and
— use utilisation and condition monitoring to reduce spares holdings.

5.2.3 Initially, focusing on a few known areas of interest will help prove the system's effectiveness. In contrast to an undisciplined 'scatter-gun' approach, a focused approach is more likely to gain early success.

Examples: rushed approaches, or rough runways at particular aerodromes. Analysis of such known problem areas may generate useful information for the analysis of other areas.

5.3 The FDAP team

5.3.1 Experience has shown that the 'team' necessary to run an FDAP could vary in size from one person for a small fleet, to a dedicated section for large fleets. The descriptions below identify various functions to be fulfilled, not all of which need a dedicated position.

(A) Team leader: it is essential that the team leader earns the trust and full support of both management and flight crew. The team leader acts independently of others in line management to make recommendations that will be seen by all to have a high level of integrity and impartiality. The individual requires good analytical, presentation and management skills.

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(B) Flight operations interpreter: this person is usually a current pilot (or perhaps a recently retired senior captain or instructor), who knows the operator's route network and aircraft. This team member's in-depth knowledge of SOPs, aircraft handling characteristics, aerodromes and routes is used to place the FDAP data in a credible context.

(C) Technical interpreter: this person interprets FDAP data with respect to the technical aspects of the aircraft operation and is familiar with the power plant, structures and systems departments' requirements for information and any other engineering monitoring programmes in use by the operator.

(D) Gate-keeper: this person provides the link between the fleet or training managers and flight crew involved in events highlighted by FDAP. The position requires good people skills and a positive attitude towards safetythe only person permitted to connect the identifying data with the event. It is essential that this person earns the trust of both management and flight crew.

(E) Engineering technical support: this person is usually an avionics specialist, involved in the supervision of mandatory serviceability requirements for FDR systems. This team member is knowledgeable about FDAP and the associated systems needed to run the programme.

(F) Replay operative and administrator: this person is responsible for the day-today running of the system, producing reports and analysis.

5.3.2 All FDAP team members need appropriate training or experience for their respective area of data analysis. Each team member is allocated a realistic amount of time to regularly spend on FDAP tasks.