Changes in Aviation Organisations

Perspective and retrospective assessment for a medium size Airline

P. C. Cacciabue, M. Cassani
KITE Solutions, SRL,
Laveno Mombello (VA),
Italy
carlo.cacciabue@kitesolutions.it

I. Oddone, A. Ottomaniello
Air Dolomiti,
Safety Department,
Dossobuono di Villafranca, Verona, Italy
IOddone@airdolomiti.it

***Abstract*— This paper describes a methodology for the practical and straightforward implementation of risk assessment processes to be implemented as part of SMS and able to tackle real problems. The general features of a tool for risk assessment are identified. Then the actual flow chart of the methodology is presented and the stepwise procedure is discussed. Finally, three specific practical applications are presented that show how the methodology may be implemented in response to specific needs of an organisation.**

Aviation Safety, Safety Management System, Risk Analysis, Management of Change

I. Introduction

The Safety Management System (SMS) is an elaborate and comprehensive approach aiming at assessing proactively the level of safety reached and maintained by an organization at operational level. The national and international authorities responsible for implementing an orderly development of civil aviation moved from a traditional attitude towards safety to SMS in recent years.

In particular, the International Civil Aviation Organization (ICAO), the Federal Aviation Administration (FAA), the European Aviation Safety Agency (EASA) and the European Commission (EC) included the implementation of SMS in their strategic plans [1] [2] [3].

In many technologically advanced domains, such as energy production, oil and gas industry and process systems the implementation of SMS is a consolidated approach to assess safety [4] and to comply with regulatory requirements [5]. The methodologies and techniques for hazard assessment and risk management are widely established and are commonly applied [6].

Essentially, the implementation of SMS requires the move from the concept of deterministic safety assessment, based on the capability of an organization to respond and contain the maximum credible accident, to the capacity to face the risks associated to credible events in a probabilistic perspective. The deep cultural change and effort that the application of SMS requires, at economical and organizational level, has led to a delay in the definition of shared mandatory guidelines by the international civil aviation authorities. This paper describes a methodology based on the concept of risk assessment and able to tackle real problems, to be straightforwardly implemented as part of SMS. The Risk Assessment Methodology for Company Operational Processes (RAMCOP) supports the safety manager of an aviation organisation in respecting the requirements of a SMS and in selecting and implementing, in practice, a well-defined set of methods for risk assessment. Firstly, the general features of a tool for risk assessment are identified. Then the actual flow chart of the RAMCOP approach is presented and the stepwise procedure is discussed in detail. Finally, three specific practical applications are presented that show how the methodology may be implemented in response to specific needs of an organisation and in accordance to authority requirements.

II. Risk Assessment for Managing Company Operational Processes

A. Theoretical formulation

The RAMCOP methodology, developed during the span of MASCA (MAnaging System Change in Aviation) EU Funded Project during the 7th Framework Programme under grant agreement n° 266423, consists of a practical approach that offers a simple operational procedure for implementing the prerequisites of safety management systems set by the Authorities (Figure 1).

The methodology, previously described in detail in the open literature [7], focuses primarily on prospective analyses, given that a “change” in an organisation is associated to futuristic situations that can arise as a consequence of the change itself. The basic Steps of implementation the methodology are:

1. Development of the case by selecting the scope of the Change, identifying sources of data and available methods and methodologies.
2. Development of the Risk Assessment at qualitative and quantitative levels.
Following a very classical risk assessment approach, this process can be implemented combining technical solutions, based on numerical solution of theories about hazard definition and combination, with more practical and expedite approaches that make use of the

Expert Judgement (EJ) of knowledgeable staffs within the organisation. This process is repeated and revised for all hazards under scrutiny and represents the second Step of the methodology.

3) Finally, Step 3 implements the barriers and safety measures proposed by the safety analysts aimed at reducing the unacceptable risks identified in Step 2. It also implies the re-evaluation of the overall design for ensuring risk acceptability for the entire system in the revised configuration.

B. *Practical Implementation: The ORAT Table*

The methodology RAMCOP is a quite standard process of implementation of risk analysis and risk management. For an initial assessment of risks, the methodology ARMS [8], and the original approach called based on Cause –Consequence Analysis also known as BOW-TIE [9] can be fruitfully applied. In practice, the judgement of safety analysts is taken as principal source of information. In a second instance, the consideration for more sophisticated and alternative methods may be utilised in the case of situations and events of particular importance.

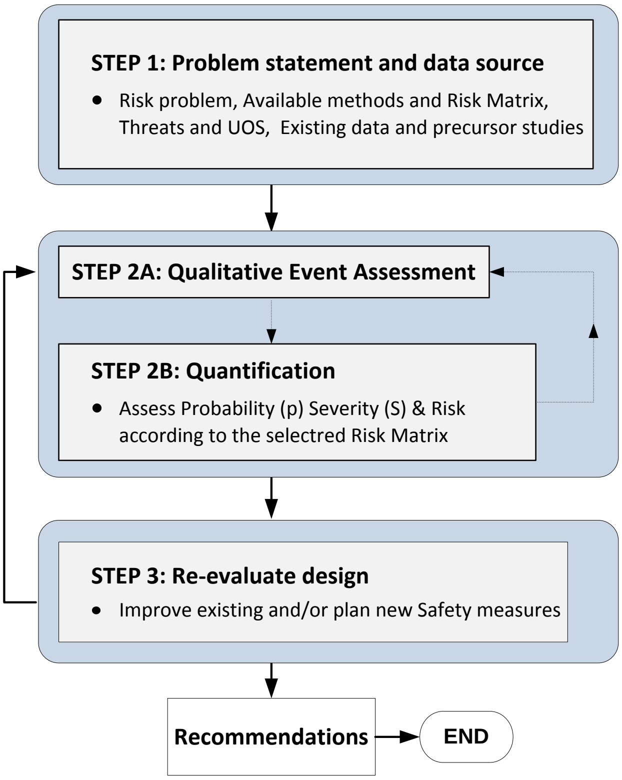

Figure 1. Risk Assessment Methodology for Company Operational Processes.

In practice it is proposed to gradually fill an Overall Risk Assessment Table (ORAT) that contains the key elements of the analysis and represents the way in which the methodology can be put into operation.

The ORAT Table is essentially equivalent to a standard ARMS/BOW-TIE application, where the first main columns are equivalent to the left-end side of a Bow-Tie methodology implementation and contain essentially the Threats that lead to Hazards, or Undesirable Operations States (UOSs). The remaining columns are equivalent to the right-end side of the Bow-Tie.

However, the number of columns contained in the ORAT Table, i.e., on both side of the “bow”, can vary according to the complexity of the case under study. For each specific hazard under study defined in the initial set of columns and corresponding to Step 1 of the methodology, all possible incidental evolutions are described and the associated consequences are identified with their probabilities of occurrence. The existing control measures (barriers) that contribute to reduce either severity of consequences or probability of occurrence are identified. Their effects are assessed in terms of reduction of consequences (Severity) and/or of probability of the sequence. The overall risk can therefore be assessed, in accordance to the reference Risk Matrix adopted by the organisation, by combining severity and probability associated to each sequence. This completes Step 2 of implementation.

The need of further mitigation is dealt in Step 3 and it is shown in a specific set of columns of the ORAT table. This phase implies the identification of additional barriers/mitigations and the assessment of new value of risks. When all risks are deemed, at least, acceptable, the actions to carry out for implementing the new safety measures and the subsequent process of monitoring and reviewing are made operative.

The ORAT table represents the practical implementation of the RAMCOP methodology. A table of this nature must be generated for each UOS to be studied. Moreover, depending on the specific activity or process, it may be convenient to split the table in several different sub-tables, associated, for example, to each consequence resulting from the same hazard, or to the combination of different threats leading to the same UOS, or else, to the implementation of different mitigation measures.

This simplification and optimisation of the process represents a further step of implementation of the methodology that cannot be formalised in a procedure, as it requires experience and engineering understanding of the way in which a risk assessment evaluation may be carried out.

III. The Dynamic Features of the RAMCOP Methodology

The dynamic nature of real systems and organisational processes implies that a number of questions are faced when evaluating and assessing real changes that occur, either as a consequence of management choice or for necessary modifications occurred for practical, regulatory or institutional reasons.

In particular, some key questions on validation of effectiveness and on completeness of barriers and safety measures implemented in the system for managing changes need to be addressed and require a deep understanding of the concepts of risk analysis and the application process RAMCOP methodology. In practice the questions to be tackled can be:

- Is it possible to apply the methodology proposed for handling risk associated to Change Management in a retrospective manner? Or how is it possible to validate the solutions implemented as the result of the prospective analysis specifically aimed at ensuring the overall safety in the presence of a change. Moreover, and more importantly:
- Are there other hazards, not identified in the prospective analysis, that need to be addressed as they may result in unacceptable risk for the organisation?

This implies the implementation of an appropriate process of retrospective analysis within RAMCOP that can be structured and combined with perspective assessment so as to ascertain that:

1. The hazards identified during Step 1 and studied in Step 2 of the prospective process are actually limited and contained by the mitigations and barriers implemented in Step 3.
2. No new hazards appear in practice after the implementation of the change in the Organisational processes.
3. On the other side, if new hazards are discovered during the retrospective analysis, they need to be studied and adequately dealt with, so as to ensure that they are contained in terms of the associated risks.

This typical retrospective type of analysis closes the loop of overall risk assessment. It must be implemented and become common practice in an organisation, in order to complete the SMS process of regular auditing and validation of the new hazards encountered by an organisation in its everyday operational processes, as well as during extraordinary circumstances.

The overall process is described in Figure 2 where the prospective analysis of a certain "change" is combined and correlated with the retrospective assessment process for the evaluation of the effectiveness of the barriers put into action and for assessing new hazards and barriers in order to completely contain the risks of the change within acceptable boundaries.

In practice, the retrospective approach differs from the prospective approach only in relation to Step 1, which implies that the validation of previously assessed hazards (UOSs) and/or the identification of new hazards is carried out by a field process. This process follows the classical steps of observation and data collection using integrated on-board technological systems as well as interviews and questionnaire implementation. These are widely known and fully discussed methods in the literature. The goals of these field assessments are clear and the results may be that all hazards identified in the prospective analysis are well contained and that no new hazards have been found. However, this is probably a very rare situation, as it is unlikely that that all possible and relevant hazards due to the "change" are discovered by the a-priory study. Therefore, it is expected that in most cases a further evaluation of new additional hazards is needed. Steps 2 and 3, when required, are exactly the same as those carried out for the prospective analysis.

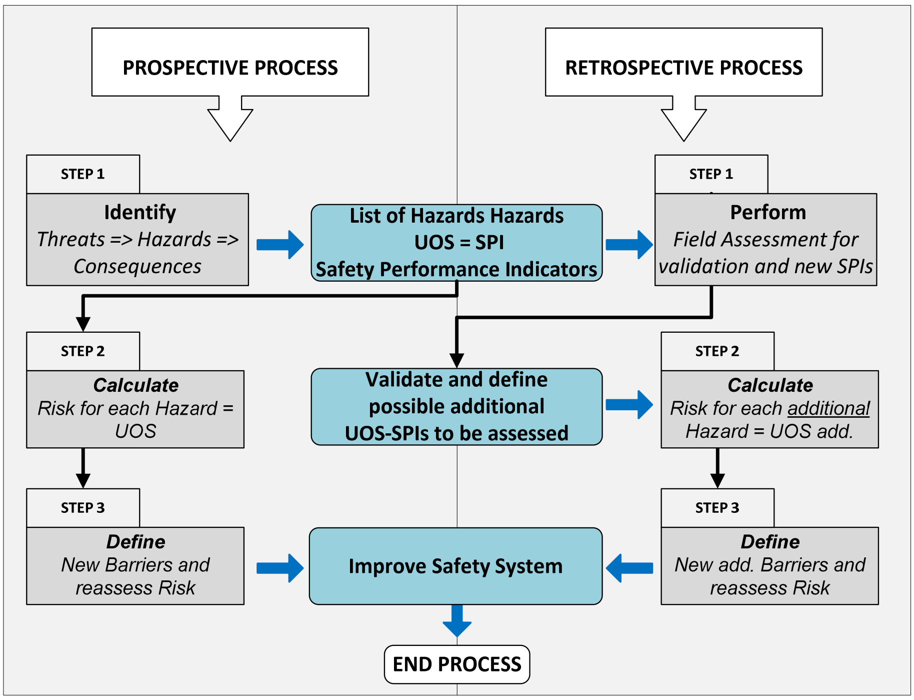

Figure 2. RAMCOP for prospective and retrospective risk assessment.

IV. THREE CASE STUDIES

The RAMCOP method has been applied to three real case studies of realistic changes that occurred in the Air Dolomiti (AD) Airline with important implications on the operational processes.

These three cases will be briefly discussed in the remaining of this paper and they show different ways of implementation of the methodology.

A. Flying in airspace contaminated by volcanic ash

The first case study discusses the assessment flying in airspace contaminated by volcanic ash, i.e., a modern and complex aviation issue. The problem presents the typical characteristics of a change management situation about novel conditions not previously encountered by the organization, requiring prospective risk assessment methodology [10].

Air Dolomiti objective was to develop and subsequently request acceptance of the risk assessment to fly into Area of Low and Medium concentration of volcanic ash, accordingly to EASA [11] and the Italian National Authority [12] bulletins.

In particular, the "investigational structure" applied to the flight into volcanic ash cloud was used as guideline for further analyses of critical activities of operational environments. Results obtained demonstrated a clear representation of the process underlining the most critical aspects that require immediate action in order to guarantee an acceptable safety level. These include the implementation of corrective actions able to mitigate the associated risk.

On the basis of literature studies and on the EJ of the AD safety team and operational and maintenance departments a total of 19 UOSs were selected that required assessment from a risk point of view and were associated to the threats that may generate them and the likely incident sequence that may follow from them.

An ORAT Table has been developed table that summarises the safety and risk considerations and assessments for all 19 UOSs. From this analysis it results that:

1. No unacceptable or high levels of risk were encountered.
2. For those UOSs showing risk levels requiring long term improvements or continuous monitoring, according to the adopted Risk Matrix, the appropriate mitigation activities have been planned.
3. No actions were planned for the UOSs showing negligible severity, i.e., area acceptable risk of the Risk Matrix.

TABLE I shows excerpt of such final overall risk assessment and control activities, with the corresponding mitigation action, for UOSs 2, 3, 11 and 14.

TABLE I. THE ORAT TABLE (PARTIAL) FOR ASH CLOUDS SAFETY STUDY.

Hazard		Existing Control	Outcome (Pre-Mitigation)			Additional mitigation required	Outcome (Post-Mitigation)			Actions and owners	Monitoring and Review requirements
No.	Incident sequence description		Severity	Likelihood	Risk		Severity	Likelihood	Risk		
2	Inadvertent volcanic ash encounter	VAAC data	Medium	Remote	Low	OPS monitoring data, IOC alert crew, NOTAM	Medium	Extremely remote	Negligible	IOC, Flight ops	Improved volcanic ash modelling
3	Inadvertent volcanic ash encounter	SOP procedure, OM	Medium	Remote	Low	Crew detailed information "comunicazione di servizio", Recurrent training program	Medium	Extremely remote	Negligible	Flight operation, training	
11	Emergency descent. Diversion. Pilot incapacitation. Loss of control. CFIT	No fly permitted into high ash concentration. Training Fuel planning Emergency procedure SOP EGPWS	High	Remote	Acceptable with mitigation	Pilot training. Avoiding procedure, emergency/contingency procedure. Recurrent training. New fuel planning due to medium low ash concentration route. MEL policy to permit flight into contaminated area	High	Extremely remote	Low	Flight operation Training IOC flight planning Maintenance	
14	Mid air collision	TCAS Pilot Training	High	Remote	Acceptable with mitigation	MEL policy to permit flight into contaminated area	High	Extremely remote	Low	Maintenance	

B. *Implementation of the Electronic Flight Bags system*

The second case study concerned the implementation within AD of the Electronic Flight Bags (EFB) system which is being gradually introduced in the company, starting with a family of modern aircraft already in operation and will expand to the whole fleet.

The implementation of the EFB technology is an operational change for an airline that aims at improving flight efficiency and effectiveness by replacing the paper copies of information and support material, typically carried on board by the pilots in their bags, with electronic files contained in laptops or integrated flight management control system [7]. The implementation and use of the EFB is an important change in the organization, as it is expected that there will be an overall return of effectiveness in the management of the operations and of efficiency by reducing the amount of time loss in correlating the work of ground and flying staff.

The RAMCOP methodology was fully applied in a prospective way for the assessment of the risks associated to the introduction of the EFB in the company practices. The qualitative and quantitative processes of evaluation of hazards and containment measures, including risks derived from possible human errors, were studied. As an example, in order to carry out the preliminary analysis of the static usage of the EFB and the configuration of the hardware carried on board and its usage for the pre-flight phase, a set of workshops and brain storming meetings have been performed in order to define the set of threats and hazards or undesirable operational states that may derive from the usage of the EFB systems.

The initial assessment of risks started by identifying the various hazards to be studied and building the associated UOSs to be assessed. In practice, 16 hazardous conditions (UOS) have been identified out of the list of hazards resulting from the preliminary analysis: 14 UOSs associated to the “static” operations of cockpit preparation and 2 UOSs occurring during the dynamic cockpit management and take-off operations. For each hazard the set of possible outcomes were selected and grouped, in accordance to the activity to carry out in Phase 2 of the RAMCOP approach.

In order to evaluate the probability of occurrence of each consequence, the process of evolution from the initial hazard (UOS) to the final event must be considered. For the static step of implementation of the EFB, the most appropriate method has been considered the TESEO approach [13]. However, TESEO requires the presence of an actual procedure or implementation of an activity carried out by operators in order to associate a probability of unsuccessful performance. Therefore, in some cases, it has been considered more appropriate the use of EJ or the analysis of the existing database of reports on incidents and near-misses.

For the sequences associated to the two UOSs of the dynamic use of the EFB, the human error probabilities have been assessed utilising an extension the THERP method [14]. In practice, the procedure of critical speed evaluation for take-off has been analysed evaluating different possibilities of errors for each pilot action, rather than utilising the simple binary alternative of success or failure, i.e., the classical THERP approach.

The results obtained from the assessment of the risk calculations associated to the 16 UOSs (Phase 2 of RAMCOP) identified a series of UOSs that demanded the implementation of further mitigation measures. These were implemented in Phase 3 of the methodology. As a result of this post mitigation activity the overall risk associated to the 16 UOS has been further reduced. The values of the risk for the post mitigation activity are shown in TABLE II, on the last columns. For readability purposes the last two columns of the standard table associated to Phase 3 of the RAMCOP methodology (“Actions and owners” and “Monitoring and review requirements”) have not been shown.

C. *Change in a company fleet with reduction of crews and redundancies*

The third case study concerns a very important change that occurred in the company in the timing period of the MASCA Project. It consist of a strategic and policy decision of the company to abandon an entire fleet of aircraft, the ATR family, and the consequent reduction of piloting staff.

Having the “70-seat aircraft” become inefficient on the feeder market in Europe in terms of revenue, the decision of replacing part of the ATR fleet with larger aircraft, has been taken, in order to be more competitive. In this way, while the available numbers of seats remained unchanged or was even increased, the overall fleet number has decreased. The plan involved a quite substantial reduction of the overall population of pilots and flying staff.

This case is, once again, a typical change management situation that required prospective assessment in order capture and consider the potential hazards or Undesired Operational States (UOSs) generated by the novel situation and the consideration of new and additional barriers and mitigation measures.

Moreover, the timing of implementation of the change covered several months. During this period the operation of the ATR fleet continue according to schedule. Therefore, this case offered a remarkable possibility to carry out a complete application of the RAMCOP methodology, i.e., the assessment and validation process for the hazards anticipated during the prospective analysis, by means of a retrospective approach.

1) *Prospective analysis*

In accordance to the process in force in Air Dolomiti an Operational Risk Evaluation (ORE) has been carried out as soon as the reduction policy was formally announced.

The ORE is a predictive programme used to detect possible hazards and negative consequences associated with the change (implementation of Step 1 of RAMCOP). As a consolidated policy within the Group the announcement of the redundancies was made one year in advance, to allow the redundant personnel to look for other employment.

TABLE II. OVERALL RISK TABLE (ORAT) FOR THE EFB CASE STUDY

Phase 1			Phase 2				Phase 3			
Hazard/ UOS No.		Incident sequence description	Existing control	Outcome (Pre-Mitigation)			Add. Mitig. required	Outcome (Post-Mitigation)		
		Consequences	Barriers	Severity	Probab.	Risk	Type of Barriers	Severity	Probab.	Risk
1	Software initialisation not completed	Flight div. or canc.	M-Q; TCAS; EGPWS	Low	Likely	Acc. with mitig.	Paper maps	*Low*	*Possible*	*Low Monitor*
2	Maps not available	Loss of separation	M-Q; TCAS; EGPWS	High	Remote	Acc. with mitig.	Paper maps	*High*	*Ext. Remote*	*Low Monitor*
3	Improper selection of portrait	Flight cancellation or delay	Training; SOP/EOP; TCAS; EGPWS	Low	Likely	Acc. with mitig.	Paper maps	*Low*	*Possible*	*Low Monitor*
4	Improper storage of PC	Damage to cables/PC and flight delay/cancel	M-Q; SOP	High	Unlikely	Acc. with mitig.	Paper maps; Training	*High*	*Ext. Remote*	*Low Monitor*
5	Pilots unable to locate maps	Loss of separation	Training; SOP/EOP; TCAS; EGPWS	High	Unlikely	Acc. with mitig.	Paper maps; Training	*High*	*Ext. Remote*	*Low Monitor*
6	Loss of SA	Loss of separation	Training; SOP/EOP; TCAS; EGPWS	High	Low	High	Paper maps; Training	*High*	*Remote*	*Acc. with mitig. Long term*
7	No charts on show	CFIT	M-Q; TCAS; EGPWS	Extreme	Ext. Remote	Acc. with mitig.	Paper maps;	*Extreme*	*Ext. Remote*	*Acc. with mitig. Long term*
8	Flying with wrong maps or without maps	Loss of separation	Training; SOP/EOP; TCAS; EGPWS	High	Unlikely	Acc. with mitig.	Paper maps; Training	*High*	*Ext. Remote*	*Low Monitor*
9	No coordinates for X-check with FMS	Ground collision with aircraft, vehicles or infrast.	ATC; SOP/EOP; Training	Extreme	Ext. Remote	Acc. with mitig.	Training	*Extreme*	*Ext. Remote*	*Acc. with mitig. Long term*
10	Getting lost on airfield	Runway incursion	ATC; EOP; Training	Medium	Unlikely	Low Monitor	-	*Medium*	*Unlikely*	*Low Monitor*
11	Missing performance	Mid Air Collision (MAC)	EOP; Training; EGPWS	High	Remote	Acc. with mitig.	Training	*High*	*Ext. Remote*	*Low Monitor*
12	Missing info. in the case of emergency	Loss of control in flight	ATC; EOP; Training; EGPWS	High	Unlikely	Acc. with mitig.	Paper maps; Training	*High*	*Remote*	*Acc. with mitig. Long term*
13	No info/news on obstacles	CFIT	ATC; EOP; EGPWS	Extreme	Ext. Remote	Acc. with mitig.	Training	*Extreme*	*Ext. Remote*	*Acc. with mitig. Long term*
14	Flying wrong departure	CFIT	ATC; EOP; TCAS; EGPWS	Extreme	Ext. Remote	Acc. with mitig.	Paper maps; Training	*Extreme*	*Ext. Remote*	*Acc. with mitig. Long term*
15	Inadequate speed for take-off	Tail strike	SOP; Training	Medium	Possible	Acc. with mitig.	Training	*Medium*	*Low*	*Acc. with mitig. Long term*
16	Inadequate speed for aborted take-off	Runway excursion	SOP; Training	High	Unlikely	Acc. with mitig.	Training	*High*	*Unlikely*	*Acc. with mitig. Long term*

The process highlighted two main critical fields:

1. The substantial loss of experience in some of the areas within the changed company due to the new business model.
2. The performance of operations with personnel under the psychological pressure and stress of having to look for a new job in a time of economic uncertainty and coming from a professional experience with limited prospective (turboprop line), due to reduced request in Europe.

The most critical threats, in relation to previous issues have been identified as: 1) The economic recession time, 2) The limited request on the European market for ATR crews, 3) Possible personal situations that can increase psychological pressure, 4) Company needs to maintain efficient operational levels (not only safety) during the phase out period.

Following all these considerations, a certain amount of hazards have been identified and can be substantiated as follows:

- "flying in not-optimum psychological conditions",
- "loss of situation awareness"
- "reduced flexibility", due to reduced motivation and
- "time availability", as most of the time is used to seek new employment.

A number of possible undesirable consequences that result from these hazards have been evaluated ranging from minor occurrences to potential catastrophic accidents (Phase 1 of RAMCOP).

Some mitigation measures have been applied. For example the use of temporary income to insure the total loss of economic support at the end of present employment, provide direct company support in order to seek new employment (in house selection with expanding companies), economic support for professional requalification, coaching for preparation to job interviews and, when requested, psychological support.

These measures are very difficult to quantify in terms of mitigation of probability or causal barriers and consequently, in this case, Phases 2 and 3 have been merged by simply evaluating of a very unsure measure of probability reduction associated to the possible evolution of incidents from the various studied UOSs.

As a consequence of this difficulty in assessing prospectively the acceptability of the risk, even in the presence of special mitigations measures, a set of verification tools has been implemented in order to identify variation in the crew behaviour and possible mitigation effects. In practice a retrospective assessment process was implemented, as foreseen in the RAMCOP methodology (Figure 2).

2) Retrospective Analysis

A field monitoring programme has been initiated by observing and possibly identifying deviation in crew behaviour. A number of flights involving the specific fleet and the pilots affected by the change were monitored by the company experts, members of safety team, performing standard "jump-seat" flights and collecting unstructured data.

Moreover, two software tools already utilised by the company have been exploited in practice for real data collection and analysis:

1. The Flight-Data-Monitoring (FDM) analysis.
2. The event/data reporting analysis by means of the Safety Database System.

In the FDM programme, new levels of attention have been introduced in the "allowed behavioural areas". An increased attention on single events to verify any possible relation with the contingency period that needs confirmation with the analyses of data of time preceding the contingency phase.

As far as the reporting by means of SDS, a new family of events has been group under the title "Crew Uncertainty". In this group have been inserted all reports that the Safety Manager and the company safety team have evaluated searching for root causes stemming from the new situation

The in-flight observations have been conducted without prior notice and on random basis. During these flights, the category of crew (instructors/evaluators vs. line captains) has been matched with a set of behaviours in order to identify deviations that could constitute a marked trend.

This process of data collection and analysis is under development and no preliminary results are yet available.

V. CONCLUSIONS

The risk assessment methodology discussed in this paper has been developed within the framework of a EU funded research project and contains elements of innovation as well as many features which are basic constituents of standard risk analysis. The user is able to select amongst a suite of tools the most appropriate one for the case under study.

In particular, and contrary to what is being proposed by other well established methodologies, EJ is not the only technique sustaining the implementation of the methodology and this enables the safety team of an organization to rely on alternative methods, possibly more suitable to guarantee consistent and reliable results.

The methodology is implemented in a software system, embedded in the Safety Data Base Plus tool, which aims at offering safety managers the possibility to collect, in a well structure database, all reports about incidents and other types of events. The SDS-Plus tool represents the basis for the development of the SMS of an organisation.

The combination of the solid database of reports and the implementation of a methodology like RAMCOP enable the performance of all safety related analysis demanded by the European Authorities.

The potential power of such a combination of tools and the planned integration with other safety related system also embedded in the company, such as for example the Flight Data Monitoring system, represent the perspective of an overall integrated safety systems that the Authorities require for future aviation organisations.

ACKNOWLEDGMENT

The MASCA project has received funding from the European Commission Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 266423.

REFERENCES

[1] Airport Cooperative Research Program (ACRP). ACRP Report 74. Application of Enterprise Risk Management at Airports, 2012.

[2] ICAO - International Civil Aviation Organisation. Safety Management Manual, Doc 9859, AN/474. Third Edition, Montreal, Canada, 2012.

[3] EASA - European Aviation Safety Agency. European Aviation Safety Plan 2012-2015 - Final Report, 2012.

[4] N. T. Byrom, The essential elements of a safety management system. In Cacciabue, P. C., Gerbaulet I., and Mitchison N., (Eds.), (1994). Safety Management Systems in the Process Industry. EUR 15743 EN. 22-30, 1994.

[5] C. Kirchsteiger, M. D. Christou, and G. A. Papadakis, (1998), Risk Assessment & Management in the Context of the Seveso II Directive. Industrial Safety Series, n. 6. Elsevier, Amsterdam, The Netherlands.

[6] P. Hudson, Safety Management and Safety Culture. The Long, Hard and Winding Road. In Pearse, W., Gallagher, C., and Bluff, L. (Eds.) (2001). Proceedings of the First National Conference on Occupational Health & Safety Management Systems. Crown Content, Melbourne, Australia, 3-32, 2000.

[7] M. Cassani, V. Licata, D. Baranzini, S. Corrigan, E. De Grandis, and O. Ottomaniello, Integrated Data Management for handling hazard of change situations: a sample case of operational implementation. Proceedings of PSAM-11 - ESREL 2012, Helsinki, Finland, June 25-29.

[8] ARMS. The ARMS Methodology for Operational Risk Assessment in Aviation Organisations. http://www.easa.eu.int/essi/documents/Methodology.pdf visited 2011.12.28.

[9] D.S. Nielsen, The Cause/Consequence Diagram Method as a Basis for Quantitative Accident Analysis, Danish Atomic Energy Commission, RISO-M-1374, 1971

[10] E. De Grandis, I. Oddone, A. Ottomaniello, P.C. Cacciabue, Managing risk in real contexts with scarcity of data and high potential hazards: the case of flights in airspace contaminated by volcanic ash. Proceedings of PSAM-11 - ESREL 2012, Helsinki, Finland, June 25-29.

[11] EASA - European Aviation Safety Agency. EASA Safety Information Bulletin: Flight in Airspace with contamination of Volcanic Ash. EASA SIB 2010-17R4, 2011.

[12] ENAC – Ente Nazionale Aviazione Civile, 2011. http://www.enac.gov.it/Servizio/Info_in_English/Operations_within_areas_for_volcanic_ash/index.html

[13] G.C. Bello, and V. Colombari, The human factors in risk analyses of process plants: the control room operator model, TESEO. Reliability Engineering. 1 3-14, 1980.

[14] Swain, A. D., and Guttmann, H. E., (1983). Handbook of Reliability Analysis with emphasis on Nuclear Plant Applications. NUclear REGulatory Commission, NUREG/CR-1278, Washington D.C.