Aviation Safety Data Collection and Processing – Singapore’s Experience

Abstract
Aviation safety data collection, analysis and exchange are at the heart of the State Safety Programme and Safety Management System. Safety management relies on the measurement and monitoring of safety indicators to identify areas of concern, and this in turn relies on effective collection of safety data.

This paper shares how Singapore, under its Safety Data Collection and Processing System, uses the Singapore Aviation Accident/Incident Reporting System to perform safety data collection, analysis, measurement, monitoring and exchange.
About the Author

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In addition to his technical responsibilities, Michael established the Singapore Aviation Accident/Incident Reporting System for the Singapore aviation industry in 2009.

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INTRODUCTION
In the early days, the conventional aviation safety approach was very much a “reactive” one that responds to events that had already happened, such as incidents and accidents. State safety agencies only acted when an incident or accident has occurred. The investigation process and outcome only determined the root cause of the accident or incident without constructing any process and action to prevent recurrences.

In the mid to late 20th century, resulting from overwhelming public concerns over safe skies, major State safety agencies began to take a more “proactive” approach in its safety management, aiming to reduce accident rates. The proactive approach actively looks for the identification of safety risks through its analysis of the organisation’s activities. Measures such as audits, inspections and reviews over controlled operating environment, processes and procedures were introduced. These measures highlight areas of concern where appropriate corrective actions and recommendations could minimise the possibilities of these deficiencies escalating to undesirable incidents or accidents.

ICAO MANDATE
In early 2009, ICAO came up with a new requirement in Annex 13 (Aircraft Accident and Incident Investigation) requiring States to establish and maintain an accident/incident database to facilitate the effective analysis of safety data collected from its reporting systems. Some of the main reporting systems include the mandatory reporting system, voluntary reporting system and confidential reporting system.

Mandatory Reporting Systems: “Reporting of certain types of events or hazards. This necessitates detailed regulations outlining who shall report and what shall be reported. Since mandatory systems deal mainly with “hardware” matters, they tend to collect more information on technical failures than on other aspects of operational activities. To help overcome this bias, voluntary reporting systems aim at acquiring more information on those other aspects.” (ICAO Doc 9859)

Voluntary Reporting Systems: “Without any legal or administrative requirement to do so, reporter submits voluntary event or hazard information. In these systems,
safety agencies and/or organisations may offer an incentive to report. For example, enforcement action may be waived for events that are reported underlining errors or unintentional violations. The reported information should not be used against the reporters, i.e. such systems must be non-punitive and afford protection to the sources of the information to encourage the reporting of such information.” (ICAO Doc 9859)

Confidential Reporting Systems: “Protect the identity of the reporter. This is one way of ensuring that voluntary reporting systems are non-punitive. Confidentiality is usually achieved by de-identification, and any identifying information about the reporter is known only to “gatekeepers” in order to allow for follow-up or “fill in voids” in the reported event(s). Confidential incident reporting systems facilitate the disclosure of hazards leading to human error, without fear of retribution or embarrassment, and enable broader acquisition of information on hazards.” (ICAO Doc 9859)

CAAS’ PREDICTIVE APPROACH – SAIRS
In mid-2009, under the State Safety Programme (SSP) and Safety Management System (SMS) initiatives, the Civil Aviation Authority of Singapore (CAAS) revamped its mandatory reporting system to collect, store and analyse safety data. This system is known as the Singapore Aviation Accident/Incident Reporting System (SAIRS). The scope of safety data collection is not limited only to accidents and incidents but also hazards and threats. This predictive approach captures real-time system performance as it happens during normal operations so that potential future problems can be identified and predicted. With these safety data, safety performance indicators (SPI), together with its acceptable level of safety (ALoS), can be determined objectively. With SAIRS, SPIs are being measured, assessed and trended continuously to ensure that the risk level of each indicator is kept within acceptable levels (see Figure 1). Once there are areas identified and predicted to be entering potential high risk levels, appropriate mitigating actions will be performed to bring the level of risk down to as low as possible.

![Figure 1: Safety cycle/workflow](image-url)
SAFETY DATA COLLECTION
In most States, the main safety data source comes from the mandatory reporting system where “actual/real time” occurrences that happened in the normal controlled operating environment were reported. This is followed by the voluntary and confidential reporting systems.

Under SAIRS, the mandatory reporting is guided by a revised list of reportable occurrences with new reporting timelines. In order to facilitate specific trending, the classification of occurrences was realigned with close reference to Annex 13’s classifications. In addition, CAAS also encourages the reporting of potential safety deficiencies that could affect flight safety and this is made possible in the CAAS SAIRS form which has the provision to report hazards and threats.

Apart from SAIRS, CAAS also started another safety management project known as the Safety Oversight Management System (SOMS) in late 2009. This system was partially launched in July 2010 and targeted for full operation in late 2010. SOMS aims to capture and manage safety data collected through routine audits, inspections and reviews conducted on airlines, design organisations and maintenance organisations holding Singapore approvals.

Once SOMS is fully operational, CAAS will integrate SAIRS with SOMS. With this integration, CAAS would be able to further expand its scope of safety data collection so as to facilitate more comprehensive data analysis (see Figure 2).

![CAAS INTEGRATED DATABASE Diagram](image-url)

*Figure 2: CAAS' safety data collection process*
SAFETY DATA STORAGE AND ANALYSIS

ICAO Annex 13 states that the safety database systems should use standardised formats to facilitate data exchange.

Currently, the European Coordination Centre for Accident and Incident Reporting Systems (ECCAIRS)\(^1\) software is the only software that operates on the ICAO Accident/Incident Data Reporting taxonomy. As such, it was adapted as CAAS SAIRS’ main operating system. With ECCAIRS, all safety data stored in SAIRS database are in a standardised format. Apart from providing a standardised format, ECCAIRS software also applies the commonly used ‘SHELL model’ in its analytical tool.

ECCAIRS’ analytical tool allows users to perform three levels of analysis by using the query builder. For every occurrence (event), the user is able to analyse level 1 (occurrence categories), level 2 (symptoms) and level 3 (casual factor) (see Figure 3). To perform these, the user first needs to determine which level of analysis is required before building the query.

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\(^1\) ECCAIRS is a cooperative network of European Transport Authorities and Accident Investigation Bodies which started in 1995. It is managed by the Joint Research Centre of the European Commission and is used by all European Union member States and is also widely used by non-EU safety agencies. Currently, both ICAO and the Airline Pilots Association are also ECCAIRS users.
Taking an example of an engine in-flight shutdown occurrence, the following could be the query builder for all three levels of analysis (see Figure 4):

Once the query is built, the user will name the query and store it in the system for future use – in this case, the query is named “In-flight shutdown (IFSD) occurrences”. When the database has collected sufficient safety data and is ready for analysis, the user will select and run the “IFSD” query. The system will then search through the database and filter all in-flight shutdown occurrences with fields (e.g. event type, event phase, descriptive factor etc) that fulfil the above criteria.

In most cases, the occurrence event type is commonly used as one of the criteria. Figure 5 is a typical event type page example:
After filtering, the data can be used to plot graphs and charts for trending and analysis. The user may choose to further enhance the query by adding more criteria to specifically look at a particular airline, engine type, aircraft type, specific period/time frame and so on.

In the event the analysis indicates an uptrend of a particular event type (see Figure 6), the next consideration would be whether this trend has exceeded the acceptable safety limit.

![Figure 6: Example of a graphical representation of IFSD occurrences](image)

SAFETY PERFORMANCE MEASUREMENT AND MONITORING

‘Safety measurement’ is not a continuous process; it is a spot check and is conducted following a pre-specified period. ‘Safety performance measurement’, on the other hand, is a continuous process and it monitors and measures selected operational activities.

The following are the definitions of key elements which will be discussed in this section:

- **Level of safety**: The degree of safety of a system – it is an emerging property of the system, which represents the quality of the system from the safety perspective, and is expressed through safety indicators;
- **Safety indicators**: The parameters that characterise and/or typify the level of safety of a system;
- **Safety targets**: The concrete objectives of the level of safety;
- **Acceptable level of safety (ALoS)**: The minimum degree of safety that must be assured by a system in actual practice;
• **Safety indicator value:** The quantification of a safety indicator; and

• **Safety target value:** The quantification of a safety target.

The selection of appropriate SPIs is important as it is an essential foundation for performance measurement and is key to the development of ALoS.

ICAO Doc 9859 states that “If the level of safety is to be represented in broad, generic terms, the selection of safety performance indicators representing high-level/high-consequence system outcomes (quantitative) and/or high-level system functions (qualitative) is appropriate.”

Some examples of SPI representing high-level/high-consequence system “outcomes” are accident rates and serious incident rates. Examples of high-level system “functions” include absence/poor legislation and regulations as well as regulatory non-compliance.

ICAO Doc 9859 also specifies that “If the level of safety of the system is to be represented in specific, narrow terms, then the selection of indicators representing low-level/low-consequence system outcomes and low-level system functions is required.”

Examples of SPI representing low-level/low-consequence system “outcomes” are the number of rejected take-off events per number of flight hours or flight cycle, the number of bird-strike events per number of departures, the number of foreign object debris events per number of departure and so on. Some low-level system “functions” examples are absence/poor procedures and instructions as well as ineffective quality assurance system such as audits, inspections, checks and reviews.

The above examples of SPI can be adopted from the ECCAIRS classification types, for example accident, incident and category type such as in-flight shutdown, bird-strike, Controlled Flight into Terrain (CFIT), traffic alert and collision avoidance system and so on. Since SAIRS’ safety data are stored in ECCAIRS format, CAAS has decided to adopt some of the ECCAIRS classification types for its high-level/high-consequence SPIs and the ECCAIRS category types for its low-level/low-consequence SPIs. In both cases, meaningful SPIs must be representative of the outcomes, processes and functions that characterise system safety.

Once the SPIs have been established, the ALoS will be set for each of these SPIs. The setting up of an ALoS may seem simple, but a good and meaningful ALoS could take years to develop. A well established database with comprehensive safety data could expedite this process.

The last element for safety performance measurement and monitoring would be to set up the safety targets. Some typical examples of safety targets are reduction in accidents, serious incidents, reject take-off events, bird-strike events and CFIT.
Figure 7 shows a sample of how SPI, ALoS and safety target are being applied. From the analysis charts and graphs, State safety agencies could interpret the trend or even predict a certain trend pattern of a particular indicator. With this information, State safety agencies can device safety intervention and/or mitigating strategies to address or break those undesirable trends.

SAFETY PRECAUTION AND RECOMMENDATION
Following the identification of areas of safety concern, safety precautions and recommendations are required to address these actual or potential deficiencies.

Safety precautions and recommendations should be practical and achievable. In cases where the areas of concern are very technical or specialised (e.g. aircraft systems-related or human factor-related), a subject matter expert who has the relevant knowledge would be able to establish good and effective mitigating actions. Safety recommendations could also be derived from investigations and safety studies.

With the application of proactive and predictive approaches, State safety agencies should establish a process/system to implement safety precautions and recommendations effectively. Apart from just implementing these safety measures, the process should also monitor the state of implementation and effectiveness.

The key safety management activities are shown in Figure 8. In order to effectively implement such safety measures, the cooperation and partnership between industry and the State safety agencies are very important. Regular safety meetings with the industry and organising regular safety seminars for the industry are key safety management activities.
SAFETY DATA EXCHANGE

Most States are not comfortable with exchanging safety data for various reasons, one of which is the sensitivity of the information. As the possibility of safety data misuse is high, there should be some form of disclaimer clauses or mutual agreements in the safety data exchange programme to protect the information, sender and any person or organisation from any legal liabilities.

Nonetheless, ECCAIRS’ software has the provision to de-identify safety data so that sensitive information can be removed and only relevant information is shared with ICAO, other States and the relevant safety organisations. This flexibility would encourage States who use ECCAIRS to share or exchange safety data with others.

With ECCAIRS, airlines and other aviation-related organisations can also be confident that their State safety agencies are not exchanging information that will compromise their safety standing or corporate image.

Therefore, if a State identifies any safety matters that are considered to be of interest to other States, it should be forwarded to them as soon as possible.

In addition, safety information that is relevant to local/foreign organisations such as original equipment manufacturers, approved maintenance organisations and vendors, should also be forwarded to them.

Under the SSP, States should also promote the establishment of safety information free exchange/sharing networks among local/foreign organisations through the SMS.
CONCLUSION
Under the Singapore Safety Data Collection and Processing System, SAIRS was established in early 2010 to fulfill the SSP and SMS initiatives for aviation safety data collection, analysis and exchange. This was made possible with the help of the ECCAIRS software and the revamping of the entire reporting system framework.

In addition to SAIRS, SOMS was also developed in 2009. Together, it will be a comprehensive one-stop operational system streamlining audits, inspections and approval functions by capturing, storing and managing safety-related information. It is a secure system that enables real time audit data capture, automated tracker on action items and comprehensive generation of management report.

With the future integration of SAIRS and SOMS, CAAS will be able to perform the collection, analysis and exchange of safety data at an aggregated State level. CAAS intends to share these web-based systems as a leading, robust and portable solution that can be easily implemented to any interested State’s safety.

CAAS is certain that, with the help of technology, these safety management functions and initiatives can be performed and freely shared at a higher level of integration globally.

References
ICAO Annexes to the Convention on International Civil Aviation