Development of NLR third party risk model and its application in policy and decision-making for the airports in the Netherlands

National Aerospace Laboratory NLR

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EXECUTIVE SUMMARY

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Problem area

In general, air transport is a relatively safe mode of transportation. However, airports generate concentrations of air traffic over the area around the airport. Combined with the fact that most accidents occur during the take-off and landing phases of flight, the local probability of an aircraft accident near an airport increases significantly and hence the risk to the population in the vicinity of the airport.

Description of work

In many countries, “third party risk around airports’ is still a relatively new subject. In the Netherlands, however, it is a standard part in the discussion and the policy on the environmental issues around airports for almost two decades.

This report is based on a presentation held at the Air Transportation System Conferences, Ecole Nationale de l'Aviation Civile (ENAC), Toulouse, FRANCE, 8-10 July 2013.

The National Aerospace Laboratory NLR has developed a number of models to determine third party risk around different airport types and the models are capable of assessing risk due to traffic of fixed-wing aircraft and helicopters.

Applicability

The model is used for evaluating scenarios of airport development and environmental impact assessment studies; it helps setting policy for third party protection and has become a valuable tool for government agencies, airports and representatives of the surrounding communities of airport. Third party risk analysis supports the decision-making process and gives a better understanding of the risk to the population around the airport.

Overview

This paper presents an overview of the development and improvement of the NLR third party risk model in supporting the policy and decision-making in the Netherlands. Two examples of application of third party risk analysis are demonstrated.

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Summary

In general, air transport is a relatively safe mode of transportation. However, airports generate concentrations of air traffic over the area around the airport. Combined with the fact that most accidents occur during the take-off and landing phases of flight, the local probability of an aircraft accident near an airport increases significantly and hence the risk to the population in the vicinity of the airport.

In many countries, ‘third party risk around airports’ is still a relatively new subject. In the Netherlands, however, it is a standard part in the discussion and the policy on the environmental issues around airports for almost two decades. The National Aerospace Laboratory NLR has developed a number of models to determine third party risk around different airport types and the models are capable of assessing risk due to traffic of fixed-wing aircraft and helicopters.

The model is used for evaluating scenarios of airport development and environmental impact assessment studies; it helps setting policy for third party protection and has become a valuable tool for government agencies, airports and representatives of the surrounding communities of airport. Third party risk analysis supports the decision-making process and gives a better understanding of the risk to the population around the airport.

In 2003, the Schiphol Act and two Airport Decrees (Airport Layout Decree and Airport Traffic Decree) came into effect with among others regulations regarding the limitation of noise pollution, third party risk and emissions for the surroundings of Schiphol airport. For third party risk, safety zones and restricted areas were defined based on the results of risk calculations for future airport scenarios. In 2009, the Aviation Act was expanded with comparable regulations for all other airports and in-land heliports in the Netherlands.

This paper presents an overview of the development and improvement of the NLR third party risk model in supporting the policy and decision-making in the Netherlands. Two examples of application of third party risk analysis are demonstrated.

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Content

Abbreviations

Acronym	Description
AAIB (UK)	Air Accidents Investigation Branch (United Kingdom)
ICAO	International Civil Aviation Organisation
IMU	Interim Model Update
IR	Individual Risk
MTOW	Maximum Take Off Weight
NLR	National Aerospace Laboratory
NTSB (US)	National Transportation Safety Board (United States)
OVE	Orientation Value for Establishments
SR	Societal Risk

1 Introduction

On 25 February 2009, a Boeing 737 of Turkish Airlines crashed on approach to Amsterdam Schiphol Airport on an open farmland. Nine people on board were fatally injured in the crash. Had this crash ended in a residential area, the consequences could have been more disastrous.

It is widely known that air transport is the safest way of transportation. An airport handles the incoming and outgoing traffic and thus generates a concentration of air traffic over the area surrounding the airport. Combined with the fact that most aircraft accidents occur during the take-off or landing phase of flight, the local probability of an aircraft accident is the highest near an airport. Hence, air traffic poses a significant risk to the population in the vicinity of the airport. And this justifies the need for protection measures against this “third party risk”.

In the Netherlands third party risk analysis method and policy have long existed for industrial installations, rail and road transport and pipelines. For air transport, a third party risk model was developed in the early 1990s, and a well-established policy for Schiphol airport has only existed since around 2003. To protect individuals against this risk due to air traffic, the Dutch government applies land use policy.

In supporting this policy the methodology and the model for third party risk developed by the National Aerospace Laboratory NLR is used. In the early 1990s, the former Ministry of Housing, Spatial Planning and Environment demanded a method to assess the environmental impacts of Schiphol airport. This initiated the development of a model of third party risk for Schiphol airport. The crash of an El Al Boeing 747 freighter aircraft into the building blocks in Bijlmermeer, on the outskirts of Amsterdam, intensified the development of the model. Numerous environmental impact assessment studies were conducted for Schiphol airport and other (regional) airports in the Netherlands in the years thereafter.

This paper gives an overview of the enhancements of the model since it was first developed. Section 2 addresses the risk metric and third party risk model which are relevant for the policy support in the Netherlands. Section 3 provides insight in the third party risk policy set out by the government in the Netherlands. Section 4 is devoted to an overview of the enhancements of the model during the last few years. Section 5 presents two cases of application of the risk model in relation to the Dutch risk policy. Finally in section 6, a discussion is given in view of the Dutch approach.

2 Third party risk metrics and model

Third party risk concerns those people that are at risk while they are not involved in the activity that induces this risk. Typically, regarding aviation, the third party concerns people living and working on the ground. While not involved in any aircraft flying overhead, they are exposed to risk due to an aircraft crash. The fatality risk of people on board the aircraft, crew and passengers, is not taken into account, because these people are involved in the risk inducing activity and therefore they are not regarded as third party.

2.1 Risk metrics

In describing third party risk, two main metrics are generally used, i.e. individual risk and societal risk. The individual risk is defined as the local probability per year that a person, who is permanently residing at a particular location, suffers fatal injury as a direct consequence of an aircraft accident on or near his or her position. Characteristics of the Individual Risk are:

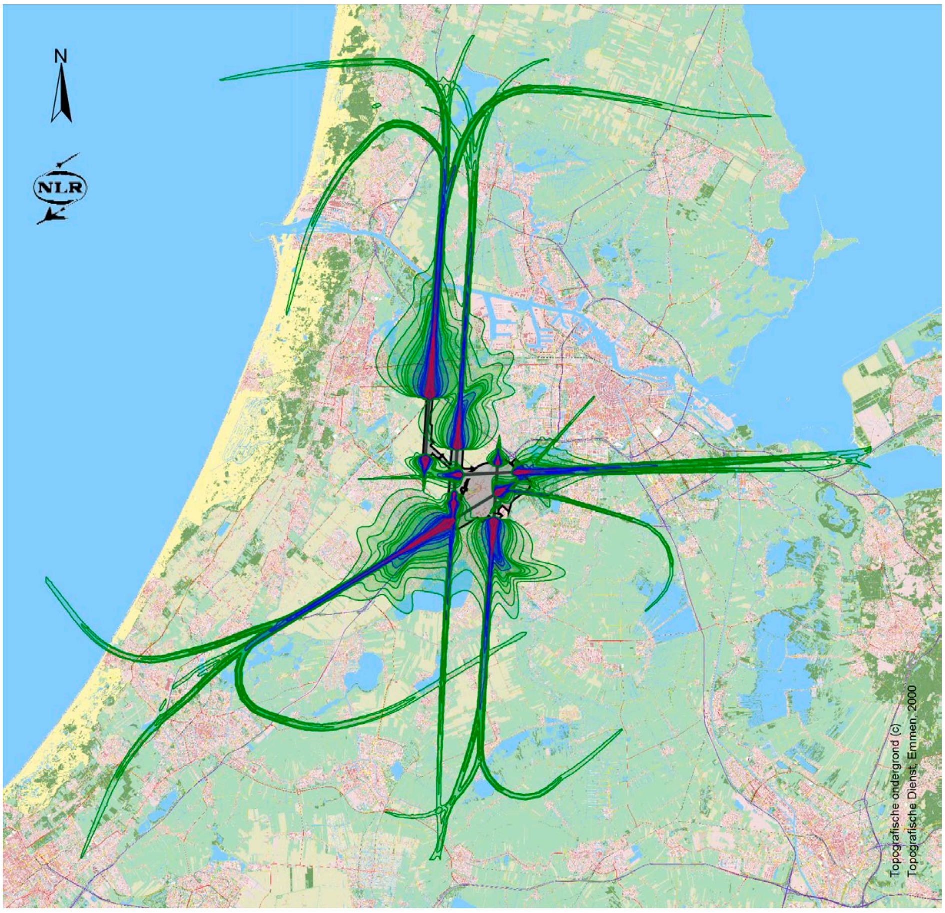

Figure 1. *The individual risk values are presented as iso-probability contours. Depicted are the individual risk contours of a scenario for Schiphol airport. Red indicates high risk value and green indicates low risk value*

- Individual risk represents a point-location risk; it is calculated separately for every location around the airport and differs from location to location.
- Individual risk is independent of the actual population around the airport; it is calculated for a fictitious person who is presumed to stay permanently in one single location.

In general, the individual risk decreases with increasing distance to the runway and flight routes. Individual risk is commonly visualised by iso-risk contours, plotted on a topographical map (Figure 1). This way of presentation is comparable to visualizing a surface plot (Figure 2), where the altitude of the mountain represents the level of individual risk.

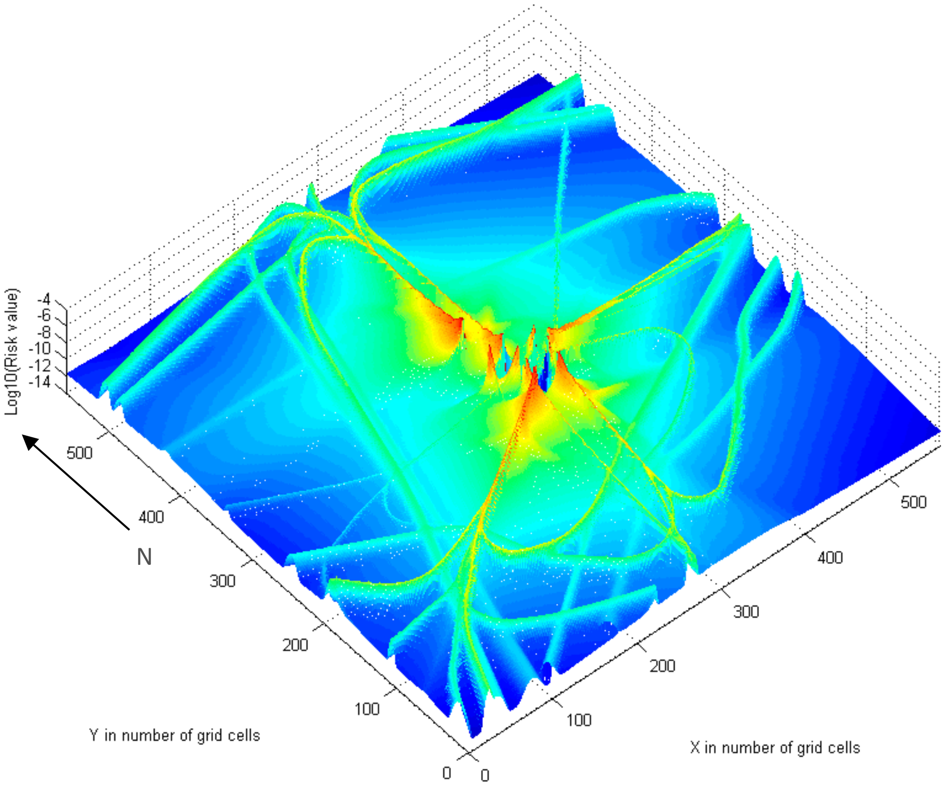

Figure 2. *The individual risk values are shown in a surface plot. The red and orange colour present the high risk values, whilst the green and blue colour present the low risk values. Remark: risk values are presented on a logarithmic scale*

The societal risk is defined as the probability per year that a group larger than a given number of persons (third parties) is killed due to a single aircraft accident. Societal Risk is presented as an *FN*-curve, where *F* stands for the probability per year and *N* stands for the group size. Due to the wide range of values of probability and group sizes, the *FN*-curve is practically plotted on a double-logarithmic scale. Characteristics of the societal risk are:

- Societal risk represents the risk over the selected study area around the airport.

- Societal risk depends on the actual population distribution around the airport; in a hypothetical situation where no population is present anywhere around an airport, the societal risk for this airport would be zero.

The essential difference between individual risk and societal risk is shown in Figure 3. Depicted in the figure are two situations, A and B, with an identical risk source. Although both situations could have the same individual risk as a consequence of the risk source, due to the different population distributions in the surrounding of the risk source, situation B has larger societal risk than situation A. It may be clear that the use of both risk metrics is important in expressing third party risk.

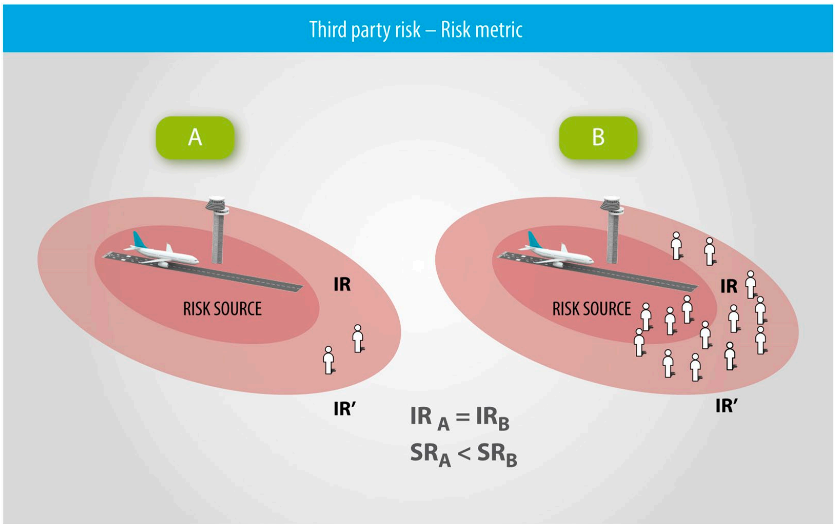

Figure 3. *Difference between individual risk (IR) and societal risk (SR). The individual risk levels are the same for situation A and B. However, due to the different distribution of population, societal risk for situation B is higher than that for A. Figure is adapted from Jonkman et al[1]*

2.2 Model set-up and components

The NLR third party risk analysis model comprises three components: **Accident Probability**, **Accident Location** and **Accident Consequences**. The three model components answer the following questions regarding the risk that an inhabitant living in the vicinity of an airport or a heliport is exposed to (thus, third party risk):

- What is the chance that an aircraft accident occurs in the vicinity of an airport? (Accident probability)
- What is the likelihood of an accident occurring at a given location around the airport, given that an aircraft accident occurred in the airport surrounding? (Accident location probability)

- What is the consequence of an aircraft accident, given that an aircraft accident occurred in the airport surrounding? (Accident consequence)

The model parameters of these three components were derived from an extensive set of data concerning historical aircraft accidents, operations and airports. These data are extracted from the NLR Air Safety Databases. Within the framework of third party risk model, the three components are brought together by means of statistical and mathematical formulations. A comprehensive description of the methodology adopted in the NLR third party risk model is given in [2, 3].

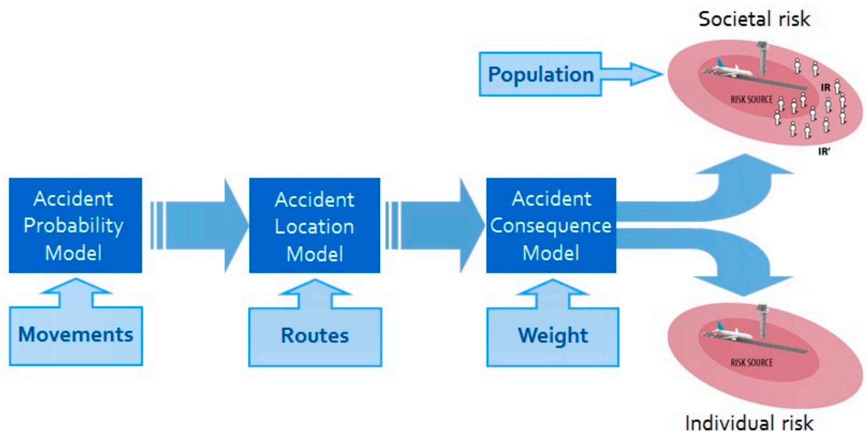

Figure 4. *A schematic presentation of the third party risk model, inputs and outputs*

When the airport scenario input data, which comprise airport runways data, flight routes and

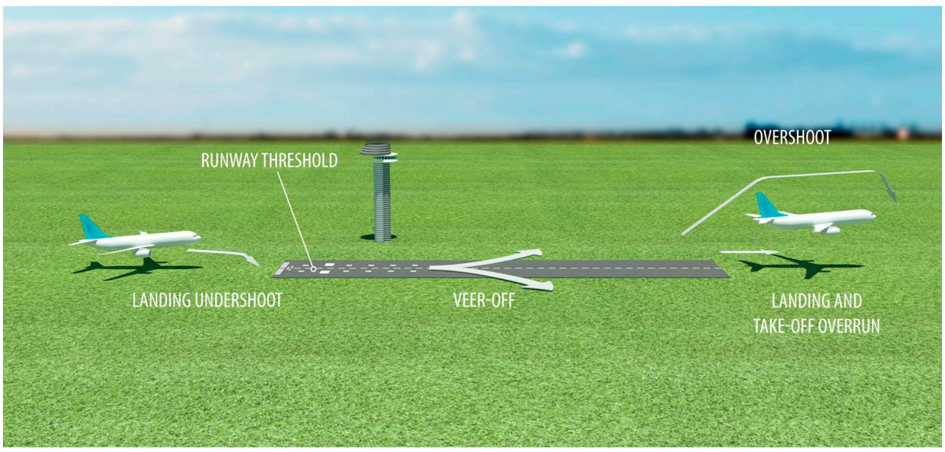

Figure 5. *The accident types used in the third party risk model. These are take-off overrun ,take-off overshoot, take-off veer-off, landing overrun, landing undershoot and landing veer-off. Note: veer-offs are not included in the standard model*

traffic and fleet composition data, are fed into the model, individual risk can be calculated. For a societal risk calculation, population distribution data are also required. Figure 4 gives a schematic depicting the relationship of different input data, risk model components and calculation results. The model distinguishes four different accident types: landing undershoot, landing overrun, take-off overshoot, and take-off overrun. These four accident types are depicted in Figure 5. A "Landing Undershoot" is an event in which an aircraft during approach crashes before reaching the runway. An "Overrun" is an event in which an aircraft rolls off the runway and comes to a stop beyond the runway. Overrun accidents may occur during both take-off roll and landing roll. A "Take-off Overshoot" is an event in which an aircraft crashes after being airborne during the take-off or initial climb phase. "Veer-off" accidents, where an aircraft rolls off the runway and comes to a stop beside the runway. It is noteworthy that veer-offs are not included in the standard model for risk calculations for airports in the Netherlands.

3 Third party risk policy in the Netherlands

3.1 Schiphol airport

3.1.1 Zoning

The Schiphol Act i.e. Chapter 8.2 of the Aviation Act [4], and the two Airport Decrees, Airport Traffic Decree [5] and Airport Layout Decree [6], came into effect on 20 February 2003. This also marked the commissioning of the Schiphol's new fifth runway 18L-36R. Regulations regarding limitations of noise pollution, third party risk and air pollution (emissions) to the airport surroundings are established in the Schiphol Act and the Decrees.

In the Airport Layout Decree, the two zones defined for third party risk are Restricted Area 1 and 3. Restricted Area 1 is based on the 10^{-5} individual risk contours whereas Restricted Area 3 is based on the 10^{-6} individual risk contours. These safety zones as shown in Figure 6 are specified

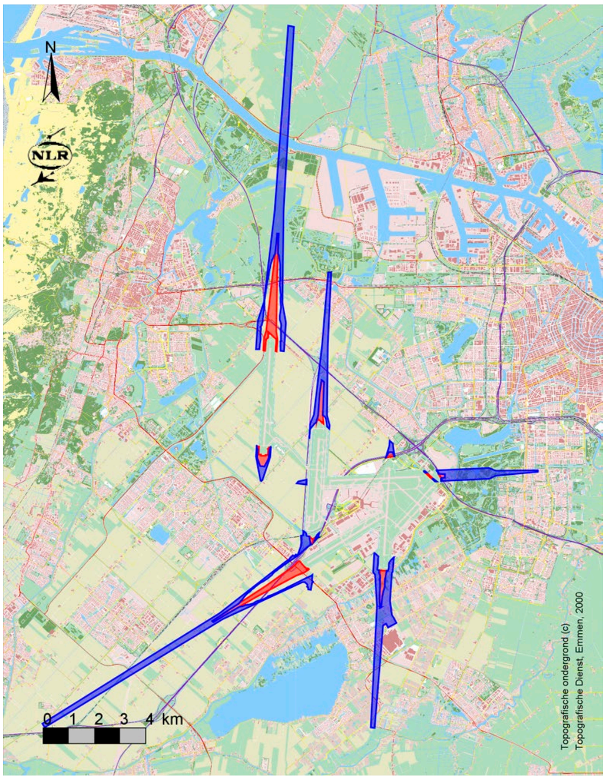

Figure 6. *Amsterdam Schiphol Airport and the restricted areas 1 and 3 as marked in Airport Layout Decree 2003. Restricted Area 1 is given in red, while Restricted Area 3 is shown in blue. These areas are derived from calculations and contours of individual risk. Note: the area between these areas is regulated by noise restrictions (Restricted Area 2)*

to keep people on the ground at a safe distance from air traffic risk and they are based on risk calculations of a number of scenarios in an Environmental Impact Assessment study.

The restrictions of Area 1

This zone is known as demolition zone. Outside this zone no individual risk above 10^{-5} (per year) is allowed. Within this zone the following applies:

- No building of new houses;
- No building of new offices and industrial buildings/factories;
- Existing houses are purchased and demolished on a voluntary basis;
- No “sensitive” (hazardous) industrial buildings.

The restrictions of Area 3

The construction of new buildings in areas exposed to local risks between 10^{-5} and 10^{-6} (per year) is not permitted, with the exception of buildings for small-scale business. An additional guideline is provided to control the societal risk, i.e. by limiting the number of persons per hectare.

3.1.2 Safety enforcement

According to the enforcement policy for Schiphol airport [7] only the third party risk metric devised by Ministry is applied: total risk weight. It is a number (total value) to indicate the third party risk of an airport by incorporating three parameters in risk determination: accident probabilities (for take-off/landing and for accident types), number of aircraft movements in a year, and the maximum take-off weight corresponding to the aircraft per movement. The method of determination is established in the Environmental Information Regulation Schiphol airport [8] (in Dutch: *Regeling Milieu-Informatie luchthaven Schiphol*).

Total risk weight is expressed in metric tonnes per year and a limit value is set for Schiphol airport. For enforcement Schiphol airport is required to provide Inspectorate of Human Environment and Transport (ILT) information about noise pollution at the enforcement points, the total noise volume index, the total risk weight, and the amount of air pollutants emitted.

3.2 Regional airports

Since the end of 2009 the Regulations on civil and military airports came into effect. With the introduction of these regulations [9, 10], the proper authorities are those directly involved, i.e. the regional government like province and municipalities. Within this responsibility, requirements with respect to noise pollution and third party risk for regional airports will be set in line with the policy for Schiphol airport.

For each regional airport, an airport decree must be made before the end of 2014. In the airport decree, the consequences for the environment will be shown for the future scenario of the airport. The intention is that after a period of a few years the airport situation will be evaluated and compared with the scenario that was initially used as baseline for the airport.

4 An overview of the enhancements of third party risk model

The third party risk model has undergone a number of enhancements since the risk model for large airports, Schiphol risk model, was first developed in the early 1990s. The first model [2] was fairly generic. In the period 1999-2000, the model was updated. The updated model for large airports, known as Interim Model Update (IMU) [3], was then based on an accurate selection of airports that are representative for Schiphol airport. The model improvements included the use of a more recent dataset to derive accident probabilities, locations and consequences. The period of data selection in accident probabilities is 1980-1998.

Besides the update of Schiphol risk model, the enhancements include a redefinition of the risk model for regional airports, the development of a helicopter risk model, and other improvements in the model in supporting the updated policy for third party risk necessitated by the government. All updates are described in more detail in the following sections.

4.1 Revision of accident probabilities for third-generation aircraft

The model for large airports, the Schiphol model, has been used intensively in the airport development plans for the introduction of the fifth runway which was realised in 2003, and in different environmental impact assessment studies. Essential for this intensive use is that the most essential model parameter, in this case the accident probabilities, are updated frequently. The accident probabilities of third-generation aircraft, i.e. the modern aircraft types like A320 and B777, have been revised in 2005 and recently in 2012. Only the third-generation aircraft is regarded since more than 95% of the air traffic at Schiphol airport comprises this category of aircraft.

In the revision conducted in 2005 [11], the airports originally selected for the model are used to derive the accident rates and the period for data collection is 1992-2004. In the recent revision in 2012 [12], the collected data now cover the period 2001-2010. In addition, the number of airports has been increased to 50 from 40. Table 1 presents the accident probabilities for different data periods.

Table 1. *Revised accident rates for third-generation of aircraft as used in Schiphol-model (data period 1980-1998; data period 1992-2004; data period 2001-2010). Accident rates are given as per million flights*

Accident type	Period 1980-1998	Period 1992-2004	Period 2001-2010
Take-off overrun	0.062	0.046	0.012
Take-off overshoot	0.046	0.015	0.037
Landing overrun	0.062	0.107	0.146
Landing undershoot	0.124	0.107	0.073

4.2 Redefinition of the third party risk model for regional airports

Next to the first model of third party risk for Schiphol airport various separate model components were derived to determine the risk around regional airports. After the update for Schiphol model was established in the beginning of 2000, the former Ministry of Transport put her focus on other airports in the Netherlands. A need existed in assessing the risk to the surrounding of regional airports in the context of the Key Planning Decision.

In 2002 the third party risk model for regional airports was set up to calculate risk for regional airports and small airfields [13]. Operation and level of safety at these airports are different from those at the major airports in Europe due to the varied traffic mix and operator types.

In the regional airport model the accident probability, accident location and accident consequences have been derived separately for fixed-wing aircraft with an MTOW below 5,700kg (light-weight aircraft) and for aircraft with an MTOW of 5,700kg or more (heavy-weight). In order to reflect the changes in safety, the accident probabilities for heavy-weight aircraft differentiated in passenger, cargo and business jet traffic are being updated at this moment. For the light-weight aircraft, the accident probabilities have been updated recently.

4.2.1 Updating accident probabilities for light aircraft

Since the original accident probability model for light weight aircraft had been derived for more than fifteen years and the data used were obtained from the period 1989-1993, an update of this model was required. Research was carried out in 2010 to derive new accident rates [14].

For updating accident probability model for light weight aircraft, only the accidents and exposure data in the Netherlands were used and aircraft with an MTOW between 390 kg and 5.700 kg were considered. Accident data were collected from the website of Dutch Safety Board [15], where an extensive collection of accident reports or summaries was kept. The aircraft movement data (data on the number of departures or arrivals) were made available to NLR by the airports. These data were obtained from the regional airports and small airfields, Schiphol airport (light traffic), military airbases where civil aircraft movements were allowed. The numbers of aircraft movements were checked against with the data published by the Statistics Netherlands for consistency. The results of the updated accident probabilities (accident rates) are given in Table 2.

Table 2. *Updated accident rates for light weight aircraft. The accident rates are derived from accidents and exposure data in the Netherlands*

Phase of flight	Accident rate (per million flights)
Take-off	1.58
Landing	5.53

4.2.2 Improvement of lethality for light aircraft

In the risk model, lethality is defined as the ratio between the number of third party persons who were fatally injured within the crash area and the number of third party persons present within this area.

The original lethality as used in risk calculation of light weight aircraft in the regional airport model was estimated from a large number of US accident data obtained from NTSB database. In the update of the parameter lethality, a revision of data selection took place. NLR attempted first to collect usable information obtained from UK AAIB and Dutch Safety Board to estimate the lethality value. However, in both sources the information about the number of persons present in the crash area was limited. In contrast with the UK AAIB and Dutch Safety Board data, the US NTSB accident database contained information of the number of persons present in the crash area. Although the accidents are related to traffic of light weight aircraft in USA, it is assumed that this information is also usable for the situation in the Netherlands.

A set of 123 accidents, occurred in the period 1982-2007, was selected. These data provide usable information in deriving the model parameter lethality. With the reported number of third party persons fatally injured and the number of third party persons residing in (the neighbourhood of) the crash, a value of lethality was determined [16].

4.3 Development of a risk model for in-land heliports

The latest addition to the third party risk model is the methodology to calculate the risk due to helicopter accidents near helicopter landing sites [17], specifically that of ground-level heliports and helicopter traffic on airports. The model set-up is fairly generic and can only differentiate between helicopters with different engine types: singe engine piston, single engine turbine and multi-engine turbine.

4.3.1 Helicopter accident probability

Considering the operation, regulations (JAR-OPS 3) and helicopter usage, only the data of nineteen West European countries including Scandinavian countries and Switzerland are selected. Furthermore only accidents that occurred within a limited range from the heliport are representative for the initial and final parts of the helicopter flight. Excluded from consideration were accidents during operations like testing, air shows and aerial work, and accidents due to sabotage. In addition, only accidents are selected subjectively which could be representative for the Dutch situation. The helicopter accident data are obtained from the NLR Air Safety Database.

Exposure data are also required in deriving accident probability. Unlike the scheduled, commercial fixed-wing aircraft operations, a central reporting of helicopter operations does not exist in most countries. The number of helicopter flights published by authorities in their statistics or safety studies is mostly based on estimates. For this reason, the commercial helicopter data package HeliCAS data are used to convert flying hours into number of flights in the determining the accident rates. The HeliCAS data cover primarily the turbine helicopters.

The resulting accident probabilities in the risk model are differentiated for single engine piston, single engine turbine and multi-engine turbine. The single engine piston helicopters are further divided into (i) training and instruction purpose, and (ii) other purpose (non-training).

4.3.2 Helicopter accident location

Helicopters are capable of operating from a take-off and landing site (almost) in all directions due to their unique flying capability. Therefore in the risk model the traffic to and from the heliport is defined in “cake wedges”, sectors with the take-off and landing point situated in the centre of the circle. For each sector the contribution to the location probability is determined by the proportion of helicopter movements assigned to that sector.

The accident location model is based on the distribution of accident data. These data include the distances to the helicopter take-off and landing point. By applying data-fitting a one-dimensional statistical distribution function is derived based on the distances. This distribution function (Weibull function) is translated into a two-dimensional probability distribution function that is tailored to the sector traffic input used in this model.

4.3.3 Helicopter accident consequences

The accident consequences contain two parameters: consequence area and lethality. The consequence area is derived from an analysis of crash area data points. An empirically determined correlation between consequence area and helicopter Maximum Take-Off Weight (MTOW) is obtained. The correlation is usable for helicopters with an MTOW up to 12 metric tonnes.

The lethality is determined as the ratio of the total number of fatalities and the number of persons present in the crash area. The persons regarded are those who are inadvertently exposed to the risk of a helicopter accident and are not involved in its operation. In official accident reports, the number of fatally or non-fatally injured third party persons on the ground is given as factual information. The number of persons that were present inside the helicopter crash area is obtained by using the reported number of injured and non-injured persons, and by making assumptions of the number of persons in objects like damaged buildings or cars reported in the accident.

5 Examples of applications of third party risk analysis

The NLR third party risk models have been applied in context of third party risk discussions and in supporting decision-making in the Netherlands. Two applications of third party risk analysis are presented here.

5.1 Airport zoning

It is recalled that restricted areas around the runways of Schiphol airport have been effected since in the introduction of both Airport Layout Decree and Airport Traffic Decree in 2003. These areas were established for limiting noise pollution and third party risk.

As mentioned before, the Boeing 737 of Turkish Airlines crashed on an open farmland north of Amsterdam Schiphol airport. The location of the crash lies within the restricted area (Figure 7) as marked in the Airport Layout Decree. It means that construction of new buildings is not allowed and the existing buildings should be removed on a voluntary base. Had those restriction zones not been established, buildings might have been allowed. The accident could have ended worse if constructions were located on the farmland. Then, the result of the crash could be aggravated for both the persons on board and third parties.

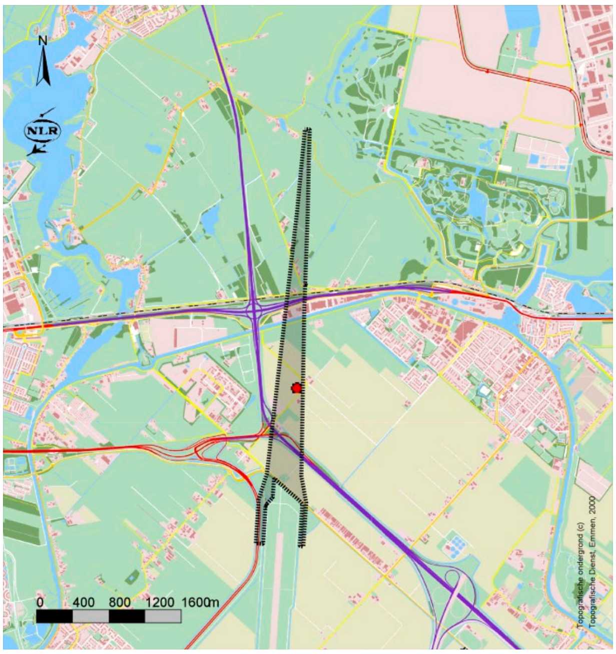

Figure 7. *The crash site of Turkish Airlines aircraft on 25 February 2009 (red circle), Flight 1951, lied at the north of runway 18R of Amsterdam Schiphol Airport. Depicted in the figure are the crash site (red dot) and the Restricted Area 1 (in grey shade) as established in the Airport Layout Decree of Schiphol Airport*

5.2 Evaluation of development plans

In supporting the regional spatial planning and area development around Eindhoven airport, an analysis is carried out to provide an insight in the societal risk as a consequence of various building plans. The results of the risk analysis are discussed and used by the City-Region Eindhoven, other cities and municipalities around the airport and the regional fire-fighting service.

The societal risk due to the air traffic has been analysed in detail. Besides the classic use of *FN*-curve for presenting the societal risk, an alternative way of showing the risk for a certain group size in an area is also applied [18]. For this area-specific presentation of societal risk, use of a risk reference is made. This reference is derived from the orientation value for establishments (OVE) used in the Netherlands. As a guideline, the societal risk of a risk source must not exceed this value. The OVE is described by the relation: $10^{-3}/N^2$, where N is the group size number. For a group of ten persons (N=10), the value is 10^{-5}. It is noteworthy that for air transport no such orientation value is available.

In the area-specific presentation, the societal risk is visualised on a topographic map. The societal risk determined for each calculation grid cell (e.g. 1 hectare) relates to the OVE for different victim group sizes. For each grid cell, colour presentation is applied to show if the probabilities for a victim group size are lower or higher than the OVE. Figure 8 depicts the area-specific presentation of societal risk for Eindhoven airport. Through this way of presenting the societal risk the City-region Eindhoven together with the municipalities in the airport surrounding can obtain an idea on the distribution of the risk over the area and the extent of risk for a particular group size.

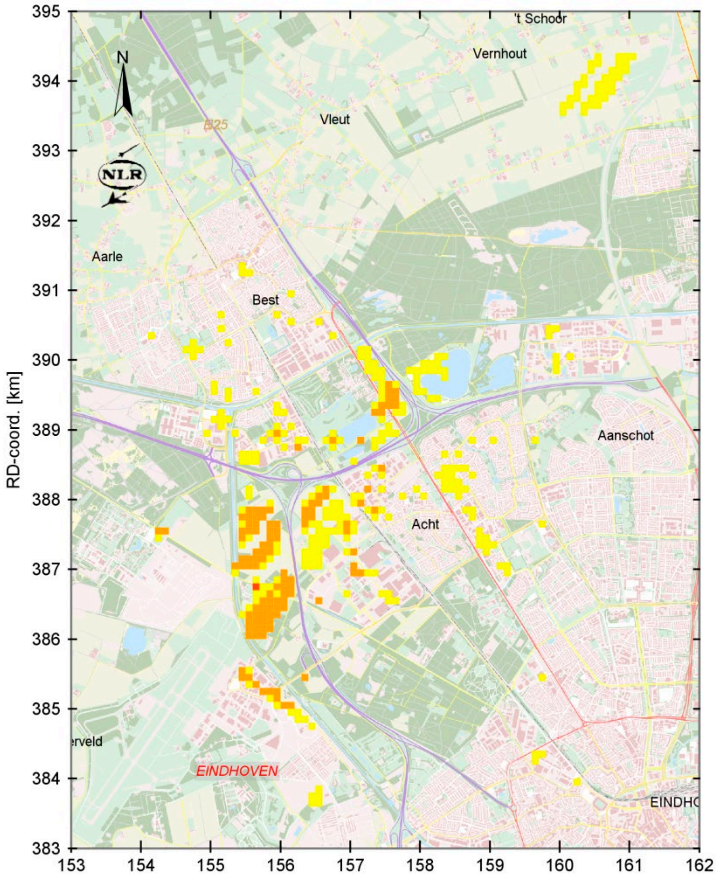

__Figure 8.__ The area-specific presentation of societal risk for a group of 10 persons (or more). Presented is the north side of the Eindhoven airport where a number of building projects is planned. Yellow squares show the area (per hectare) in which the societal risk lies between 1% to 10% of Orientation Value for Establishments (OVE). Orange squares are for the range 10% to 100% OVE; and red squares are 100% or above OVE. Note: the OVE for 10 persons is $10^{-3}/10^{2} = 10^{-5}$

6 Discussion

This paper presented the development and enhancement of the NLR third party risk model since it was first developed for Schiphol airport in the early 1990s and updated later in around the year 2000, and provided an insight on the policy of the Netherlands with respect to third party risk. The third party risk policy pursued by the Dutch government is sophisticated and is still developing.

With the Schiphol Act, set out in both Airport Layout Decree and Airport Traffic Decree, and the regulations for Regional airports (including small fields and in-land heliports), the Dutch policy in the protection of third party is more developed in comparison with other European countries. Without the restricted land-use regulations in the Airport Layout Decree for Schiphol airport, the crash of Turkish Airlines could have been more disastrous. Severe consequences could be expected for both the occupants of the aircraft and the third parties on the ground, if residences were allowed on the location where the aircraft came down. The use of risk contours in airport zoning can be considered as an option in safeguarding third party risk.

For the current practice of controlling societal risk, no risk norm is employed. Only a limit in the number of persons and the type of objects or buildings are allowed in the restricted areas. This implies that the area enclosed by individual risk contours is applied in constraining the societal risk. As outlined in the Government White Paper 2006 [19], an alternative societal risk policy will soon be made available for Schiphol airport. It is expected that this alternative policy will further refine the limits in the number of persons and in the types of objects or (vulnerable) structures allowed in the airport surroundings. By setting these spatial restrictions on the new buildings and (high) structures in the airport vicinity, not only can the third party risk (societal risk) be constrained, but also the risk for air traffic (the persons on board) can be controlled [20].

Regarding the enforcement of third party risk, it is less comprehensive than the noise pollution in the enforcement policy for Schiphol airport. For limiting noise nuisance, enforcement points around the airport as well as restrictions in land use in the restricted area specific for noise are applied. Such enforcement points do not exist for third party risk. Above all, the current limit of total value of risk is such that the value will practically not be exceeded.

From 2009, the regional government is responsible for the application of regulations for the regional airports and small airfields. These regulations are still relatively new. It is expected that the requirements with respect to noise pollution and third party risk will be set in line with the policy for Schiphol airport, and probably in a dedicated fashion.

Third party risk around an airport deserves more attention than now is the case. With the expected growth of the air traffic worldwide, it means that not only noise pollution and air quality, but also third party risk could be a major challenge in the environmental issues. Development of a third party risk model and policy depends primarily on the opportunities of a country. No international standard has been set yet to which risk level a person who lives in the surrounding of an airport, is allowed to be exposed to. The same holds for the methodology on how third party risk should be determined. It is recommended that a concerted framework for setting up third party risk policy be promoted by organisations like ICAO.

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