HARISH RABADIA, Msc
Email: harish.rabadia@wfp.org
United Nations World Food Programme
PO Box 120390, SAIF Zone, Sharjah, UAE
IVAN SIKORA, PhD
Email: ivan.sikora.1@city.ac.uk
Department Mechanical Engineering and Aeronautics
The School of Mathematics, Computer Science and Engineering
City University London, SCME,
Northampton Square, London, EC1V 0HB, United Kingdom

CUSTOMIZING RISK ASSESSMENT FOR OPERATION IN CHALLENGING ENVIRONMENT

ABSTRACT

Safety management systems (SMS) are being implemented globally by stakeholders in the aviation industry. Safety risk management, which includes identification of hazards, assessment of risk and the mitigation of risk, forms a core element of the SMS. Many service providers that are required to implement a SMS use standard risk assessment processes without first establishing if it is most effective for their organization and customising it to meet their objectives. This paper discusses the need for development of a customized risk assessment process that reflects an organizations appetite for risk. A detailed risk assessment process is also developed for humanitarian operations and practically applied to determine the high risk concerns that that enables a mature decision making process to determine controls for mitigating the risk.

KEY WORDS

Risk; Safety Risk Management; Risk Assessment; Risk Matrix; Humanitarian Air Operations

1. INTRODUCTION

The aviation industry comprises of a wide range of service providers that are required to implement a safety management system which, at the least, is required to identify hazards, assess the associated risks and implement remedial actions to maintain an acceptable level of safety.

There are several instances when service providers are faced with challenging situations in which they have to accept relatively higher risk to carry out an operation. For example, even though there is a higher risk of operation into 'stolports'[1] and 'altiports'[2], whose standards are not precisely defined by ICAO, these airports are created because their benefits outweigh the risk of operating at these locations and their infrastructure is developed to support as safe and effective a public air transport as possible under the circumstances. This offers social and economic advantages in areas constrained by limited space or restricted terrain.

[1] ICAO defines stolports as "unique airports designed to serve airplanes that have exceptional short-field performance capabilities".

[2] An altiport is a small airport in a mountainous area with a steep gradient runway, used for landing up the slope and for take-off down the slope, thereby making use of only one approach/departure area.

Similarly, air operations conducted during emergency and rescue missions in wars and natural calamities are carried out with relatively higher risks but offer the all-important benefit of saving lives of individuals affected by such emergencies.

From the examples above, we understand that the ‘amount’ of risk that is tolerable in different organizations is unique and closely tied to its objectives. The standards and guidance included in the Safety Management Manual (SMM) (ICAO Doc 9859 2013) provide the foundation for the notion of Acceptable Level of Safety (ALoS) and continuous improvement. According to the SMM the criteria for ALoS “may vary depending on the specific context” (ICAO Doc 9859 2013: 4-12). For this reason, each organization must first establish clear guidelines on how it determines the amount of risk that is acceptable to them.

This paper discussed the development of a customized risk assessment process that can be implemented in high risk environment such as the operation carried out by the United Nations Humanitarian Air Service (UNHAS).

2. RISK CALCULATION

2.1 Probability and severity

ICAO defines safety risk as “the predicted likelihood and severity of the consequences or outcomes of a hazard.” This definition in itself forms the foundation of the risk assessment process outlined in the SMM. There are two important elements to this definition:

1. Risk is only a “prediction”, therefore, it is a highly subjective term and organization must develop proper guidance to standardize its use.
2. Risk is a combination of likelihood and severity of an occurrence. This combination can be done in many ways to determine a value that best represents the risk.

The calculation of ‘risk value’ is based on the worst foreseeable consequence of a hazard. It is important to account for this because one hazard can to lead to several occurrences and the outcome may be different each time. For example, a hazard report involving a ‘near air miss’ when two airborne aircraft miss colliding with each other may be classified as a significant occurrence, but the worst foreseeable consequence of this hazard could well be an accident if the crew are unable to take the right actions to avoid a mid-air collision.

The process developed by ICAO is in the form of an alphanumeric risk assessment matrix (Figure 1). This matrix allows the determination of a risk value that represents the risk. The alphanumeric values can often be confusing but nevertheless this matrix is widely used to estimate the risk.

Risk probability		Risk severity				
		Catastrophic A	Hazardous B	Major C	Minor D	Negligible E
Frequent	5	5A	5B	5C	5D	5E
Occasional	4	4A	4B	4C	4D	4E
Remote	3	3A	3B	3C	3D	3E
Improbable	2	2A	2B	2C	2D	2E
Extremely improbable	1	1A	1B	1C	1D	1E

Tolerability description	Assessed risk index
Intolerable region	5A, 5B, 5C, 4A, 4B, 3A
Tolerable region	5D, 5E, 4C, 4D, 4E, 3B, 3C, 3D, 2A, 2B, 2C, 1A
Acceptable region	3E, 2D, 2E, 1B, 1C, 1D, 1E

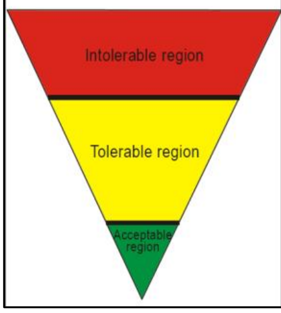

Figure 1 - Risk assessment matrix in Safety Management Manual: [4]

To simplify the estimation of the risk, UNHAS uses a similar risk assessment matrix using numerical values only (Figure 2). It denotes a linear risk value ranging from 1 t0 25 (1 being the lowest and 25 being the highest risk) as a product of severity and likelihood (probability). Though it is easier to comprehend risk using a linear scale, it can be argued that this process makes no distinction between the values used for severity and probability as indicated in Figure 2. This is a limitation because the outcome of severity is far more significant than probability.

SEVERITY		LIKELIHOOD				
		FREQUENT	OCCASIONAL	REMOTE	IMPROBABLE	EXTREMELY IMPROBABLE
	VALUES	5	4	3	2	1
CATASTROPHIC	5	25	20	15	10	5
HAZARDOUS	4	20	16	12	8	4
MAJOR	3	15	12	9	6	4
MINOR	2	10	8	6	4	2
NEGLIGABLE	1	5	4	3	2	1

Figure 2 - Risk assessment matrix in ASM: [8]

2.2 Defences

A two dimensional risk assessment process as shown above fails to account for the key element of 'defences' that have been developed by the aviation industry over many decades. It is a mature industry that has built several layers of defences to prevent accidents and serious incidents. It is vital to carry out an analysis of the existing defences and evaluate their effectiveness before concluding the risk value of any given hazard.

To explain using an example, even though the risk of Controlled Flight Into Terrain (CFIT)[3] is 'unacceptable' in humanitarian air operations, there are already several defences in place. These include performance of flights in day visual conditions only, establishing minimum safe altitudes for each route, the operation of twin engine aircraft with consideration for single engine ceiling and installation of Class A Terrain Awareness and Warning system (TAWS). All these defences are quite effective and hence make the risk of CFIT in humanitarian operations quite low.

It is therefore important to factor all the existing defences before determining the final risk value of a hazard.

3. RISK GUIDANCE

The objectives of UNHAS obliges the organization to provide humanitarian assistance wherever it is needed or requested. Many of these operations are carried out during emergencies and therefore leave no choice but to engage in air operations that have a generally high risk.

The organization must therefore find ways in which it can maintain an acceptable level of safety performance (ALoSP). The key term here is 'acceptable'. Since UNHAS management accepts a much higher risk when compared to other commercial air operations around the

[3] This refers to an inflight collision or near collision with terrain, water, or obstacle without indication of loss of control

world, it needs to go beyond conventional methods to understand and manage the risk in the air operation.

In line with its objectives, the risk assessment guidance was developed to identify those hazards that pose the greatest danger to fatally or seriously injure any occupant travelling in UNHAS contracted aircraft. The damage to aircraft and property is important but is a secondary consideration because these are adequately covered through insurance.

The below risk assessment process was tested using a trial and error method over a six month period (March to September 2014) utilising data from the UNHAS hazard database. The main elements used in the development of this process are:

- Severity of the consequence of a hazard
- Probability that an occurrence will happen
- Effectiveness of existing defences to reduce the risk

The trial and error method involved testing various numerical values for these three elements in a formula that was developed to calculate the 'risk value'. Fixed values were assigned with designated descriptions that best represent the risk in humanitarian operations. According to the description, a value for each element is chosen and used in the formula to derive the 'risk value'. The values and descriptions are given below:

Severity	Value (*S*)	Description of Severity of Occurrence
Catastrophic	25	Accident where most passengers are likely to be fatally injured
Major	20	Accident where passengers are likely to get injured and some fatally
Significant	15	Degradation of safety margins where passengers and/or external people are likely to get injured
Minor	10	Limited consequences causing slight injury to passengers and/or external people
Negligible	5	No injuries

Probability	Value (*P*)	Description of Probability of Occurrence	Approx rate of occurrences per 100,000 Hours
Certain	4	It is certain that the aircraft will be exposed to the hazard as there are no defences in place	100
Frequent	3	There will be several occurrences due to the hazard	50
Likely	2.5	There may be occurrences due to the hazard	10
Possible	2	Isolated occurrences may happen	1
Exceptional	1.5	Rare occurrences known to occur in similar operations	0.1

Effectiveness of Defence	Value (*D*)	Description of Effectiveness of Defence
Missing	0%	no defence in place
Weak	10%	may work some of the time but needs improvement
Likely	25%	likely that defence can work but needs improvement
Assured	50%	effective most of the time
Certain	100%	hazard has been removed

Using the above values, a final risk value ranging from 0-100 is deduced using a simple formula. This formula is based on the relationship that the risk value *R* is equal to a product of the severity *S* and probability *P*. Since this paper incorporates the third factor i.e. existing defences, the probability is reduced based on the effectiveness of the defence *D.* Therefore the risk value,

$$R = S \times [P - (P \times D)] \quad (1)$$

Applying this formula to a practical scenario in humanitarian operations, the calculation of the risk value for 'runway incursion by wildlife' is explained below.

The example considers an unfenced aerodrome located close to a settlement with a focal point on ground who is responsible for ensuring that the runway is clear before an aircraft arrives.

Severity: There is likelihood of an accident where passengers are likely to get injured and some fatally due to incursion by large domestic animals such as cattle, donkeys, camels etc. i.e. Major (*S* = 2o).

Probability: There will be several occurrences due to the hazard based on historical information for similar aerodromes and the fact that the runway is unfenced and located close to a settlement i.e. Frequent (*P* = 3)

Effectiveness of defence: May work some of the time but needs improvement since a focal point cannot always ensure that the entire runway is clear of wildlife at the time of landing i.e. Weak (*D* = 10%)

Therefore, the risk value

$R = 20 \times [3 - (3 \times 10/100)]$, so

$R = 54$

The risk value obtained can then be assessed using the customized risk tolerability matrix in Figure 3 for decision making and acceptance of the risk. It indicates four levels of risk ranging from:

- 0-24 Low risk
- 25-49 Medium risk
- 50-74 High risk
- 75-100 Extremely high risk

Severity		Probability				
		Certain 4	Frequent 3	likely 2.5	Possible 2	Exceptional 1.5
Catastrophic	25	100	75	63	50	38
Major	20	80	60	50	40	30
Significant	15	60	45	38	30	23
Minor	10	40	30	25	20	15
Negligible	5	20	15	13	10	8

Figure 3 - Risk Matrix [Authors]

The formula assumes that the defences always reduce the probability of an occurrence. Though this is true in majority of the cases, in rare instances a defence may also reduce the severity of an occurrence. In this case, it is important to reduce the severity value of the occurrence when calculating the risk value. For example, the severity of runway excursion on a gravel runway with a ditch running along the side of the runway is 'catastrophic' (*S* = 25), however, if the ditch is levelled, the probability of the runway excursion still remains the same, but the severity is reduced to 'significant' (*S* = 15). Hence, the levelling of the ditch is a defence that reduces the severity and not the probability of the occurrence.

4. APPLICATION OF RISK ASSESSMENT

UNHAS has a comprehensive database of occurrence and hazard information containing over 20,000 reports recorded from 2004 to date.

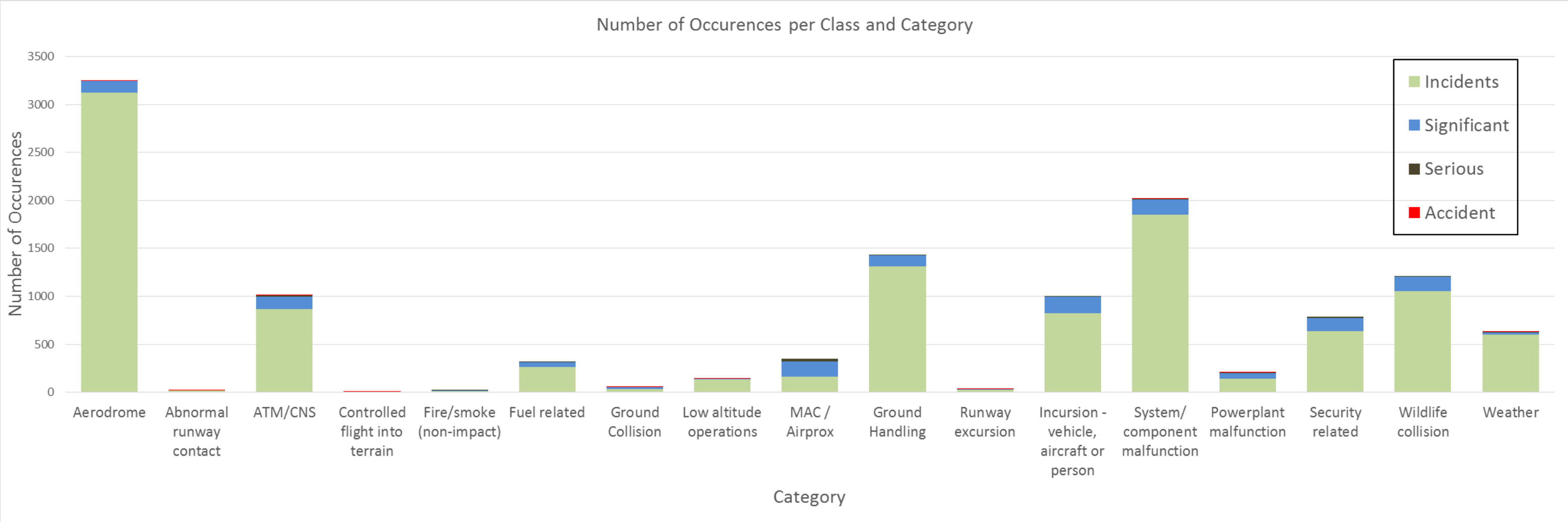

Figure 4 - Total number of WFP occurrences per category of events [Authors]

The graph in Figure 4 shows the most prominent category of occurrence reports in the database. It includes the number of occurrences which are further broken down into different categories and classes. It does not include all the categories used in the database to avoid cluttering the report with categories that do not represent a high risk. The graph shows that aerodromes, aircraft system/component malfunctions, wildlife collision, ground handling, Air Traffic Management (ATM), runway incursions by vehicles, aircraft, and people are the most reported occurrences in UNHAS operations in that order.

The risk assessment process described in this paper was applied to this database to identify those high risk hazards that have the greatest potential to lead to serious incidents and accidents. The analysis revealed the main categories of hazards that represented the highest risk in humanitarian air operations. These high risk categories are put into two groups that are deemed to be broadly similar. The Mid-Air Collision (MAC) and Air Traffic Management (ATM) related categories form the first group and all other categories come under the second group, aerodrome safety standards. These are further explained below.

5. NEAR MID-AIR COLLISION

MAC and ATM represent the high risk hazards that have the potential of causing inflight collisions with other aircraft. The primary reasons that this category is a serious concern for areas in which humanitarian operations are carried out include:

- Poorly designed airspace structure
- Unqualified air traffic controllers
- A combination of military and civilian operations
- Operation of Drones and Unmanned Air Vehicles (UAV)
- English language proficiency of Russian and Eastern European flight crews
- Aircraft not installed with transponders or transponders that are intentionally switched off

Even though the threat of Mid-Air Collisions is one of the main safety concern in areas where humanitarian flights are conducted, there are already some controls in place such as the mandatory requirement for a functional Aircraft Collision Avoidance System (ACAS II) on every flight. This is especially enforced in high risk countries such as Afghanistan, Sudan and Somalia which have weak air traffic management.

6. AERODROME SAFETY STANDARDS

The high risk categories of reports that are either directly or indirectly linked to the lack of standards for operations in unlicensed aerodromes are abnormal runway contact, runway excursion, runway incursion by vehicles, aircraft, people and wildlife and security related events. There are several occurrences in these categories primarily due to the poor conditions in unlicensed aerodromes used for humanitarian operations.

The state in which an air operation is carried out is normally responsible only for certified aerodromes in the country. However, the state assumes no responsibility for ‘unlicensed’ aerodromes and it is therefore eventually up to the operator to assume the final responsibility for carrying out safe operations in such aerodromes.

The operators therefore develop their own procedures, which are approved by the state of the operator, to ensure safe operation in these aerodromes. With no clear standards and guidance available for operations in remote locations, most operators develop basic standards which do not restrict them from carrying out operations and rely primarily on the decisions of experienced pilots to ensure the safety of operation.

7. CONCLUSION

A robust risk assessment process forms the foundation for an effective risk management system. Organizations must first have a clear understanding of risk, and standardize its assessment in a way that is useful and relevant to the organization. The process needs to clearly identify those hazards that have the potential to lead to serious incidents or accidents. The identification and addressing of these high risk hazards forms the key to preventing accidents.

The customization of the risk assessment process is essential since the appetite for risk is unique in each organization and based on its objectives. The process for developing a customized risk assessment process that is described in this paper should be followed by each organization to develop a practical tool that clearly identify high risk hazards.

The risk assessment tool developed for humanitarian air operations was practically implemented to identify the main high risk hazards in the operation. This forms the foundation that allows a mature decision making process to determine controls for mitigating the risk.

REFERENCES

[1] Global Aviation Information Network 2nd edition of the Role of Analytical Tools in Airline Flight Safety Management System, 2004
[2] Annex 19 to the Convention on International Civil Aviation Authority – Safety Management, ICAO, 2013
[3] Christopher A. Janicak, Safety Metrics: Tools and Techniques for Measuring Safety Performance, 2010
[4] Doc 9859 3rd edition of the Safety Management Manual, ICAO, 2013
[5] Manuel, A.: Reviewing Heinrich: Dislodging Two Myths from the Practice of Safety, 2011
[6] Muller R., Wittmer A., and Drax C.: (2014) Aviation Risk and Safety management: Methods and Applications in Aviation Organizations, 2014
[7] Stolzer A., Halford C., and Goglia J.: Safety Management Systems in Aviation, 2010
[8] 3rd edition of the Aviation Safety Manual, WFP, 2009