



→ KNOWING NO BOUNDARIES

FlySafe: an early warning system to reduce risk of bird strikes

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The risk of 'bird strikes' is a serious problem in aviation flight safety. Tackling this urgent issue, FlySafe is one of the first pre-operational services developed by ESA's Integrated Applications Promotion (IAP) programme.

Birds inhabit every continent on Earth. Every year, billions of birds migrate from breeding areas to regions where they spend the winter. The incredible mobility of birds, not only during migration, but also during daily movements between resting and feeding areas, is a

fantastic expression of the connectivity and complexity of our global environment.

Birds can serve as an excellent flagship for habitat and species conservation, as a tool for education and as a source of inspiration to humankind. Birds show us the importance and requirements needed for a global approach to biosphere preservation and coexistence between humans and nature.

Many people are becoming more interested in bird movements, for example in relation to the spread of disease, conservation, ecology, education, urban planning, meteorology and even the operation of wind turbines and oil platforms.

But one of the most important issues is the threat that birds pose to flight safety: collisions of birds with aircraft, or 'bird strikes', can cause very serious and sometimes devastating accidents with severe consequences in both human and economic terms.

Bird strikes

Collisions between birds and aircraft are very common, with most bird strikes fortunately resulting in little or no damage to an aircraft. However, depending on the specific

circumstances (such as the speed of the aircraft, the point of impact, the mass of the bird, the number of birds and the type of aircraft) some bird strikes result in the total destruction of the aircraft and the loss of human lives.

One bird strike that captured the attention of millions of people was the crash landing of the US Airways plane in the Hudson River, New York, in January 2009, after geese were ingested into the engines. Although the Airbus 320 was destroyed, luckily everyone survived the crash.

Bird strikes can occur en route, or locally in and around airfields. These local bird strikes occur in critical phases of flight, i.e. the few minutes after take-off or before landing, and so they are the cause of the majority of major mishaps.

Commercial airliners are in most danger from local bird strikes because at anywhere over 10 km from an airport, these aircraft are generally flying too high for birds. In contrast, military aircraft en route are usually flying very fast and very low, at 'bird rich' altitudes, so these bird strikes very often result in serious damage to the aircraft.

Birds know no boundaries

Understanding bird movement is no easy task. Several technological and traditional techniques are used to



↑ Every year, billions of birds migrate from breeding areas to regions where they spend the winter, some travelling more than 10 000 km

→ Bird strike facts

track bird movements and understand the relationship between patterns in space and time and the environment. These techniques include, for example, space-based systems, ground-based military radars, mobile radar units and weather radars, infrared cameras, genetic and chemical markers, bird tagging (or 'ringing') and traditional visual observations.

However, these sources of data are often collected sporadically, at a limited number of locations or for a small number of species, and therefore can rarely be used to solve problems on an international scale.

Because bird migration is not a local phenomenon, it follows that information about bird movements on a global scale is fundamental for understanding migration and modelling their behaviour. This issue can be addressed by using space and ground-based technologies that bring together bird migration information on various geographical and time scales.

Added value of space

ESA's Integrated Applications Promotion (IAP) programme is stimulating and promoting European and international projects that result in user-driven services for European citizens on

UK – At least **110 serious bird strikes** suffered by military aircraft (from earliest records to **2004**), resulting in aircraft that were either destroyed, damaged beyond repair or involved human fatalities

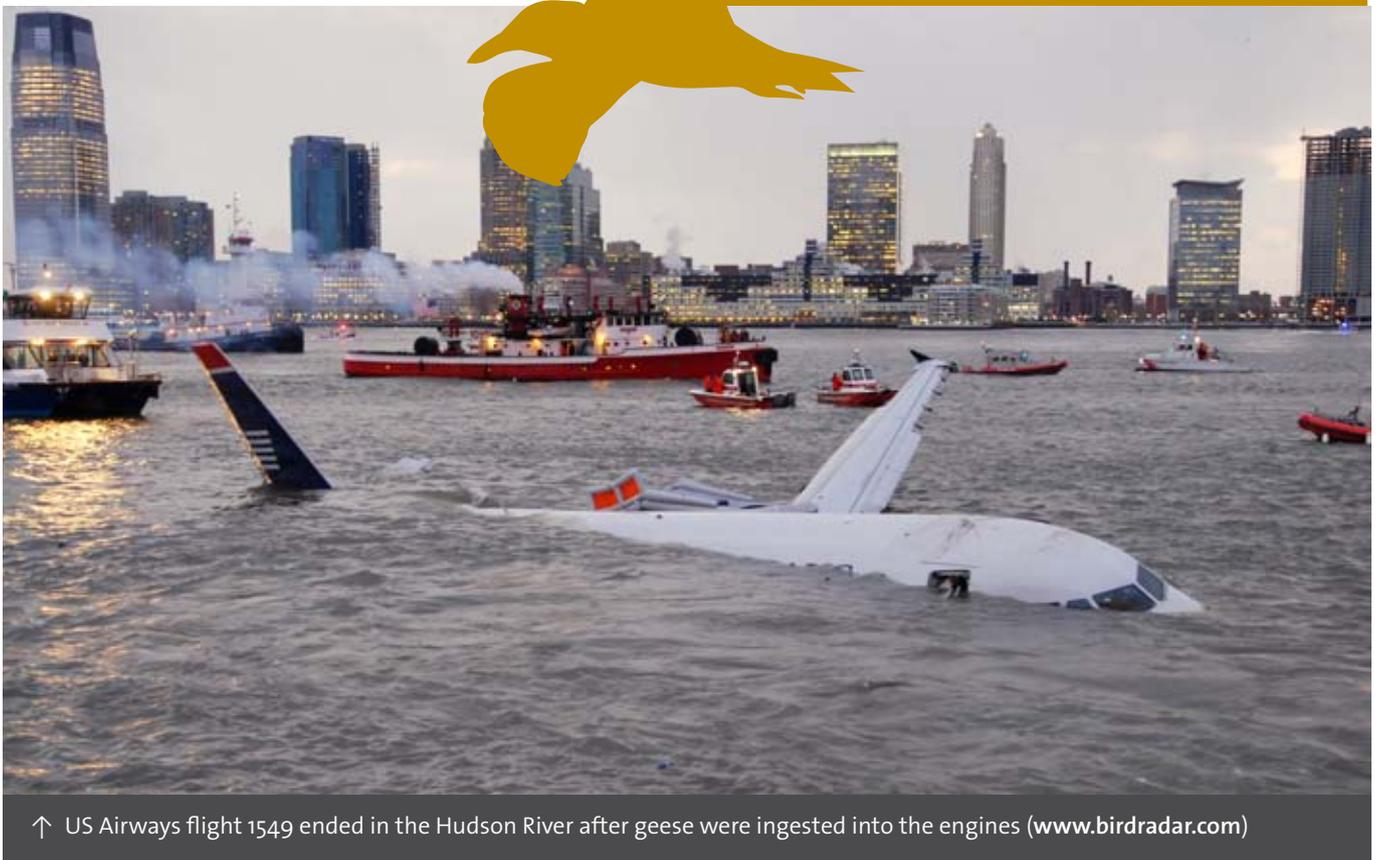
Worldwide – **47 fatal accidents** in civil aviation have been recorded, with 88 aircraft destroyed and **243 people killed (1912–2004)**

USA – **7000 per year in 2005**, the number of wildlife strikes (mammals and birds) to civil aircraft, quadrupled since **1990**

USA – **\$97.9 million per year**, the minimum direct and associated costs of bird strikes to civil aviation recorded by the Federal Aviation Association. If this figure is corrected for estimated **unreported strikes**, it could **exceed \$489.9 million annually**

Worldwide – **\$1.2 billion**, the conservative estimate for the annual cost of bird strikes due to damage and delays of commercial aircraft

These are highlights of reported national bird-strike statistics, although actual numbers are probably higher because in most countries bird-strike reporting is not yet obligatory.



↑ US Airways flight 1549 ended in the Hudson River after geese were ingested into the engines (www.birdradar.com)



← Remains of a Belgian C-130 aircraft that crashed in July 1996 at Eindhoven Air Base in the Netherlands due to a multiple bird strike with starlings and lapwings. 34 people were killed and 7 people were seriously injured (RNLAf).

regional, national and international levels. IAP activities are carried out in partnership with stakeholders and user communities (see <http://iap.esa.int>).

The key feature of these new applications is the added value of space, which not only makes them possible, but also gives a long-term sustainability to the resulting services. Space technologies, such as Earth observation, satellite navigation, satellite telecommunications or human spaceflight, whether taken alone or in combination with terrestrial systems, play a major and sometimes unique role in providing such solutions.

IAP is already active in diverse fields, ranging from energy grid management to aircraft safety, developing novel solutions and services that were previously unimaginable. Integrated applications are thus already benefiting European industrial competitiveness, while serving the needs of European society and global communities.

Because 'birds know no boundaries', ESA used the global space capability of its IAP programme to launch the 'FlySafe' demonstration project. Initiated in July 2007, ESA established a fruitful partnership between the air forces of the Netherlands, Belgium, Germany and France to develop a bird warning system to improve flight safety in northwest Europe.

FlySafe would combine the necessary and available space and ground-based systems, and the scientific research and technological applications from various user communities, to provide a sustainable service for the observation of large-scale bird migration.

In 2009, following a successful demonstration phase, Dutch and Belgian air forces proposed the creation of an

operational service, to be hosted by the Royal Netherlands Meteorological Institute (KNMI), which is currently taking over this service. FlySafe is now being rolled out as an operational bird warning forecast service, providing enhanced real-time forecasts and 'nowcasts' – meaning the prediction of very near-future situations.

The bird warning centre is the first successful operational service initiated by ESA's IAP programme. FlySafe services are now being used by a variety of customers, including air forces, airlines, airports, agriculturalists and oil platforms.

IAP and the problem of bird migration

Through several international workshops and brainstorming sessions with experts (from academia, research institutes, nature conservation organisations, military and civil aviation authorities as well as health and agricultural organisations), the IAP team found that user groups needed data on bird movements at different resolutions, efficient access to bird-related and environmental data, integrated analysis results and finally a transfer of knowledge from migration ecologists to the other user groups.

They found four main themes related to bird migration: flight safety, human health, migration ecology and conservation and education. Based on the high impact that birds have on flight safety, both on routes and near airports, safety for military aviation was selected as the key subject of the project. Moreover, military aviation authorities acknowledged the need for improvements to current systems, closer cooperation between users and the setting up of a core 'cross-border' community.

FlySafe in detail

Current 'state of the art'

Around the world some air forces and civil airports practise various degrees of bird-strike reduction, which can roughly be divided into local and en route risk reduction activities. Locally, the populations of birds on airfields can be controlled or manipulated to some extent. However, this is impossible en route, therefore, to reduce the risk of bird strikes along aircraft routes, birds must be avoided.

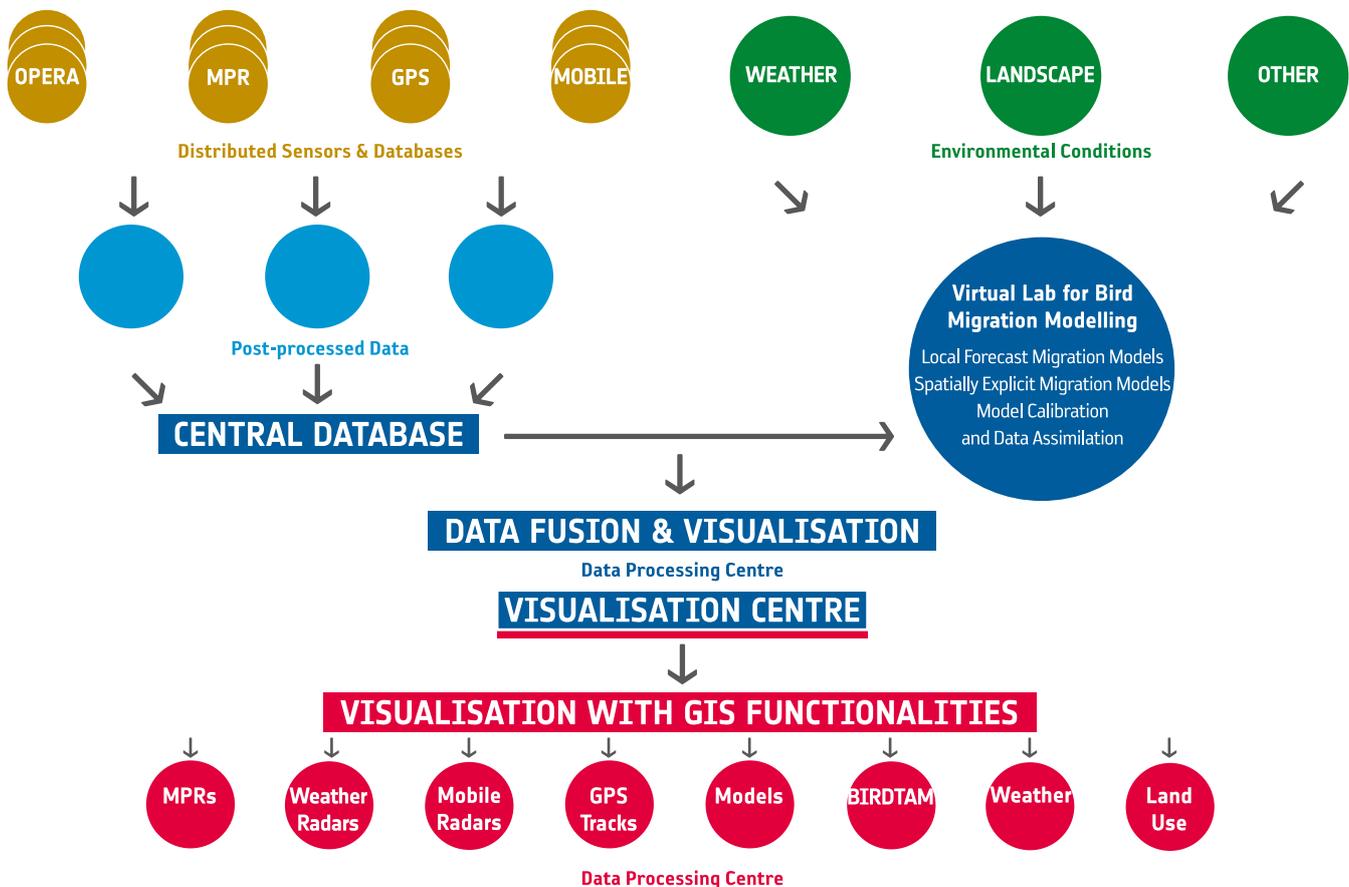
In Europe, a few air forces have recognised this problem and are promoting national activities focusing on ground-based technology, but these still miss the true global dimension of migration. In its risk reduction, the Royal Netherlands Air Force uses, for example, military radars to monitor bird densities in the air in near real-time, computer models that predict migration and techniques to identify bird remains after bird strikes. Nevertheless, these activities are spatially restricted and require further improvement.

Many European air forces have no bird risk reduction programme at all, so a systematic coverage of bird movements in space and time, interoperability between existing systems and standardisation of signal interpretation are completely missing.

How is 'space' used in FlySafe?

FlySafe incorporates data coming from several sensors to monitor bird movements, such as long-range military surveillance radars, short-range local radar systems, meteorological radars in the OPERA network (Operational Programme for the Exchange of Weather Radar Information) and tracking of individual birds from space. These data sources are complementary to a large extent.

Satellite telecommunications are being used for data transfer in areas where terrestrial infrastructure is unavailable, as well as for tracking individual birds (GPS tags).



↑ The information flow within the FlySafe system

Environmental information is essential when modelling bird migration, so information on meteorological conditions from the European Centre for Medium-range Weather Forecasts (ECMWF) and land cover maps from Earth observation satellites are used to support the interpreting and modelling of bird behaviour and bird migration dynamics.

Data from all the sensors used in FlySafe, including individually tracked birds, ECMWF and landscape data are now stored in a central database. This is the first time that such a large amount of data from different space and terrestrial sensors – including surveillance radars from several countries – has been stored together in one database. The database contains tens of millions of radar tracks. A new web service, ‘BirdView’, was developed to access this information directly from remote locations and interactively view multiple layers of FlySafe data.

New computer models have been developed to provide bird migration information at various scales. Landscape and land use data from Earth observation satellites as well as ECMWF data are used in these models to simulate the migration patterns of some key bird species over Europe and Africa.

Global tracking of birds from the GPS/Argos system is used to increase the knowledge about bird behaviour and interaction with the environment (Global Positioning System (GPS) tracking devices can transmit data via Argos, a satellite-based communications system that has been in use since 1978).

Regional computer models are predicting the intensity of bird migration over Belgium and the Netherlands. Hourly bird migration intensity forecasts are generated over the next 72 hours by an ensemble forecast of 50 models. These models use hourly updated weather variables forecasted by ECMWF.

FlySafe achievements

To meet FlySafe’s objective of reducing the risk of bird strikes, the following issues needed to be addressed:

- federation and coordination of the users and their requirements;
- BIRDTAM standardisation;
- interoperability;
- increased efficiency of operational systems;
- calibration and validation of current sensors;
- development of forecast models to fill gaps caused by lack of real time information.



← Flight paths of gulls tracked from space during FlySafe between June 2007 and January 2008

For the first time since BIRD TAMs were introduced, the four participating air forces are working towards producing internationally coordinated BIRD TAMs.

To use meteorological radar data to track bird migration, simultaneous measurements were conducted between the Swiss Ornithological Institute's bird detection radar, three weather radars in the Netherlands, Belgium and France and two long-range military surveillance radars in the Netherlands and Belgium. These measurements were used to develop algorithms to extract vertical profiles of bird movements from wind profile data that were demonstrated and validated during the activity.

To improve the understanding of the daily and seasonal flight patterns of key bird species, and to test if bird movements around an air force training area are detectable by the medium-powered military radar in northern Holland, the movements of individual birds were tracked in real time.

Fascinating patterns of individual behaviour are already emerging from this study of tagged migrating gulls in the Netherlands. Fourteen lesser black-backed gulls and nine herring gulls trapped at a breeding colony in Vlieland, were tracked from space with GPS/Argos tags. The data show that these birds regularly cross a military training area at low altitudes. All of the lesser black-backed gulls were migrating, mostly to southern Spain (with some via the UK) whereas the herring gulls remained within the Netherlands.

A pre-operational FlySafe system, developed as a web-based service (<http://public.flysafe.sara.nl/bambas/index.php>) during the project, is now in use by the Belgian and Dutch air forces.

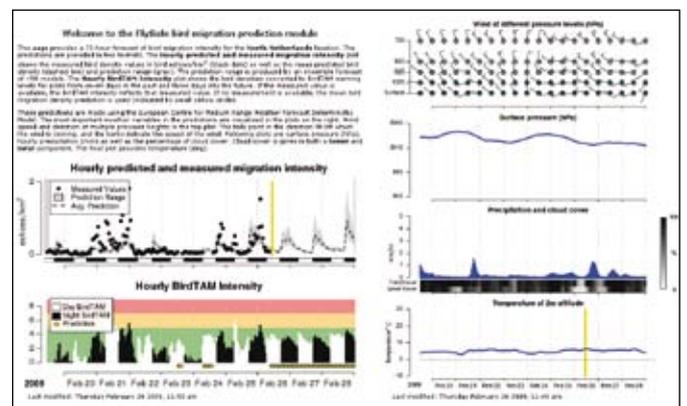
Short-term bird migration density predictions for the evening are announced during the course of the day for night flying. These announcements are treated as 'reliable' BIRD TAM predictions by both air forces with the same consequences for warnings and restrictions as a normal BIRD TAM.

Significantly, BIRD TAM predictions in the range of 5–8 (warnings and restrictions) can result in flight cancellations or even cancellation of all scheduled night flying activities for that specific evening. Thanks to the BIRD TAM predictions, air forces are now able to improve their training programme and avoid last-minute cancellations of, for example, night flight training exercises, which are expensive to prepare.

The Belgian and Dutch air forces have acknowledged the positive results of FlySafe, and have already demonstrated the potential of such approaches to reduce the risk of bird strikes. According to the Belgian Air Component, "FlySafe has already considerably improved the Belgian air force's mission operations, resulting in better flight planning, leading to relevant operational cost savings."

Follow-on for civil aviation

Following the bird strike accident on the Hudson River, in 2009, and inspired by the successful demonstration of FlySafe bird migration pre-operational services, a number of civil aviation authorities from Netherlands, UK, Belgium, Switzerland, Portugal and Germany have expressed their interest in the FlySafe project, enquiring with ESA as to whether FlySafe could be tailored to civil aviation purposes.



↑ The FlySafe web site, <http://public.flysafe.sara.nl/bambas/index.php>



Based on this user community request, ESA's IAP has initiated 'Bird Strike Risk Reduction for Civil Aviation', a feasibility study to assess the technical as well as the economic and regulatory viability of bird-strike risk reduction services for civil aviation.

The study is being supported by London Heathrow, Amsterdam Schiphol and Manchester Airports. It is also being supervised by the Bird Strike Risk Reduction Advisory Board, comprising representatives and experts from KLM/Air France, the Dutch Airline Pilot Association, Lisbon Airport, the Dutch Civil Airports Association, BAA, the UK Civil Aviation Authority, the Dutch Ministry of Transport, Public Works and Water Management, the UK Food and Environment Research Agency and the Royal Netherlands Air Force.

Future perspectives

The service capabilities demonstrated through FlySafe could pave the way for new developments to serve wider geographic areas and user communities (such as 'GoogleBird'). Many different communities need more comprehensive, easily accessible and interpretable information about bird distribution and movements at different scales and their interaction with the environment.

An essential foundation of a successful bird migration early warning system is the transfer of knowledge from the scientific community to the users, in areas such as flight safety, epidemiology and conservation. Therefore a platform is needed for technological improvements and trans-disciplinary communication and cooperation. Sustainable services could

Imagine a sustainable system, where the tools and information developed and gathered for one purpose are used by many others, serving broad human interests such as public safety, health, science, energy, agriculture, education, conservation and quality of life. That is the vision demonstrated by FlySafe.



← Almost a serious bird strike: a British Airways Boeing 757 aircraft about to land, apparently through a flock of birds. However, this amazing photo captures an optical illusion, the plane landed safely and no birds were harmed. They were actually some distance away from the aircraft (Adam Samu)

There are numerous groups that need services to study, mitigate and prevent the spread of bird-carried diseases, such as 'bird 'flu' (avian influenza). These diseases can pose a major threat to human health and the world economy, either by directly affecting humans or by affecting our food sources. The World Bank estimates that a human influenza pandemic caused by a virus mutated from avian 'flu' could cost the global economy US \$800 billion per year.

The spread of bird-carried diseases and parasites may also have direct effects on global biodiversity through the decimation of large populations of birds. However, the true role of migratory birds is unclear, particularly due to the lack of sufficient information needed at large and local scales. International agencies such as the World Health Organization (WHO), the Food and Agriculture Organization (FAO), Wetlands International, the World Organisation for Animal Health (OIE) and the Convention on the Conservation of Migratory Species (CMS) have already shown interest in a potential FlySafe follow-up initiative.

Improvements in the collection, dissemination and interpretation of data are also expected in the near future. For example, it is expected that information on bird movements at population level can be collected from over 150 weather radars in Europe through the OPERA network within a few years.

The successful operational outcome of the FlySafe project has proved that ESA's IAP can play a fascinating role in bringing together user interests and communities. IAP uses a 'win-win' approach that promotes the added value of 'space' in a fair and unbiased way, and supports the development of sustainable space-based services for the benefit of society.

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combine various existing bird migration measurement systems, tracking of individual birds from space and ground-based systems, improvement and enhancement of existing technologies, modelling tools, improved access to environmental data and diverse web services.

In flight safety alone, the possibilities for expansion could include all European air forces and those interested in operationally addressing bird hazards to flight safety. Following an invitation from 27 air forces, the FlySafe initiative was presented to the Air Force Flight Safety Committee (Europe), AFFSC(E) and received warm appreciation and several expressions of interest, confirmed by the AFFSCE's recent interest in establishing a dedicated FlySafe sub-committee. AFFSC(E) consists of flight safety representatives from several European air forces as well as the South African Air Force, Canadian forces and European-based elements of the US Air Force.

Civil aviation is a huge community that includes many stakeholders, including airlines, pilots, airports, air traffic control, government and EU transport. In some areas, efforts to reduce bird hazards remain minimal and localised. A coordinated and concerted effort between these various stakeholders is needed in order to make a significant advance in tackling bird hazards to civil aviation in airport vicinities. ESA is well positioned to stimulate and facilitate this task, but these communities are advised to prepare for and look at the sustainability of such a service by using the example of the Belgian and Dutch air forces.