



ASSEMBLY — 42ND SESSION

TECHNICAL COMMISSION

Agenda Item 24: Aviation Safety and Air Navigation Priority Initiatives

STANDARDIZING QUANTIFICATION OF ACCIDENT SEVERITY

(Presented by Canada)

EXECUTIVE SUMMARY

This paper introduces a methodology to quantify accident severity based on injury, fatality and aircraft damage level information that is typically available in accident reports for all member states. It is intended to complement existing unsafe outcome measures used in State's safety risk management such as the fatality risk measure and other reactive and proactive indicators in support of prioritizing safety risks. The methodology offers a standardized global accident severity measurement that considers direct human impacts (fatalities and serious injuries) and material impacts (aircraft damage levels based on average sector value of aircrafts). Adopting this standardized method would enhance benchmarking of accident severity across operation sectors and member States, which could serve as the indispensable element in advancing the standardized and structured approach for the quantification of risks in the aviation safety management under Annex 19 – *Safety Management* of the Chicago Convention.

<i>Strategic Goals:</i>	This working paper relates to <i>Every Flight is Safe and Secure</i> .
<i>Financial implications:</i>	Negligible
<i>References:</i>	Annex 19 – <i>Safety Management</i> Doc 9859, <i>Safety Management Manual</i> (SMM) Doc 10159, <i>Safety Intelligence Manual</i> (SIM) Doc 10004, <i>Global Aviation Safety Plan</i> (GASP)

1. INTRODUCTION

1.1 ICAO provides a wealth of documentation, guidance and tools to support States and aviation stakeholders in the effective management of safety. From Annex 19 – *Safety Management*, the *Global Aviation Safety Plan* (GASP, Doc 10004) and roadmaps, the *Safety Management Manual* (Doc 9859) and the recently published *Safety Intelligence Manual* (Doc 10159), ICAO continues to put forward taxonomies and risk management approaches that help structure and standardize how we manage aviation safety globally. Implementing these practices facilitates sharing and benchmarking across the world.

1.2 Existing safety risk management guidance provides many options to quantify risks that have materialized as well as to evaluate potential consequences of safety hazard with the view to prioritize mitigation of risks that pose the highest threat. Effective prioritization must consider retrospectively, the risk that has materialized; and proactively, the risk that could materialize. Aside from accident counts and the fatality risk measure, very few methods are offered for States to use to quantify the severity of aviation accidents that have occurred, even less so a severity measure that considers fatalities, injuries and damage to aircraft. The accident severity quantification serves as the indispensable reference for the assessment and forecast of risks that ever happened. It is not meant to substitute existing risk measurement in safety management activities.

1.3 The methodology proposed in this paper introduces a quantitative approach to use as part of a State's suite of safety risk management measures that can be applied to accidents which supplements the fatality risk measure. It includes a broader set of criteria (fatality, serious injuries and aircraft damage) and uses accident data that is generally widely available to all States. Its adoption is therefore not dependent on States accessing operational or protected industry data.

2. STANDARD METHOD TO QUANTIFY SEVERITY OF ACCIDENTS

2.1 Severity score of an accident

2.1.1 First and foremost, while there is consideration of monetary value (value of statistical life and value of aircraft), as a matter of principle the methodology was intentionally designed so that (1) the resulting score does not represent a monetary value, and (2) the impact to human life has greater weight (70%) than aircraft damage (30%) in the severity formula. All scores in this methodology are set in a range from 0 to 100, where score is higher as severity increases. The accident severity score is the sum of the weighted casualty score and of the weighted aircraft damage score, as illustrated by the following formula:

$$\text{Accident Severity Score} = \text{Casualty Score} * 70\% + \text{Aircraft Damage Score} * 30\%$$

2.2 Casualty score

2.2.1 The casualty score is based on the fatalities equivalent concept measure loss of life and serious injury that resulted from an accident (onboard passengers and crew; and any related casualties on the ground). Minor injuries have been excluded from this methodology considering the minimal impact that they have on those that have sustained them.

2.2.2 Fatalities equivalent

2.2.2.1 The Fatalities Equivalent formula creates a single variable combining fatalities and injuries:

$$\text{Fatalities Equivalent} = \text{Number of Fatalities} + \text{Lamda} * \text{Number of Serious Injuries}$$

2.2.2.2 Based on life insurance industry practices in North America, serious injuries typically represent 1/6th of the value of statistical life (VSL). To reflect this valuation, the coefficient *Lamda* of 1/6 is applied to serious injuries to convert them into fatalities equivalents. For example, an accident with 2 fatalities and 2 serious injuries would therefore have a fatalities equivalent of 2.34 Fatalities Equivalent (2 fatalities + 1/6*2 serious injuries).

2.2.3 Mapping fatalities equivalent to casualty score

2.2.3.1 Fatalities Equivalent ranges were created based on historical statistical distribution and mapped to a corresponding Casualty Score band (Table 1). In this method, an accident with a Fatalities Equivalent of 2.34 would have a Casualty Score of 40.

Table 1 Criteria in mapping fatalities equivalent to casualty score

Fatalities Equivalent	Casualty Score
0	0
(>0, 1]	20
(>1, 5]	40
(>5, 20]	50
(>20, +∞)	100

2.3 Aircraft damage score

2.3.1 The Aircraft Damage Score is based on the reported damage level in accident investigation reports and on the average value of aircraft in a given sector of operations. Other asset categories (e.g. vehicles, buildings) and on-board cargo are excluded considering the great variability in the value of those assets. This accident severity methodology only uses damage to aircraft.

2.3.2 Aircraft damage value

2.3.2.1 The aircraft damage value is based on the sector average cost of the aircraft involved in the accident, and the extent of the damage reported, illustrated by the following formula:

$$\text{Aircraft Damage Value} = \text{Aircraft Sector Average Cost} * \text{Aircraft Damage Percentage}$$

Table 2 Typical aircraft damage levels in accident investigation reports and suggested corresponding damage percentage for aircraft damage score

Damage Level Description	Damage Percentage
Hull Loss	100%
Substantial	40%
Minor	10%
No Damage	0%

2.3.3 Mapping aircraft damage value to aircraft damage score

2.3.3.1 Aircraft damage value ranges were created based on typical aircraft values in different operational sectors (e.g. flight training, air taxi, etc.) and mapped to a corresponding Aircraft Damage Score (Table 3). In this method, an accident with an aircraft damage value of \$900K would have an Aircraft Damage Score of 20.

Table 3 Criteria of mapping aircraft damage value to aircraft damage score

Aircraft Damage Value in Dollars	Aircraft Damage Score	Operational Sectors
0	0	NA
\$1 – 100,000	5	UAS, Flight Training, Recreational Aviation
\$0.1 - 1 million	20	Flight Training, Recreational Aviation
\$1 - 3 million	40	Aerial Work, Air Taxi, Air Commuter, Recreational Aviation
\$3 - 10 million	50	Air Commuter, Private Aviation
>=\$10 million	100	Airlines, Foreign Airlines

2.4 Benefits of adopting this standard accident severity method

2.4.1 Consideration of fatalities, serious injuries and aircraft damage better recognizes the actual severity of aviation accidents. The method can be applied universally to all aviation operations irrespective of size and complexity. Application across States would support international benchmarking and collaboration.

2.4.2 The method offers several potential applications supporting State safety risk management. For example, for cumulative or average severity by sector, by occurrence category; criteria in the identification of high-risk categories (HRC) of occurrences; component in safety risk formulas; part of any tool to guide resource allocation to higher-risk areas in the aviation system.

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