Applying SMS and sustainability principles to airport wildlife hazard management

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ABSTRACT: Collisions between aircraft and wildlife constitute a problem with serious economic, environmental and safety implications. The International Civil Aviation Organization (ICAO) has created and introduced a standard for Safety Management System (SMS) in aviation corporations. Airports implement a Wildlife Hazard Management Plan (WHMP) to mitigate the risk from aircraft-wildlife strikes. The available wildlife strike risk assessment methods are not accepted internationally as a common standard and published material is lacking related to integrating WHMP into SMS. The aim of this study was to provide a structured and holistic approach to airport wildlife hazard management and raise awareness of aviation safety and sustainability. The objectives of our empirical research were 1) to evaluate the wildlife strike risk assessment methods, 2) to provide an SMS approach to WHMP and 3) to design a sustainable development strategy for a WHMP. This research study gathered data with the development of two questionnaires and their distribution to airports and other industry stakeholders. The usefulness of the current wildlife strike risk assessment methodologies is highly debated and questioned. We provide an initial guide to integrate WHMP into SMS and we incorporate the existing best practices for the sustainable development of a WHMP. The promotion of a safety culture and its components are also discussed. This study provides a useful guide to airport wildlife hazard managers (AWHM), airport safety managers (ASM) and to the World Birdstrike Association (WBA) with its recent Joint Action Plan to bring about innovative solutions to mitigate wildlife strike risk and improve flight safety.

Key words: Aircraft. Bird. Integration. Safety Management System. Risk assessment. Wildlife strike.

Aplicando princípios de SMS e de sustentabilidade no gerenciamento do risco de fauna em aeroportos

RESUMO: Colisões com fauna representam um problema com graves implicações econômicas, ambientais e de segurança para a aviação. A Organização de Aviação Civil Internacional criou e introduziu o Sistema de Gestão de Segurança Operacional (SGSO) como método padrão para as organizações de aviação. Aeroportos utilizam o Programa de Gerenciamento do Risco de Fauna (PGRF) para mitigar o risco de colisões com fauna. Não há método padrão de avaliação de risco de colisão com fauna, internacionalmente aceito, assim como existe carência de material publicado que verse sobre a integração do PGRF no SGSO. O objetivo deste trabalho é apresentar uma abordagem estruturada e holística para o gerenciamento do risco de fauna nos aeroportos, bem como elevar a consciência situacional sobre a segurança de aviação e a sustentabilidade. Os objetivos de nossa pesquisa empírica são: 1) avaliar os métodos de avaliação de risco de fauna; 2) inserir o PGRF com abordagem baseada no SGSO; e 3) planejar uma estratégia de desenvolvimento sustentável para o PGRF. A obtenção de dados para esta pesquisa foi feita por meio de dois questionários, distribuídos aos aeroportos e a outros *stakeholders* do setor aeronáutico. A utilidade dos métodos em uso atualmente para a avaliação do risco de fauna é altamente debatida e questionada. Este estudo fornece uma orientação inicial para integrar o PGRF no SGSO do aeroporto, incorporando as melhores práticas existentes para o desenvolvimento sustentável desse Programa. A promoção da cultura de segurança e seus componentes também são discutidos. Este estudo fornece orientação útil aos gerentes de segurança de voo e de risco da fauna em aeroportos, bem como para a *World Birdstrike Association* no âmbito de seu recente Plano de Ação Conjunta, que tem por objetivo a geração de soluções inovadoras na mitigação do risco de fauna que aumentem a segurança de voo.

Palavras-chave: Aeronave. Ave. Integração. Sistema de Gerenciamento da Segurança Operacional. Avaliação de Risco. Colisão com Fauna.

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1 INTRODUCTION

Safety is a cornerstone in all aviation operations and highly expected by the aviation customers, governments and other stakeholders. The major threat from bird strike is engine ingestion which accounts for 76% of accidents (Thorpe, 2012). Bird strikes are known to have caused 296 human deaths in civil aviation (Thorpe, 2012; ERAU, 2013) and at least 146 human losses in military aviation (CENIPA, 2011; Richardson & West, 2005). It has been estimated that bird strikes cost the aviation industry worldwide USD 1.2 billion per year in terms of damages and delays or cancellations to commercial transport aircraft (Allan, 2000). A more recent estimation by McCreary (2012) found an average cost of USD 22,741 per strike. This average cost results from the fact that 92% of bird strikes cause no damage, 6% of bird strikes result in minor damage with an average cost of USD 75,000 and 2% cause substantial damage with a roughly estimated cost of USD 676,000 per strike. The US Airways landing on the Hudson

River in January 2009 with the successful evacuation and rescue of all aircraft occupants raised awareness of bird strike prevention worldwide. Airports implement a Wildlife Hazard Management Plan (WHMP) to manage wildlife strike risk. Wildlife presence at airports poses a hazard to aviation safety but also an opportunity for sustainability initiatives, since many wildlife species are subject to nature protection laws. Wildlife management can support airports to turn these safety risks into environmental protection advantages.

SMS has introduced new principles to holistically manage safety risks. It is an important business/operations tool that helps to determine the costs of implementing safety management measures versus not implementing measures (IHST, 2007). Risk assessment is an important part of SMS as it prioritizes management actions and helps organizations to avoid wasting financial and human resources on insignificant issues (ICAO, 2013; CAA, 2010). Nowadays, it is widely recognized from the aviation corporations that it has contributed to a further reduction of aircraft accidents (Flouris & Yilmaz, 2011). The implementation of SMS requires the development and promotion of an organizational safety culture (ICAO, 2013). According to Reason (1997), a safety culture cannot be achieved through an overwhelming transformation but only socially engineered by identifying its components and bringing them together in union with the application of practical measures.

We predict that a similar approach to SMS will soon be needed to manage wildlife hazard. According to the Australian Civil Aviation Authority (CASA, 2011), the WHMP should have a consistent approach to identify hazard and manage risk with procedures which are developed and implemented as part of an airport´s SMS. To the best of our knowledge there is no published guidance material on how to apply SMS principles to wildlife hazard management. Furthermore, formal wildlife risk assessment is a relatively new field and various methods have been presented only during the last 14 years. The considerable number of variables which are involved in wildlife strikes such as aircraft speed, wildlife species body mass, behavior etc., hindered the development of data-based methods that bring together into a single metric various parameters to calculate risk (IBSC, 2006). There are currently no internationally agreed regulations on how to assess wildlife strike risk. The Table 1 presents the currently available methods to perform wildlife strike risk assessments.

Few other methods were found at a later stage of our survey but they follow similar approaches to rank wildlife hazard levels and are not included in this study. Various problems arise when the proactive SMS approach is applied for the assessment of a historical event, such as a bird strike that has already occurred. Considering the worst case scenario for damaging bird strikes that have an effect on flight, results in the classification of such events as catastrophic in the severity table. Thus, such a risk is unaccepted at the safety risk tolerability matrix, which typically means ceasing airport operations under existing circumstances. Various methods exist for the investigation of incidents such as the Root Cause Analysis, the Airline Risk Management Solutions Methodology (ARMS), Corrective and Preventive Actions, etc. Corporate sustainability is a business approach and strategy in order to create long-term shareholder value by embracing opportunities and managing risks deriving from the economic, environmental, ecological and social developments or changes (RobecoSam, 2013). Flouris & Yilmaz (2011) suggested that sustainability must be embedded in all mainstream management processes and an airport sustainable development strategy must address the economic, social and environmental concerns of its stakeholders and an optimization process of these objectives.

In absence of actual data, an empirical study was designed to portray the new challenges of airport wildlife hazard management, focusing on the efficiency of risk assessment methods and the integration of WHMP into SMS and sustainable development strategy of an airport. With the aim to provide a systematic and holistic approach that can be applied to airports of various sizes and operations, we have decided to elaborate on the following research questions:

a) How efficient and credible are the currently available methods for wildlife strike risk assessment?

b) How can we apply the SMS principles to a WHMP?

c) How can we design a sustainable development strategy for WHMP?

2 METHODOLOGY

A literature review was conducted to identify new concepts of safety and sustainability that can be assigned to airport wildlife hazard management. Main international airports and other industry stakeholders were surveyed with the development and electronic distribution of two questionnaires. The first questionnaire with 38 questions was sent to Airport Wildlife Hazard Managers (AWHM) and the second one with 23 questions was sent to Airport Safety Managers (ASM). The questionnaires are cited at the end of this paper as Appendices. A preliminary survey with interviews was conducted with the ASM at Berlin

Brandenburg International Airport and the AWHM at Athens International Airport to identify the most critical questions for this study and test the questionnaires in practice.

Nineteen (19) out of forty-eight (48) distributed questionnaires were returned fully completed, eleven (11) by AWHMs and eight (8) by ASMs. The airports of our survey included major international airports in North America, Europe, Asia and Australia. In accordance with our research objectives, we have included in the analysis of the results only airports that attempt to calculate wildlife strike risk, implement a WHMP, an SMS, and include sustainability in their strategic goals.

To supplement our data, we also interviewed experts from civil aviation authorities, the European Aviation Safety Agency (EASA), birdstrike committees, and airport environmental managers. In Germany for example, we received completed questionnaires from Munich International Airport and Berlin Brandenburg International Airport and

Table 1: Wildlife strike risk assessment methods used worldwide

Method	Reference	Country of use
Ranking the hazard level of wildlife species to aviation	Dolbeer et al. 2000	USA
A risk assessment technique for birdstrike management at airports	Allan, 2003	UK and some Australian, Canadian, USA and European Airports
The flight safety relevance index of bird species	Morgenroth, 2003	Germany
The airport bird hazard risk analysis	Sowden et al. 2007; Transport Canada, 2012	Canada
Ranking the risk of wildlife species hazardous to military aircraft	Zakrajsek & Bissonette, 2005	USA (Air Force)
The Performance based model	Transport Canada, 2008	Canada
A quantified species specific bird hazard Index	Both et al. 2010	Netherlands (Air Force)
The Bird risk assessment model for airports and aerodromes	Paton, 2010	Australia
An ecological approach to birdstrike risk analysis	Soldatini et al. 2010	Italy

communication with the German Birdstrike Committee provided us with additional information for the remaining German airports. A similar approach was adopted to gather more data from major international airports in North America, Australia, Asia and Europe. Much of this research took place in the form of informal emails and telephone communication, resulting in a significant volume of data that enabled global comparisons. All data is treated confidentially and presented anonymously.

We have based our evaluation and comparative analysis of the wildlife strike risk assessment methods on the following criteria:

- General Concept and Assumptions;
- Data / Number of Strikes; and
- Applicability of the methods within a WHMP.

We collected SMS guidance material from ICAO and civil aviation authorities to conduct comparisons between WHMP and SMS, identify similarities and bridge their gaps. Furthermore, we considered numerous airports environmental and sustainability management reports to define an approach, develop a strategy and apply sustainability principles to wildlife strike prevention. At the end of our study, a check was performed to ensure that the research objectives have been met.

3 RESULTS

3.1 EVALUATION OF THE WILDLIFE STRIKE RISK ASSESSMENT METHODS

3.1.1 GENERAL CONCEPTS AND ASSUMPTIONS

The most complicated aspect of risk assessment for the AWHMs, which were consulted during this study, is the quantitative calculation of the overall risk. The methods by Dolbeer et al. 2000; Both et al. 2010; Zakrajsek & Bissonette, 2005; and Paton, 2010; construct a bird hazard index and categorize wildlife species according to the hazard they pose. These methods are based on past bird strike data, damages and costs. They assign relative hazard scores to wildlife species that are involved in strikes. Such a ranking system is then complemented with data on local wildlife populations at an airport, which is derived from an implemented WHMP. Furthermore, in countries such as the UK, US, Germany and The Netherlands, additional current weather data and geospatial characteristics obtained from computer based models are combined with data from avian radars in order to perform a risk assessment over time and space which is based on qualitative and quantitative data.

The risk assessment method by Allan (2003) analyzes risk in its two components, namely severity of a safety outcome and probability of its occurrence combined in a risk assessment matrix. It is a species-based approach that requires a minimum of five years of bird strike data and the identification of the species involved. Our survey data indicated that this method is the most widely used by airport operators worldwide. We have additionally found that private agents and various civil aviation authorities adopt this method as an auditing tool and as a basis for their wildlife strike risk assessment. However, these civil aviation authorities are not prescriptive on how airports assess their wildlife strike risk, nor do they approve their strike risk assessment process.

The methods by Morgenroth (2003) and Soldatini et al. (2010) use advanced mathematics and rely on modeling the aviation system and the natural environment in which it operates in order to combine numerous parameters in an algorithm and construct an index. The results of these methods are always measured against an expert's opinion. The method by Sowden et al. (2007) develops hazard buffer zones around an airport by analyzing the bird strike risk into its aircraft related elements, numerous wildlife species parameters and land use data by hazardous species.

The performance-based model by Transport Canada (2008) is an innovative approach. Instead of employing data from historical events, this method adopts the SMS proactive approach to manage safety risks. It employs specific safety performance indicators that reveal the real causes of weaknesses of wildlife strike prevention and assists in the planning of new improvements. The performance nodes of this method are soundness, appropriateness and effectiveness. These nodes assess the foundations of wildlife strike prevention, and determine whether the preventive actions achieve the targeted results in a consistent and effective manner.

3.1.2 DATA / NUMBER OF STRIKES

The AWHMs and the ASMs of this study emphasized the quality of data as a critical factor to construct an index and perform a risk assessment. Six AWHMs pointed out that misleading results are occasionally produced for the risks assigned to some species. They added that wildlife strikes are subject to a considerable number of parameters such as species, size, behavior, distribution patterns, season of the year, time of day, additional regional differences and are also subject to aircraft-related factors. They pointed out that simply considering the number of strikes per 10,000 aircraft movements at an airport is a negative performance indicator that misdirects by underlying failures. This fact was not directly reported by the ASMs of this study, but in 3 out of 8 returned questionnaires, they suggested that safety performance targets should not be measured by a single indicator but always with the utilization of more indicators and various built-in mechanisms such as wildlife monitoring, data collection and the quality of reporting. Reporting of bird strikes and identification of species involved appeared to be significant for all AWHMs of this survey.

3.1.3 APPLICABILITY OF THE METHODS WITHIN A WHMP

The bird strike hazard indexes require for their reliability various data for long periods of time that create a high workload according to the AWHMs. The Allan (2003) method appears to be a relatively simple one by analyzing risk in its two components, severity of a safety outcome and probability of its occurrence. However, our data revealed that this method produces occasionally misleading results for the risks assigned to some species, a fact that questions its objectivity. The method by Sowden et al. (2007) appears to be generic rather than specific according to bird strike experts. This risk assessment tool results in an area classification scheme (with zones) around an airport. It is generic because it assumes that the existence of a specific land use in an airport buffer zone results in a risk, even if no birds are present there or are present but never come close to an aircraft. Other responses during this survey appeared to be less enthusiastic of this model, which classifies risk more outside an airport rather than inside and places a bow-tie over an airport.

We have found a considerable body of evidence suggesting that the most problematic point in deriving a flight safety relevance index that will enable comparisons among airports is the necessary mathematical combination of numerous criteria and of their weighting which has a decisive influence on the result. The development of such a method that will mathematically combine the sum of the species' risks as an absolute measurement was strongly questioned by the participants of this survey and is not considered feasible in the near future. Such a model will always be limited and therefore inappropriate to assess risk. Representatives from birdstrike committees, AWHMs and ASMs argued that such a method will also need a correction factor for the fleet and the aircraft types to enable risk comparisons among airports with differences in traffic, size of aircraft, types of aircraft and flight speed.

3.2 APPLYING SMS PRINCIPLES TO WHMP

3.2.1 WHY INTEGRATION IS NEEDED?

None of the AWHMs reported measuring performance by their total contribution to the organization they work. As functional managers, they tend to measure performance only by specialized criteria related to bird strike prevention. Furthermore, we have found a conflict of different assumptions and concepts regarding safety between AWHMs and ASMs. The problem becomes more perplexing if we include the cultural differences between pilots, air traffic control, and other airport operations personnel. Reporting, which is a key factor for the success in managing safety risks, is affected by cultural differences, according to the ICAO Safety Management Manual (ICAO, 2013). An integrated approach is needed not only for the coordination of numerous activities to manage safety risks but also for the maintenance of good communication levels between all relevant stakeholders (ICAO, 2012). We were surprised to find in few airports of this study a lack of communication between ASMs and AWHMs. Most of the airports though have reported regular formal and informal meetings for this purpose. These briefings are considered necessary not only for exchange of additional information but also for the interpretation of results and the selection of the appropriate performance indicators.

3.2.2 RISK ASSESSMENT SOLUTIONS

Problems have been reported during the application of the SMS approach in order to assess historical events, such as bird strikes that have already occurred. By taking into account the worst case scenario after a bird strike which has an effect on flight and results for example in an emergency landing, the airport operator is faced with the challenge of ceasing operations in the zone where the event took place. The ceasing of operations must occur until there are guarantees that the risk level has decreased significantly, following an extensive internal investigation. This is obvious in a worst case scenario since such an event can accelerate a crash and is classified with an "A" at the severity table, as a catastrophic one. Our data from interviews with safety managers at German international airports indicated that the ARMS Methodology is commonly applied for the classification of real life events. They have proposed this method, among other incident investigation methods, as a valuable tool that could assist AWHMs in the classification of historical wildlife strikes. The ARMS methodology is based on the fact that risk always has an element of future uncertainty about an undesired outcome (ARMS, 2010). It provides guidance for the correct analysis of the column and row in the risk matrix in order to achieve coherent and consistent assessments. This method considers

the effectiveness of avoidance and recovery barriers that prevent the escalation of an event into an accident. While it does not completely remove subjectivity, it is believed to be currently the most objective method in the aviation industry (ARMS, 2010).

3.2.3 FRAMEWORK ELEMENTS OF A WHMP

Wildlife strike prevention is always tailored to the local conditions of an airport. The bird strike problem appears for several wildlife managers to be seasonal with peaks during the migration period or the breeding season, depending on the species. The ability of a bird species to avoid aircraft has also been reported to vary. Species from the Corvid family appear capable of avoiding bird strikes, while Seagull species react slowly to an approaching aircraft with a tendency to fly along the runway which makes them more susceptible to a strike. Furthermore, behavior variation for the same species among different regions significantly affects the selection of bird control measures by the AWHMs.

Management commitment and responsibility were outlined by the ASMs and AWHMs in order to achieve the desired safety outcomes. The Chief Executive Officers, having final authority over all aviation activities at the airports of this study, sign the safety policy with its objectives. The safety policy is then communicated through the intranet, articles, publications and the SMS manual. A similar approach should be considered for the WHMP. Clear policies and objectives are needed together with the assignment of accountabilities and responsibilities to trained and competent personnel. Most of the airports during this survey were found already to implement such an approach. SMS requires an efficient reporting system, risk assessment, proactive and reactive mitigation measures, and an evaluation system to monitor safety performance. Our data indicated performance reviewing to be conducted by safety committees and other safety action groups (usually once per month) to assess the need to adopt any corrective or preventive actions. Attendance of AWHMs to these meetings was also reported.

Our discussions with safety managers signaled the importance of a consistent method for hazard identification and proper documentation to manage risks. They pointed out the following critical questions requiring a response by airport operators who attempt to build well established mechanisms for documenting wildlife strikes under the SMS framework:

- Who reports wildlife strikes at an airport?
- In which form and what method are wildlife strikes reported?
- How does an airport ensure that all wildlife strikes are reported?

Ideally, the wildlife strike data is included automatically in the SMS database. The data includes information on confirmed or suspected wildlife strikes and daily applied wildlife control measures at the airfield. Such an automated data transfer system was found at international airports in Germany. Others airports around the world have reported a linkage of the wildlife strike database to the SMS documentation.

3.2.4 WHMP AND SAFETY CULTURE ENGINEERING

Reason (1997) emphasized that a trust culture is not easy to achieve because reporting can expose own mistakes or mistakes from colleagues and skepticism may arise about future difficulties, about the extra amount of work to report, or about the likelihood of management to act upon the information. These parameters were also mentioned from bird strike experts during this survey, together with a desire to forget non-damaging strikes.

Engineering a safety culture includes safety promotion and training on safety management and SMS operation. Such training has either been provided to the airport wildlife control teams of this survey or it is planned to take place within the next year. The assurance of a WHMP under the SMS framework includes performance monitoring, management of change and continuous improvement. Specifically designed audits for this purpose have been reported by the AWHMs at regular intervals, performed by national and international regulatory control bodies or upon request from external consultants and other agencies.

A safety culture implies close cooperation amongst airports and authorities and the involvement of all internal and external aviation system stakeholders that have an impact on safety performance (ICAO, 2013). This study collected data on building cooperation between airports, civil aviation authorities and other authorities responsible for the area outside the airport. These responses are presented in the table 2 and shall be of assistance to airport operators.

3.2.5 DESIGNING A SUSTAINABLE DEVELOPMENT STRATEGY FOR A WHMP

Modern airports such as Frankfurt International Airport have a special department that promotes sustainability as one of the core elements of corporate strategy. In such a strategy, sustainability is embedded in all management processes with an alignment of the social, environmental and financial goals. Our paper integrates the current best practices found in applying sustainable development principles to a WHMP. We present a holistic and systematic approach that brings together wildlife conservation and other environmental initiatives with stakeholder engagement and public involvement.

3.2.6 WHMP & ENVIRONMENTAL SUSTAINABILITY

Airport wildlife hazard managers can promote biodiversity conservation inside an airport and its surroundings or they can assist ecotourism development projects in the greater area an airport serves. At Munich International Airport, almost two thirds of the overall airport areas are green and the area around the airport is now home to many rare wildlife species and plants. Parts of the airport and most of its surrounding conservation areas have been declared

part of the North Erdinger Moos Bird Sanctuary in order to help endangered species populations (Munich Airport, 2011). London Heathrow is committed to conserving biodiversity and has already recorded 134 species that are listed with some level of rarity or that are part of the UK Biodiversity Action Plan (Heathrow Airport, 2011). Another interesting case study was documented at Athens International Airport and the restoration of a wetland's ecosystem in its vicinity. This program, funded by the airport operator, helped a variety of species to recover their populations, informs locals and visitors, and promotes the area with its natural and cultural heritage as an ecotourism destination. Ensuring environmental sustainability implicates close cooperation with nature conservation authorities and associations. We found that such cooperation can assist bird strike prevention with annual actual data on species populations and can be used additionally to monitor the WHMP results.

3.2.7 WHMP & SOCIAL RESPONSIBILITY

Airport operators communicate outputs of their sustainable development strategy to customers, third parties and local communities. (Berry et al., 2008; Flouris & Yilmaz, 2011). London Heathrow is an example of an airport that uses this strategy. The Biodiversity and Landscaping Manager sends a letter each year to all those partners with whom they work to inform them on news, issues and projects of biodiversity conservation at the airport. This letter distribution is part of their commitment to protect the environment and its wildlife species at the airport site (Heathrow Airport, 2011).

Airports can further strengthen the local economy by promoting local business development and growth. The AWHMs have reported to purchase the necessary equipment for wildlife control from local business partners, whenever possible. These businesses should be checked as to whether they adopt environmental friendly practices. If not, airports should include those suppliers in their environmental awareness training/campaigns to introduce and help them to embrace environmental-friendly practices.

Sustainability principles can also be applied to human resource management. Bird strike experts consulted during this study pointed out that in many cases the wildlife controllers have a low status internally within the company they work, which possibly undervalues their qualifications and consequently results in low retention rates. Retaining qualified and motivated employees is a challenging task and different measures can be adopted by an employer to remain attractive. Recruitment of people from the local area has also been reported as an initiative to achieve a socially sustainable WHMP.

Social responsibility contributes to research and development. Such cooperation can be developed with universities and other research institutions. An interesting case study was found at Athens International Airport and a long-term insect monitoring program on- and off-airport, which is conducted in cooperation with the Agricultural University of Athens. This research program identifies species and census their populations in order to apply insect control measures inside the airport and minimize the bird food supplies.

It has given a significant amount of data for the presence of insects in the greater region of the airport; it has observed species for the first time in the area of concern; it provided the opportunity to university researchers to conduct their doctoral thesis, and provided both the airport and the university with a number of publications and conference presentations.

3.2.8 WHMP AND ECONOMIC SUSTAINABILITY

Airport operators and owners are very often private with shares listed on the stock exchange market. In this case, they have a duty to safeguard the investments of their investors, succeed a profitable growth, and create positive value. The implementation of a WHMP is highly important for safety but 7 out of 11 AWHMs of this survey reported difficulties in obtaining the financial resources. Different concepts and assumptions on wildlife strike risk and the seasonality of the bird strike problem have been identified as potential reasons for such a failure together with limited negotiation power to influence airport senior management. Adequate funding has been identified by most of the participants in this survey as crucial in order to significantly reduce the number of wildlife strikes at an airport through effective wildlife management.

During this study, we didn't find any airport operators addressing the cost savings from wildlife strike prevention. The cost estimations from bird strikes published by Allan (2000); Allan & Orosz (2001); Cleary et al. (2006) and the more recent estimations from McCreary (2012), can assist AWHMs to demonstrate to senior management the importance of implementing, operating and promoting a sound and effective WHMP. Airport operator companies with a consulting group that offers expertise and customized solutions to clients can obtain supplementary financial resources for a WHMP by identifying opportunities of providing wildlife control consulting services at other airports.

4 DISCUSSION

4.1 WILDLIFE STRIKE RISK ASSESSMENT

The aviation industry is still faced with the challenge of calculating the overall risk from wildlife strikes at an airport. None of the currently available risk assessment methods is widely accepted. We have solicited the opinions of several experts and found that these methodologies are limited with high levels of subjectivity and cannot permit comparisons among airports. Furthermore, whether such methods can reproduce the complexities of the system in which a wildlife strike occurs is yet to be proven. These methods have been criticized by Njå et al. (2012) as inappropriate to assess risk because they do not address future uncertainties. They have additionally proposed the reassessment of the various wildlife strike databases in terms of their reliability, validity and

Table 2: Development of cooperation amongst airports and authorities

Close alignment and mutual coordination of the WHMP activities
WHMP awareness seminars which point out not only the safety but also the environmental protection issues
Experience exchange / Collaborative techniques / Sharing of data / Sharing of lessons learned / Sharing of best techniques and practices
Airports can provide advice to civil aviation authorities on how to improve regulations, if needed

relevance to address the bird strike risk. In addition, Paton (2010) argued that the current methods fail to identify potential hazardous species until they are involved in several strikes and at least one damaging.

Our results indicate that even if we assume that the complicated aspect of risk assessment is calculating quantitatively the overall risk from bird strikes and that research efforts should be focused towards this direction, then this overall risk should consist of the sum of the species' risks. However, species' risks can be measured in relative terms, whereas total wildlife risk needs to be an absolute measurement. Furthermore, each aircraft type has a different risk profile and the total risk at an airport is related to the aircraft fleet mix that then makes the comparison between airports difficult as well as complicating temporal comparisons if the fleet-mix changes.

Simply counting the number of strikes is a negative indicator pointing out what is not working rather than indicating effective actions (IBSC, 2006; Transport Canada, 2008). Such an approach misdirects by concluding that safety exists because no accidents have occurred or safety management does not exist due to an increase on the number of strikes which can occur as a result of better reporting. According to Reason (1997), the number of negative outcomes can be used as a safety indicator, only when the accident rates are high enough and only in systems where the managers have complete control over all possible factors that contribute to the production of these negative outcomes. In all other cases, the risk assessment procedure is left with the problem of chance, and the combination of different factors at a particular place and time. The occurrence of negative outcomes in low rates, such as the bird strike and damaging bird strike rates, reveals very little about the organization's accident resistance and safety levels. According to McCreary (2012), 2.1 bird strikes occur per 10,000 movements, a fact that supports Reason's argument. Wildlife strikes are subject to many uncontrolled factors that can be defended against, but not completely eliminated.

According to Njå et al. (2012), the goal of accurately predicting wildlife risk levels should be removed from the IBSC recommended practices, and emphasis should be given to the decision-making process and the level of knowledge. Prominent experts who were consulted during our study have strongly questioned the development of a method that will mathematically combine the sum of the species' risks as an absolute measurement and such a method is not considered feasible in the near future. It is therefore expected that the World Birdstrike Association (WBA) will shift focus in future research efforts towards developing a performance measurement model that establishes measurement points other than the number of bird strikes, focusing on the strengths of a WHMP and future uncertainties, rather than on past failures. Thus, our study results support the argument of Njå et al. (2012) that such a model should address future uncertainties and be related to decision making. The performance-based model proposed by Transport Canada (2008) adopts the proactive SMS approach to manage risks and evaluates a WHMP according to its appropriateness, soundness, and effectiveness. This approach can be used as a basis concept for the development of a more sophisticated method.

4.2 INTEGRATION OF WHMP INTO SMS

SMS implementation has promoted a global acceptance of good safety practice and initiated a chain of changes for wildlife hazard management. Airports can prepare for a likely future event that may emerge with the form of a regulation. This anticipatory type of change is usually initiated by a firm without any external demand and aims at gaining a clear competitive advantage over other players of the industry (Hayes, 2002). We found that a systematic procedure determining how information is gathered and organized for wildlife strike prevention is needed. A standardized approach would be most beneficial for the international community so as to manage wildlife risk, collaborate on common topics of interest and share lessons learned. Our framework can serve as an initial guide with succinct, practical and feasible suggested approaches that will assist airport operators and other industry stakeholders in integrating WHMP into SMS. Such an approach prioritizes management actions to reduce wildlife strikes and improve flight safety.

As highlighted by Sprenger (2007) in his book "*Trust-The best Way to Manage*", a trust culture is the only basis for communication, especially when the management model emphasizes personnel responsibility. Such is the case of airport wildlife control teams who, more often than not, work independently on the airside. The wildlife controllers should be seen as business partners and intelligent supporters of the company development, rather than just task executers. According to the ICAO SMM (2013), the success of a reporting system depends on the continuous flow of information from the front-line personnel. The proactive management of safety depends on the establishment of a sound and effective hazard reporting culture. The front-line personnel are of upmost importance in this process. Drucker (2008) has emphasized the importance for first-line managers to always connect their work with the organizational objectives and results, both for short-range and long-range considerations. Such an approach can be useful for AWHMs, the wildlife control teams and their integration purposes (Table 3).

Table 3. Integration of WHMP into SMS

WHMP Policy and Objectives
Top management commitment to manage wildlife hazards and achieve the highest safety standards
Accountabilities, roles and responsibilities
Appointment of key personnel, selection of qualified personnel
Documentation, reporting (who reports what and how), development of a national wildlife strike reporting form
Development of protocols and procedures in order to ensure that all wildlife strikes at an airport are reported
Wildlife Strike Risk Management
Hazard identification and reporting through the WHMP team and the SMS forms
Risk assessment with a data-based and risk-based tool
Employment of the ARMS methodology to assess historical wildlife strikes
Wildlife strike risk mitigation with the implementation of appropriate remediation measures
Continuous hazard monitoring, continuous adaptation of mitigation techniques
WHMP Assurance
Performance monitoring and measurement
Performance reviews from safety committees and safety action groups
Development and use of selected performance indicators such as appropriateness, soundness and effectiveness of a WHMP
Management of change, identification of new hazards
Continuous improvement with internal and external audits
WHMP and Safety Promotion
Training on wildlife hazard management and SMS
Bridging the gap between different cultures among birdstrike committees and other aviation professionals
Safety communication with workshops, safety newsletters or bulletins
Develop cooperation with civil aviation authorities and other authorities responsible for the area outside the airport
Raising awareness of corrective actions resulting from submitted SMS forms

Table 4: Integration of WHMP into an airport's sustainable development strategy

Economic Stability
Quantify airport monetary savings
Show the clear connection between WHMP and financial advantages to the upper level management
Identify opportunities of providing wildlife management consulting services at other airports
Environmental Sustainability
Protect wildlife and plant species inside the airport
Set aside areas inside the airport for conservation purposes
Assist the restoration of ecosystems outside the airport
Cooperate with biodiversity conservation groups and nature protection associations for projects on and off-airport
Capture and translocate endangered species that pose a hazard to aircraft operations
Social Responsibility
Hire local people
Purchase equipment from local businesses
Assist the equipment providers to adopt environment-friendly practices
Sponsor non-governmental organizations by means of financial contributions
Make contributions to research & development
Provide environmental awareness training
Include third parties, local groups, and schools in the environmental awareness training
Publicize the airport´s performance regarding the conservation of natural resources
Consider improving the cooperation with the Civil Aviation Authority

4.3 DESIGNING A SUSTAINABLE DEVELOPMENT STRATEGY FOR A WHMP

A sustainable development strategy can be compliance-driven, but also profit-driven since it promotes corporate profitability in various markets due to improved reputation (Flouris & Yilmaz, 2011). Such an approach to airport wildlife management includes wildlife conservation measures, stakeholder engagement, public involvement, improved profitability for an airport and increased customer satisfaction with the provision of a high quality service. Sustainability must be embedded in all processes and activities of wildlife strike prevention, including the social, environmental and financial parameters. The table 4 summarizes our findings and brings together the current best practice examples in applying sustainability principles to a WHMP.

5 CONCLUSION

We addressed the current challenges of wildlife strike prevention and provided a structured and holistic approach to integrate wildlife hazard management into a safety management system and sustainable development strategy of an airport. This study contends that a new approach, in the style of SMS, is needed to manage wildlife risks. Our framework can serve as an initial guide and future research efforts should empirically test this guide with the intention to incorporate all safety and sustainability aspects of a WHMP. We argued that a new improved performance measurement tool will shift focus from past failures to future uncertainties. The development of protocols and procedures for the standardization of these new approaches is needed to enable their application to airports of various sizes and operations worldwide. Such an approach will enhance wildlife management strategies and contribute significantly to safe airports and aircraft operations.

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APPENDIX A

SURVEY QUESTIONNAIRE FOR AIRPORT WILDLIFE HAZARD MANAGERS

"Integration of Wildlife Hazard Management into an Airport's Safety Management System and Sustainable Development"

A Master-Thesis' Questionnaire by Dionysios Ntampakis, Master of Aviation Management, Wildau Institute of Technology, Technical University of Applied Sciences Wildau, Germany

(all information will be treated confidentially and results will be presented anonymously)

Airport Name:		
Airport Wildlife Hazard Manager / Date:		
Information Review	**Yes/No**	**Comments/Observations**
Wildlife Hazard Management Plan		
Which of the following parameters do you use for the wildlife strike risk assessment?		
Ecological / Behavioural parameters (such as flocking behavior of birds, migration patterns, or habitat preference)?		
Do you identify species for your risk assessment?		
Do you use number of strikes from past records to assess wildlife strike risk?		
Do you use a specific method to assess wildlife strike risk? If yes, please name the method		
Do the results from wildlife risk assessment affect decision making and wildlife control methods? If yes, explain how		
Review of Wildlife Control actions		
Pyrotechnics (if yes, which type? Automated system?)		
Fencing		
Lethal control / trapping		
Nest removal		
Other		
Do you control land use activities at the periphery of the airport?		
Assurance of Wildlife Hazard Management		
Is there an audit for the Wildlife Hazard Management Plan? By an external or an internal agent? Frequency?		
Are there any procedures in place to review wildlife hazards for continuous improvement purposes?		
Is there a Safety Committee that reviews performance?		
Does the Safety Committee include personnel from the Wildlife Hazard Team?		
Are there any other safety action groups?		
Integration with the Airport's SMS	**Yes / No**	**Comments / Observations**
Who is responsible to report wildlife strikes at the airport and in which form?		
Have you received voluntary wildlife hazard/threat reporting? (through SMS forms)		
Did these reports (SMS forms) affect the Wildlife Hazard Management Plan?		
Have mentioned wildlife hazards (on SMS forms) brought about difficulties or exposed mistakes of the Wildlife Control Team?		

Have any preventive / corrective actions taken place?		
Are there any briefings (formal or informal) between the Wildlife Hazard Manager and the Safety Manager?		
Is there any training on SMS provided to the Wildlife Hazard Management Team?		
Is it ensured at the airport that all wildlife strikes are reported? If yes how?		
Integration with the Airport's Sustainable Development Strategy		
Is there a specialized department with a manager responsible for sustainability initiatives at the airport?		
Environmental Initiatives		
Are there any species protected at the airport?		
Does the airport support any biodiversity conservation programmes?		
Is there any sustainable use of land / or countryside initiatives?		
Are there any areas set aside inside the airport for nature conservation?		
Economic and Social Sustainability	**Yes / No**	**Comments / Observations**
Do you hire local people for the Wildlife Hazard Management Plan?		
Do you purchase equipment from local businesses?		
Do the businesses you purchase the equipment adopt environmental friendly practices?		
Do you sponsor with financial contributions any Non-Governmental Organizations?		
Do you quantify airport monetary savings from the application of the Wildlife Hazard Management Plan?		
Do you make any contributions to Research & Development?		
Is there any awareness training on environmental issues?		
Do you report publicly the airport´s performance regarding conservation of natural resources?		
Do you consider improving the cooperation with the Civil Aviation Authority? If yes, in which ways?		

APPENDIX B

SURVEY QUESTIONNAIRE FOR AIRPORT SAFETY MANAGERS

"Integration of Wildlife Hazard Management into an Airport's Safety Management System and Sustainable Development"

A Master-Thesis' Questionnaire by Dionysios Ntampakis, Master of Aviation Management, Wildau Institute of Technology, Technical University of Applied Sciences Wildau, Germany.

(all information will be treated confidentially and results will be presented anonymously)

Airport Name:		
Airport Representative / Date:		
Information Review	**Yes/No**	**Comments/Observations**
Safety Management System		
Management Commitment and Responsibility		
Is there a safety policy in place?		
Does the safety policy reflect senior management commitment regarding safety management?		
Is the safety policy communicated throughout the organization? If yes, how?		
Safety Accountabilities		
Is there a Safety Management System in place at the airport? If yes, since when?		
Is there any Accountable/Executive responsible for the implementation of SMS?		
Does this executive have final authority over all aviation activities of the organization?		
Is there a Safety Committee reviewing performance?		
Does this Safety Committee include personnel responsible for the Wildlife Hazard Management Plan at the airport?		
Are there any other safety action groups?		
SMS documentation		
Who reports wildlife strikes at the airport and in which form?		
Is wildlife strike data included in the SMS database?		
Are wildlife control activities included in the SMS database? If yes, how often data is updated?		
Is it ensured at the airport that all wildlife strikes are reported? If yes how?		
Safety Risk Management	**Yes/No**	**Comments/Observations**
The SMS methodology is a proactive approach. Reactively, for real life outcomes, do you use another method to assess risk? If yes, which one?		
Is there an SMS form (anonymous or through intranet) for hazard reporting? Is it available to all employees?		
When an SMS form delivers information on hazards by a named person, do you provide feedback to this person on actions taken thereafter?		
Have you received voluntary wildlife hazard/threat reporting? (through SMS forms)		
Did these SMS forms affect the Wildlife Hazard Management Plan?		

Did the mentioned wildlife hazards (on SMS forms) bring about difficulties or expose mistakes of the Wildlife Control Team?		
Have any preventive / corrective actions taken place?		
Are there any briefings (formal or informal) between the Wildlife Hazard Manager and the Safety Manager?		
Is there any training on SMS provided to the Wildlife Hazard Management Team?		
Do you consider improving the cooperation with the Civil Aviation Authority? If yes, in which ways?		