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# Potential Bird Strike Problems

Comments on recent studies and recommendations for further investigations

21 januari 2000



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Report prepared for Directie Noordzee, Rijkswaterstaat

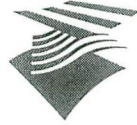
Dit rapport is opgesteld in het kader van ONL ten behoeve van het vervolgonderzoek 'vogels en vliegveiligheid'



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# 1 INTRODUCTION

The duties for this contract that had been proposed originally were to provide comments on the reports by contractors, who had been retained by Directie Noordzee to study various aspects of the expected bird problems at the proposed new Schiphol Airport in the North Sea (SANS). These contractor reports are listed in the Table of Contents and are dealt with individually in the text.

It soon became clear that for a proper evaluation of these reports it would be useful to study and comment on the document "Plan van Aanpak Vliegveld in Zee; Thema Vogels en Vliegveiligheid", which is used by Directie Noordzee to guide the planning and monitoring of the many research projects needed to obtain the information that is required to make the go/no go decision.

The contract duties were further extended to provide recommendations for further research. After studying the "Plan van Aanpak" document, I made a comprehensive list of primary questions (or fields of inquiry) and put those in a table (as described in Chapter 3). I used that table as my guiding document when commenting on the contractor reports (Ch. 4) and, again, when making recommendations for further research (Ch. 6).

Because of the short time-frame (1-14 December 1999), I concentrated my efforts on what I consider to be the most important documents, i.e., the "Plan van Aanpak" document, the report "A method for predicting fatal bird strike rates at airports", and the concept report "Een Eiland in de Noordzee: Luchthaven of Vogelparadijs?" (Ch. 5), in which the various project reports are pulled together by Directie Noordzee in order to arrive at preliminary, overall findings.

Most of the reports are still in the concept stage. Assuming that the final reports will become part of the official documentation pertaining to any decision regarding a new Schiphol Airport in the North Sea, I made editorial suggestions for improvements in the reports, especially for better organization of the material. I made no comments on errors in grammar, syntax, style, typos, etc., except in cases where these made the text confusing.



## 2 COMMENTS ON "PLAN VAN AANPAK VLIEGVELD IN ZEE; THEMA VOGELS EN VLIEGVEILIGHEID"

### 2.1 The need for a comprehensive plan and a method to monitor progress

Section 3 (onderzoeksprogramma) of the "Aanpak" document should make clear how all the individual projects are part of an overall plan that is both logical and transparent. Section 3, and especially the table on p. 2, tries to do that, but it does not provide the quick overview that one would expect and it would benefit from a more rigorous, consistent, and comprehensive approach. It would be useful to break down the highly complex problem in a set of smaller, related **primary questions (or fields of inquiry)** that can be dealt with separately, but that can also be looked at in the aggregate. Together, the primary questions should cover all aspects that have to be dealt with in order to answer the key question "What is the risk of a fatal bird strike?". **A list of the primary questions will thus provide a complete overview of what has to be done.** Required changes can be made to the list at any time. The list will be a work in progress, as it keeps track of a much larger program, which itself will also be a work in progress. Rather than commenting here in more detail, I present my suggestions in the next chapter "Suggestions for a comprehensive method to analyze the problem and monitor investigations".

### 2.2 Further Comments

The planned projects mentioned in Bijlage 1 van het "Aanpak" document will be mentioned in Chapter 6, "Advice for further studies".

In the foot note of page 1, the term "bird control" is defined as consisting of prevention and active bird scaring measures. I suggest to use the term "bird management" to include both approaches and then reserve "bird control" for the active bird scaring activities.

In Section 8, Afbakening, it is made clear that the research should provide data needed to arrive at a go/no go decision. As this lies at the core of the whole program, I suggest it be moved to, or repeated in, the Introduction.



### 3 SUGGESTIONS FOR A COMPREHENSIVE METHOD TO ANALYZE THE PROBLEM AND MONITOR ALL INVESTIGATIONS

The key question that ONL wants to have answered by Directie Noordzee is: "How high is the risk of a fatal bird strike at the Schiphol Airport in the North Sea?" A more precise way to phrase the question is "How high will be the risk of a fatal bird strike in 2015 at a New Schiphol Airport in the North Sea (SANS), which has been designed and built as a bird-unfriendly airport and which operates an optimal bird management program?"

To answer the second question, one needs (a) method for calculating fatal bird strike risk, (b) aircraft data, and (c) bird data. In addition, there will be a need to account for three main complicating factors ("falls", gulls seeking shelter, and a bird warning system) in the model. Analysing the key question in more detail leads to a number of related further, primary questions (denoted by capitals) as follows:

**A--- Is there an adequate method or model for estimating fatal bird strike risks in general, and at SANS in particular? And if not, can such a model be developed?** This first question leads to further questions as follows:

**A1--- What model is available (or can be developed) using expected air traffic data and expected bird data for "normal operational conditions"?** In other words, a model that takes into account bird management at SANS in 2015, but that does not take into account the effects of falls, of gulls taking shelter in bad weather, and of a bird warning system. This basic Model 1 would allow basic or Level 1 calculations of the risk of fatal bird strikes at SANS.

"Falls" are a phenomenon that is almost unique to airports at sea and, therefore, would not likely be part of a model for estimating risk based on information for mainland airports. Thus the next question becomes:







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### 3 SUGGESTIONS FOR A COMPREHENSIVE METHOD TO ANALYZE THE PROBLEM AND MONITOR ALL INVESTIGATIONS

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To answer the second question, one needs (a) method for calculating fatal bird strike risk, (b) aircraft data, and (c) bird data. In addition, there will be a need to account for three main complicating factors ("falls", gulls seeking shelter, and a bird warning system) in the model. Analysing the key question in more detail leads to a number of related further, primary questions (denoted by capitals) as follows:

**A--- Is there an adequate method or model for estimating fatal bird strike risks in general, and at SANS in particular? And if not, can such a model be developed?** This first question leads to further questions as follows:

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"Falls" are a phenomenon that is almost unique to airports at sea and, therefore, would not likely be part of a model for estimating risk based on information for mainland airports. Thus the next question becomes:

**A2--- Can Model 1 be modified to take into account the effect of "falls" of migrants (but still excluding the effects of gulls seeking shelter during bad weather and of the bird warning system)?** This improved Model 2 will allow Level 2 calculations of risk.

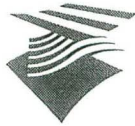
Gulls are expected to try to find shelter at SANS in very large numbers during days of bad weather and will be unusually persistent because there are no other sites nearby. This leads to:

**A3--- Can Model 2 be modified to take into account the effect of gulls looking for shelter during bad weather?** The resulting Model 3 will allow Level 3 calculations of risk.

Any existing model of fatal strike risk in civil aviation would not likely have included the beneficial effects of a truly operational bird warning system, because such a system has never been used in civil aviation. The next questions is:

**A4--- Can Model 3 be modified to take into account the effect of the bird warning system that has been proposed for SANS?** The resulting Model 4 will allow Level 4 calculations of risk.





As mentioned, any model to estimate fatal bird strike risk would have to include information on expected aircraft operations and expected numbers of airborne birds. So the next two primary questions are:

**B--- What are the expected numbers of aircraft that will use SANS when it opens in 2015?, and**

**C--- What are the expected bird numbers in/around SANS in 2015 when a bird-unfriendly SANS is operational and operating an optimal scaring program?**

Further to primary question C, there are the following questions:

**C1--are there adequate bird data for the SANS area to give a fair idea of what birds are using the area now?**

**C2--are there methods of estimating the likely bird numbers in/around SANS in the absence of any efforts to reduce local bird numbers, and what would be the range of those estimates?**

**C3--using the best available methods for reducing bird numbers at/around SANS, how many birds would still be expected at/around SANS and what would be the range of those estimates?**

The last question, C3, can be subdivided into the following questions:

**C3-1 --- What are the are the main species that will likely pose serious threats at SANS?**

**C3-2 --- What are the risks of high-risk species? And what do we know about their ecological needs so that we can design and run SANS in a bird-hostile manner that is aimed at the local high-risk species and based on an understanding of their ecological needs?**

**C3-3 --- What are, in general, the best methods to make SANS unattractive to birds through location, design and habitat manipulation?**

**C3-4 --- What are, in general, the best methods to scare, live-trap and release, and/or kill birds that are still attracted to SANS despite measures mentioned under C3-3 above?**

**C3-5 --- By what percentage will the expected bird numbers at/near SANS be reduced by implementing activities presented and discussed under C3-3 and C3-4 above? And what would be the range of those estimates?**

As mentioned under question A above, there are three factors ("falls", gulls seeking shelter, and a proposed bird warning system) that further complicate the risk calculations at SANS and they can best be dealt with as three separate primary questions:

**D--- What are the expected effects of falls at SANS on the estimates of fatal bird strike risks?**

**E--- What are the effects of large numbers of gulls seeking shelter at SANS on the fatal bird strike estimates?**

**F--- What are the effects of an operational bird warning system at SANS on the fatal bird strike estimates?**

Regarding **question D**, "falls" probably cannot be prevented and may result in temporary closing of SANS. Because falls represent a distinct and complex problem by themselves, they are dealt with as separate primary question. Question D gives rise to the following questions:

**D1--- How frequent and how serious are falls likely to be, how long will they last, and how much variability between years can one expect?**

**D2--- Is it possible to predict or monitor falls, and can warnings be given?**



**D3---** How can the airport cope at the operational level with falls, or with warnings of falls?

**D4---** How likely is it that birds involved in a fall on SANS will cause or contribute to a fatal bird strike? To what extent will these falls affect the risk calculations of the risk model?

Regarding **question E**, gulls looking for shelter during bad weather are another unusual problem that also needs to be dealt with separately. The following questions need to be addressed:

**E1 ---** How serious is the problem?

**E2 ---** Can occurrences be predicted and/or monitored?

**E3 ---** How can the airport cope with large numbers of gulls seeking shelter at SANS?

**E4 ---** To what extent will this problem affect the risk calculations of the model?

Regarding **primary question F**, a new proposed bird warning system would lower the risk of fatal bird strikes. After receiving operational bird warnings, pilots would delay takeoffs (and, less likely, landings) and thus avoid likely encounters with birds. The question is of course by how much the risk of fatal strikes would be reduced by the implementation of the new system. Such a system would require co-operation among air line companies, air line pilots, and ATC personnel and its implementation will therefore probably take some time after the opening of SANS. That is the reason for dealing with this issue as a separate primary question. **Question F** leads to further questions, such as:

**F1---** What does the proposed bird warning system consist of, and does it apply equally to birds over SANS and to birds in SANS's approach areas?

**F2---** Can it be developed and approved by all stakeholders by the time SANS will open?

**F3---** To what extent will the operational bird warning system lower the results of the fatal bird strike calculations, i.e. the Level 4 calculations mentioned in A4 above?

The final primary question is, of course, what are the results of the calculations? (One could argue that this question resorts under primary question A, but I prefer to have it at the end, as the final product.) Thus the primary question becomes:

**G--- What are the results of the calculations of fatal bird strike risk?**

This question will have the following sub-questions:

**G1 ---** What are the results of the Level 1 risk calculations?

**G2 ---** What are the results of the Level 2 risk calculations?

**G3 ---** What are the results of the Level 3 risk calculations?

**G4 ---** What are the results of the Level 4 risk calculations?

To provide an overview of what is being done and/or still has to be done, a table should show for each primary question a list of research questions, the planned activities to address those, and the expected or actual products. In other words, the logical approach is to go from the general to the specific.

Table 1 shows how this system would deal with the 1999 work. In the right-hand column of Table 1, the numbers of the reports are those given in the Table of Contents. Table 1 shows what work has been done and what still has to be started. An enlarged version of Table 1 can be used to plan work further into the future while maintaining the basic comprehensiveness because all primary questions are dealt with in one table.



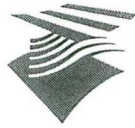


Table 1 will always be a work in progress. As the studies progress there will be more research questions to be answered and they can be added under the appropriate field of inquiry in Table 1. In addition, if Table 1 becomes unwieldy because a growing number of research questions under many of the primary questions, new tables for the individual primary questions can be made to keep track of research activities and their progress. But even in that situation it is a good idea to maintain one comprehensive table (such as Table 1) to plan and monitor all program elements.

**Table 1. Research questions, their associated research activities and products in 1999, by primary questions (or fields of inquiry, A-E). SANS=Schiphol Airport in the North Sea.**

RESEARCH QUESTION	1999 ACTIVITY	1999 RESULTS
<b>A. DEVELOPMENT OF RISK MODEL DEVELOPMENT</b>		
A1. Model 1 development	Development of Model 1	Contract report #1
A2. Model 2 development	None	None
A3. Model 3 development	None	None
A4. Model 4 development	None	None
<b>B. EXPECTED AIR TRAFFIC AT OPERATIONAL SANS</b>		
B1. Expected aircraft movements, by type	Contract (movements only)	Contract report #1
B2. Expected birdworthiness levels, by type	None	None
<b>C. EXPECTED BIRD NUMBERS AT OPERATIONAL SANS</b>		
C1. Estimates of birds now using the area of the future SANS		
C1-1. General information on bird movements, incl. migration in the area	Radar study at IJmuiden Visual obs's at IJmuiden	Interim Report Interim report
C2. Estimate of bird numbers at/near SANS, no anti-bird management	Special Workshop	Workshop Report
C2-1. What is the effect of a bridge or dam to island, as a guiding line?	Special Workshop Contract work	Workshop Report Contract report # 3
C2-2 What is the attractiveness of island as nesting habitat?	Special workshop	Workshop Report
C2-3 Evaluation of attractiveness of island for migrants (excl. D and E)	Special workshop	Workshop Report
C3. Estimate of bird numbers at/near SANS with anti-bird management aimed primarily at high-risk species		
C3-1. Information on high-risk species in area of future SANS	Literature review	Contract report #2
C3-2 Risk assessments of gulls, cormorants and other high-risk species	Literature review	Contract report #3
C3-3 Methods to make SANS physically unattractive to birds	Literature review Workshop	Contract Report #6 Workshop Report
C3-4. Methods for scaring, trapping, and killing of birds	Literature review Workshop	Contract Report #6 Workshop Report



	C3-5. Estimates of expected bird numbers at SANS	Workshop	Report "Eiland in de Noordzee"
<b>D.</b>	<b>D. EFFECTS OF "FALLS" ON RISK CALCULATIONS</b>		
	D1. What is the species composition, frequency, intensity, and duration?	Literature review	Contract report #4
	D2. Can falls be predicted and/or monitored, and warnings be given?	Literature review	Contract report #4
	D3. Evaluate how to cope operationally with falls of different sizes.	None	None
	D4. What are effects on risk calculations?	None	None
<b>E.</b>	<b>E. EFFECT OF GULLS SEEKING SHELTER ON RISK CALC'S</b>		
	E1. What is the species composition, frequency, intensity, and duration?	Literature review	Contract report #3
	E2. Can occurrences be predicted and/or monitored, and warnings be given?	None	None
	E3. What are effects on risk calculations?	None	None
	<b>F. EFFECT OF BIRD WARNING SYSTEM ON RISK CALC'S</b>		
	F2. Will ATC, airlines and pilots use system and be ready by 2015?	None	None
	F3. What are effects on risk calculation?	None	None
	<b>G. RESULTS OF THE FATAL BIRD STRIKE RISK CALCULATIONS</b>		
	G1. Level 1 calculations of risk	Level 1 risks calculated	Contract report #1
	G2. Level 2 calculations of risk	None	None
	G3. Level 3 calculations of risk	None	None
	G4. Level 4 calculations of risk	None	None





## 4 COMMENTS ON REPORTS PREPARED FOR DIRECTIE NOORDZEE

### 4.1 Comments on report 1 "A METHOD FOR PREDICTING FATAL BIRD STRIKE RATES AT AIRPORTS" (final)

#### 4.1.1 Overall comments

This is an important report because it develops a model for predicting fatal bird strike rates. There is, however, a need to clarify and elaborate the procedures used and to present the original data so that interested parties can follow the entire procedures and check the calculations.

The reported finding of a linear relationship between bird density of the laughing gulls at JFK and the laughing gull bird strike rate at JFK is not unexpected, but the finding that the resulting formula can be used for other species as well, certainly is unexpected. This makes it even more important to present the data and method in sufficient detail so that they can be checked.

The model has a number of limitations, some of which are acknowledged by the authors. A revision of the report should try to overcome those limitations. Detailed questions are given in the next section.

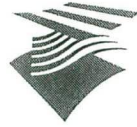
#### 4.1.2 Technical and editorial comments, queries and suggestions

**3.1 Example accidents---** Consider adding to example 3, p. 12, the fact that this was not a fatal accident only because all passengers were highly trained airline employees. This shows that because of a fluke a potentially fatal crash did not result in a fatality. (If we assume that all crashes resulting from bird strikes have the potential of causing fatalities, we should perhaps include in the analysis all bird-caused crashes, whether or not they resulted in a fatality. This would give us more data to work with, and the data for fatal and non-fatal crashes could either be pooled or dealt with as two different data sets.)

**Section 4 Model for predicting fatal bird strike rates ---** I agree with the authors, on p.14, that it "is impossible to develop a detailed analytical model for bird strike rates for a given airport" because of the many variables involved (Section 4.1), and that, therefore, an empirical method should be used. The authors are also correct in saying that comparisons of strike data for different airports are likely to be biased and that, therefore, an analysis of data for a single airport (in this case JFK) is a more suitable approach.

**Section 4.2.1 Derivation of the method ---** This section should be far more elaborate:

- What were the bird density data and how were they arrived at? Were there one or more nests counts done in the nearby laughing gull colony, or one or more bird counts at the runways area of JFK, or all of JFK, or JFK and vicinity?
- What were the count numbers for each year during 1979-1989?
- In case the nest counts in the gull colony were used, were there any corrections to account for fledglings after the breeding season?
- What is the location of the gull colony in relation to JFK? A map of JFK and surroundings, including Jamaica Bay, the laughing gull colony site(s), and their local flights would be helpful.



- How were the weight data arrived at (averaging of male and female weights?); and how were the values for males and females obtained?
- What were the strike data?

**Section 4.2.2 Influence of bird species on strike probability** --- Again, the data and procedures should be presented in sufficient detail that they can be followed and checked:

- Were the different gull species ("gull" is not a species) that frequent Schiphol dealt with separately, and how were their weights arrived at? The same comment applies to "duck" and "falcon".
- Were the same data used as in Section 4.2.3, where bird densities stayed below 100 kg/km<sup>2</sup> for all species combined? If so, the density data for individual species must have been much lower than 100 kg/km<sup>2</sup>. Could the absence of any significant differences be due to small data sets? What test was used to test for differences between the various individual species?
- How were the bird density data collected, for how many years, do they pertain to birds in the air or on the ground or both?
- How were the counts of birds in the field converted to bird densities? What area was included in these calculations: bird counts for all parts of Schiphol or only for runways and aprons?
- Where are the calculations and graphs for the different species? What tests were used to test the differences in slopes for the different bird species?

Schiphol has had a tall grass policy for the last several years. This policy was initiated because of the large numbers of gulls and gull strikes. Thus analyzing the gull data for the years prior to and during the implementation of the tall grass would be instructive. While there are many fewer gull nowadays at Schiphol than in the past, the numbers of raptors, including owls, has increased and that group could also be looked at when trying to validate the method. There may well be other airports (e.g. Copenhagen?) that have adequate long-term data sets to validate the model, and their data should be used as well.

Lengthy data sets can be added as appendices to maintain readability of the text. Assumptions, if any, made when manipulating the data need to be stated..

**Validation of the method** --- The data (and the statistical tests employed to deal with them) should be presented, because it is impossible for the reader to see from the information presented that the Schiphol data validate the model.

In the equation in the middle of p.19, the words "for an airport island" should be added after the words "fatal bird strike rate".

**4.5 Limitations of the model** --- The model developed so far (and referred to as Model 1 in Ch. 2) has the following limitations, with three acknowledged by the authors:

- 1 --- Fleet composition** and, thus, bird-worthiness levels have changed during 1970-1999 and will change further during 1999-2015.
- 2 --- The model was not developed for an island airport**, because it is based on data for mainland airports. The authors mention this, but give no suggestion how to deal with it.
- 3 --- The model does not take "falls" into account.** The authors mention this, but give no suggestion how to deal with it.





4 --- The model does not take into account **large numbers of gulls taking shelter at SANS** during bad weather

5 --- The model does not take into account the effects of a proposed radar-based **bird warning system** for pilots

6 --- The authors mention that the model can be used for **civil transport aircraft only**.

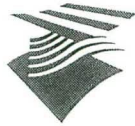
**Re. 1--- Changes in fleet composition.** In empirical studies, models are made and predictions are created based on observed historical information and on the (often tacit) assumption that things will go on as they have been in the past (i.e., the period when the observations were made). The fatal strike prediction model is based on observations that go back, in part, almost 30 years. During the period 1970-1998 the fleet composition has changed. The assumption (p.18, fourth line from the bottom) "... that there is a direct statistical relation between the number of bird strikes and the number of fatal accidents that resulted from the bird strike" is most likely correct. However, the world-wide aircraft fleet changes composition over time by the introduction of new aircraft and/or engines (both of which are becoming better able to withstand bird impact) and by the retirement of old aircraft. Thus the ratio "fatal bird strikes / all bird strikes" is likely to decline over time. This trend can be taken into account to refine calculations of the absolute (exact) risk in 2015 (by analysing the data for aircraft of different levels of birdworthiness and applying the findings to the situation in 2015), but for the immediate decision-making process this is not relevant because the "go/no go" decision will most likely be based on a comparison of the expected risk at SANS (but using current fleet data) and actual, current risks at other airports, including Amsterdam Airport Schiphol (using current fleet data). If the improved bird worthiness of the fleet results in a lower fatal strike rate at SANS in 2015, it would have the same effect at Amsterdam Schiphol Airport in 2015.

**Re 2.--- Model was not developed for an island airport.** As the authors point out, a bird control program, run in accordance with ICAO recommendations, could have a different effectiveness on an island airport than on a mainland airport.

**Re. 3. --- "Falls"** probably cannot be prevented and the model does not include them. In order for the model to take falls into account, more information is presumably needed on the frequency of their occurrence and the weights, numbers, flocking tendency and aircraft avoidance of the species involved in falls. By including the effects of falls, Model 1 would become Model 2.

**Re. 4. --- During bad weather, there will be very large numbers of gulls seeking shelter** at SANS and they would be unusually difficult to scare away because they have no other nearby areas to go to. By also including the effects gulls seeking shelter, Model 2 would become Model 3.

**Re. 5.---** a new proposed **bird warning system** would presumably lower the risk of fatal bird strikes and the question is by how much. By including the effects of the bird warning system, Model 3 would become Model 4. Model 4 would allow the best unbiased estimates of fatal bird strike risk.



**Re. 6.** --- The authors mention that the Model applies to **civil transport aircraft only**. True, but not a limitation from SANS' point of view.

**Conclusions** --- Regarding bullet # 3, the method was developed using laughing gull densities up to 250 kg/km<sup>2</sup>. Validation for different species at Schiphol is mentioned (4.2.2), but no data are presented. If the same data were used as in 4.2.3. the bird densities must have been much smaller than 100 kg/km<sup>2</sup>. In that case the laughing gull data can not have been validated up to 250 kg/km<sup>2</sup>. It is essential that the data, assumptions, and calculations are presented in detail, and the same holds true for validation of the model using pooled bird densities at Amsterdam Schiphol Airport (4.2.3).

--- There is also a need for a discussion, particularly regarding the fact that the model is supposed to be applicable regardless of the bird species involved, as long as bird control operations are in effect. For example, one reason might be that bird control operations could have a "levelling" effect on the bird strike risk of different species.

--- Regarding bullet # 4, it would be more informative to give the range of the calculated fatal bird strike risks, using expected numbers of aircraft movements. (That is what hurried readers are looking for in the conclusions.)

#### **4.2 Comments on report 2 "BIRDS: REVIEW OF RISK SPECIES AND HAZARDOUS BEHAVIOUR" (Concept)**

##### **4.2.1 Overall comments**

This report is difficult to review because pages 18 and 19, which describe part of the selection procedure, are missing. I do not know what criteria were used to arrive at the final selection of the 12 breeding species and 17 non-breeding species. Because Table 1 is missing, I do not know what breeding species were selected.

I agree that the 17 non-breeding species that were selected should all be considered as high-risk species. Common Scoters and Eiders are heavy birds, by far the most numerous birds in the area, and probably often flying in flocks. Is there really enough known about the heights of local foraging flights of these two species to exclude them from the list?

The lengthy report contains no simple table showing a list of the selected high-hazard species plus the reasons for their inclusion. A table listing high-hazard bird behaviours still has to be done.

It is unfortunate that the authors could not develop a method for assessing the risks of migrants, especially because there has been speculation of a major accident caused by swans over the North Sea.

##### **4.2.2 Technical and editorial comments, queries and suggestion**

Pages 18 and 19 and Table 1 (Section 4) are missing and Section 5 had not yet been done.

**Introduction** --- The report lacks a flight safety context. The Introduction could mention that ONL, and thus Rijkswaterstaat, are interested first and





foremost in fatal strikes. There is thus the need to put the present study in the context of what is known already on that topic. There should be references to other studies that have dealt with fatal accidents in civil aviation and the bird species involved should be briefly mentioned. It could then be stated that (a) the available data just mentioned are of a somewhat limited usefulness for SANS because SANS will be an island airport and the existing studies pertain almost exclusively to mainland airports, and that (b) there is therefore a need for further study specifically for SANS.

**2.2 Species characteristics** --- Point 1, p. 10: what is the weight criterion in grams? What are the weights of the species mentioned? Point 3, p.10: why use data for North America, when there are scores of papers pertaining to Europe and Holland?

**2.1 Towards a list of potential risk species** --- It helps the reader if the selection steps are described in a consistent way, with a brief description of the criteria used in each step (the criteria for creating Appendix 3 appear to be missing).

Point 4 , Numbers, top of p. 10, --- How are these categories defined quantitatively?

**3.4 Migrating birds** --- Paragraph 2, p.16--- Migrating birds are a risk when they are flying at any altitude (not "at low altitude") where they can encounter aircraft.

#### **4.3 Comments on report 3 "RISK ASSESSMENT OF BIRD STRIKE HAZARDS: GULLS LARIDAE" (Second draft)**

##### **4.3.1 Overall comments**

This reports provides a wealth of useful information on several gull species that will frequent Schiphol Airport in the North Sea (SANS) and its surroundings. The report is supported by an abundance of references, and the provision of summaries of some papers in the References Section makes that section even more useful.

The statements about gulls are correct and well documented. Data on the heights and numbers of gulls making local and migratory flights in the area are lacking. Information on the heights of gulls involved in thermal soaring (if any) over the island is also needed.

I agree that gulls will persistently attempt to colonise the island and to use it as a place to rest or find shelter during bad weather. The idea of providing a special roosting area for gulls (p. 41) is debatable. Because gulls act as decoys for other gulls, I would recommend a zero tolerance approach to breeding, feeding or resting gulls anywhere on the entire island under normal conditions. But in addition, there could be one designated gull roosting site, away from the runways, where gulls would be tolerated (and "herded" towards) when they are seeking shelter in large numbers during bad weather. This assumes that during bad weather the gulls arrive in large numbers, and can not be driven off, and that upon their arrival the gulls will not mill around, but will hunker down facing the wind, waiting out the storm. As soon as the weather begins to improve the zero tolerance approach will be resumed and gulls are scared away to prevent them from building up a site attachment for SANS.



I agree with the recommendations for further study (see Ch. 6 of this report). A radar study on an offshore island is an ambitious undertaking, but it would provide useful data on low-level gull movements that probably can not be obtained with a radar on the coast because many gulls at 10 to 20 km offshore would fly below the radar horizon.

The main flow of the report can be improved by a greater focus on key flight safety questions and by emphasising how the different sections hang together, as suggested in the next section.

#### **4.3.2 Technical and editorial comments, queries and suggestions**

The formatting of is still sloppy, with text missing at the transitions (bottom and/or top) between pages 13/14, 14/15, 15/16, 17/18, and 19/20. The captions for Figures 2 -10 are out of place and one caption is missing. One paragraph on food of Lesser black-backed Gulls is repeated under Great Black-backed Gulls (p. 19) and no such information is presented for Great Black-backed Gulls. The caption for Fig. 17, is incomplete. Two sections on p.34 are incomplete.

Some of the material and key findings should be rearranged to better focus on risk and risky behaviours. The table of contents must be moved from p.52 to the front, where the reader expects it to be (and its page numbers must be corrected).

#### **Table of Contents (or overall organization)**

After the chapters that introduce gulls in general and as seabirds, main chapter headings could be: "colonisation of the island", "the island and its surroundings as foraging areas", "the island as a roosting/sheltering site" (these 3 chapters explain why there will be gulls in the area), and then a chapter "risky behaviours" that describes why the gulls will be a problem (subdivided in feeding/resting/preening/dozing on/near runways, flying across approach areas during local and migratory flights, slope soaring, thermal soaring), followed by a chapter "gull avoidance and gull control" to describe what can be done about these problems, followed by "discussion and conclusions", "recommendations for further work", and "references".

**Summary** --- All 15 points are well taken, but they can be grouped under relevant headings, such as "gull numbers", "hazardous behaviours", "gull control", "suggestions for further research", etc.

**Gulls in Dutch coastal waters** --- What are the criteria for "common breeding", "rare or irregular breeding", etc.?

**Risky behaviours** --- The first sentence following the first 3 bullets on p.10 needs a verb or some other clarification.

There are 6 bullets in the middle of p.10. The three bullets on the right hand side should be dashes.

**Species account** --- The species need to be dealt with in a more consistent way, with the same topics dealt with for each species under the same subheading, one of which should be 'colonisation'. Perhaps the sloppy formatting has something to do with this as well.





To improve readability and flow of the report, the entire section on species accounts can be presented as an appendix, with the main findings presented in tables in the text and discussed from a gull risk perspective.

The main findings from the Species account section could be summarized in one or more convenient tables that show, by species, the expectations re colonisation of the island, the expected numbers of nesting pairs, the use of the area by gulls for foraging and for roosting/sheltering, and the expected risky behaviours. (This is done, but much later, in the next Section "Breeding distribution, breeding habitat").

**Breeding distribution, breeding habitat** --- The information presented is useful but copious. To help the reader get at the key findings, the bulleted table at the bottom of p. 22 can be moved to the top of p. 21, and the remainder of the text on those to two pages can then be used to explain/justify/clarify the conclusions presented at the top of p.21.

**Gulls at sea**, p.23 --- What is "the Dutch sector of the North Sea"? Provide a map?

**Gulls at offshore installations**, p.30 --- Most of the information in the first long paragraph on p. 30 could be nicely presented in a table. The Figure on p. 31 lacks a caption and the bullets below it lack some text.

**Behaviour of gulls, especially foraging and flight** --- Some of the more theoretical material would fit better in an appendix. The text should focus on the capabilities of gulls as flyers (both flapping and soaring flight) and how their flight behaviours affect their riskiness towards aircraft.

The report deals with slope soaring and mentions soaring over warm surfaces. In my copy the sections on "Intertidal foraging" and on "Behaviour and flight at bridges" still had to be completed.

#### **Bird avoidance**

In the third paragraph, p. 37, the possibility of providing the gulls (and presumably any other birds) an undisturbed roosting site on the island, but away from the runway, could use some further discussion. It seems a poor idea to allow gulls to roost on section of the island, as these would act as decoys and attract many more gulls. Thus, there should be a zero tolerance approach for gulls, at least during normal weather conditions. On the other hand, during very bad weather and "cold rushes", when gulls and other birds will try to find shelter no matter what, it might prove useful to provide such a shelter area, in order to keep the birds away from the runway. However, as soon as the weather begins to improve the zero-tolerance should kick in again and all gulls should be removed by scaring so that they will not develop a "site tenacity" for the island.

#### **Discussion and conclusions**

This section goes on for 3 long pages without any further subdivisions. Readers will appreciate subheadings that refer back to the topics dealt with in the body of the text, e.g. "expected colonisation of the island by gulls", etc. Alternatively, the text can be made more user-friendly by the use of **bolding**.



#### **4.4 Comments on report 4 "FALLS, AN ANALYSIS OF CURRENT KNOWLEDGE." (Concept)**

##### **4.4.1 Overall comments**

This report is a major effort to pull together the available information on a topic that is poorly known, difficult to study and even harder to quantify, reported in scattered documents, and of great importance to flight safety at a new Schiphol Airport in the North Sea (SANS).

The authors appear to have done a good job in amassing and analysing a large amount of information. The question to what extent falls would affect calculations of the risk of a fatal bird strike at SANS still need to be answered in more detail.

I agree with the conclusions and with all points in the Samenvatting, particularly with the suggestion to use of radar for further investigations of falls, in combination with visual bird observations and weather maps. These investigations should aim at the development of a model to predict the timing, volume, and species composition of falls.

Complementary studies should address the question what to do with that sort of information at the operational level. The numbers of birds involved in some falls are very large and the behaviour of birds circling around is especially noteworthy. From a flight safety point of view, more information is needed about the behaviour of the different species when they alight or try to alight on an island and its associated structures. Are birds always milling around or can they be encouraged to settle down by providing them with illuminated roosting sites away from the runways? Would the birds be too tired to respond to efforts to herd them to those areas? How do these disoriented and tired birds respond to approaching aircraft?

Many birds in a fall on SANS will be in poor condition and may die, especially if there is no food or water available (as is recommended, see Ch. 6, E, this report). It may be possible to rescue and rehabilitate such birds, as described further in Ch. 6, D, this report.

##### **4.4.2 Technical and editorial comments, queries and suggestions**

**Table of Contents** --- Detailed and well organized. In addition to the Samenvatting, there could also be a Summary in English.

**2.1 Falls, a definition** --- Don't the downed birds also drink a lot of fresh water and would they therefore be attracted to any pools of rain water?

**2.2 Origins of birds migrating over the North Sea** --- Give a more detailed explanation of the arrows and the associated numbers Fig. 2.1. Radar studies have reported broad-front migration across the North Sea. If needed, use more maps to show in detail what is already known about the different migration patterns across the North Sea.

**3. Methods and databases** --- Provide map(s) to show locations of Meetpost Noordwijk, Platforms K7-FA-1, etc., (pp.17-24). It would be helpful to have one big table showing what kind of data were collected by the different methods, where and when.





There have been several radar studies of migration across the North Sea (summarized in E. Eastwood's book "Radar Ornithology") and they may be useful with respect to falls.

**4.5 Weather circumstances over the North Sea in relation to falls**, and **4.7 Documented falls around the North Sea**, and **5.7 Case studies** --- Weather maps superimposed on maps of the North Sea would help illustrate the points made in these 3 sections.

**5.7 Case studies** --- In the third last line from the bottom, a decade normally means a 10-year period.

**6. Patterns of falls in different species** --- In addition to the text, the information in points 6.1- 6.16 (pages 55-58) could be shown in a table when the analyses of beached birds and of birds seen from platforms and ships have been completed.

**7. Occurrence of numerous species above the Southern North sea** --- The numbers of migrants are impressive (e.g. the 1-10 Million mallards), but it is not clear how large a proportion of these birds would likely cross SANS and its approaches. Do the birds cross the North Sea in a broad front or do they use "corridors"? A few maps showing what is known about the migration of high-hazard species would be instructive. High-hazard species would include waterfowl (esp. swans and geese), the waders (esp. lapwings), gulls, corvids (Crow, Rook, Jackdaw), and smaller songbirds that migrate in large and/or tight flocks (such as Starling and Chaffinch (?), thrushes(?), and what others?).

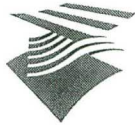
Table 7.1 provides a good summary, with the data organized according to bird systematics. But what is needed for a report on flight safety, is grouping of the species by potential threat, or the degree of risk that the migrating birds are likely to pose to air traffic in and out of SANS. As a minimum, Table 1 could add some subheadings in the table and perhaps bold those species expected to pose the greatest threat to flight safety. Alternatively, the entire Table 7.1 could become an appendix, with the data for high-hazard species presented in a smaller table in the text. And that smaller table could also show what is known about the heights of migration for the different species or groups. What are the criteria for the different levels of quality of information available for the estimation In Table 7.1?

**8.1 Databases consulted** --- The term radar signature is used for patterns in reflected energy that allow identification of the reflecting objects, so it is not used properly in paragraph 3, p.69. It is better to say that falls can be readily observed on radar by the sudden disappearance of bird echoes.

**8.3 Scale and frequency of falls** --- The numbers given on pp. 70 and 71 are truly impressive and the reported behaviour of birds circling around are especially noteworthy. From a flight safety point of view, more information is needed about the behaviour of the different species when they alight or try to alight on structures in the sea, that may or may not be lit.

**8.5 Species involved in falls, p. 72** --- Reposition the word "also" ( in line 5 of paragraph 1) between "Castricum" and "point" in that same line.

**9. Further research** --- Not yet available



#### **4.5 Comments on report 5 "RESULTS, WORKSHOP "ESTIMATION OF BIRD NUMBERS ON A NEW ISLAND IN THE NORTH SEA" (Concept)**

##### **4.5.1 Overall comments**

As there were of course no data on bird numbers on an island that had not yet been built, it was a good idea to "pick the brains of experts" in a systematic, organized way in workshop, so that the best available estimates could be obtained at short notice. (Nevertheless, the final calculations of risk should be based on the results of specially designed studies, rather than the hunches of expert biologists.)

A case can be made that there are four (not three ) categories of birds whose numbers had to be estimated by the workshop participants. (These categories are permanent residents, spring and fall migrants, winter visitors, and breeders/summer visitors.) I also wonder why under habitat types "short grass" was chosen , when at Amsterdam Airport Schiphol a "tall grass" approach is followed, primarily against gulls.

I have no comments on the various estimates for the different bird species, but I do note that for several species, including high-risk species, the estimates of the experts varied by one or two orders of magnitude. As the report correctly points out, these major differences are largely the result of the different interpretations of the participants about the expected situation on the island (the design of the island, construction materials, length of grass, presence of ponds, a harbour, development of eddy's, etc.)

The participants were in better agreement about the key information needs, and I agree with the ones listed on p. 5 of the report, and also with the comments added for "seabirds and sea ducks", "waders and shorebirds", "landbirds (passerines)", and "other waterbirds" (p.5-6).

The report has a list of 43 points regarding the "Estimation of the influence of design parameters and bird control". I generally agree with almost all of them. The suggestion to cover the entire area in concrete is interesting and needs further evaluation (there would be less to eat for land birds, which generally are low-risk species, but there would be more area to loaf for seabirds, which generally are high-risk species, but then again they would all be better visible and, therefore, presumably more easy to scare away). The suggestions to plant thick shrubbery or use rubble as ground cover may not receive approval of the airport operations people (obstruction of fire trucks, and possible Foreign Object Damage).

It must be difficult job to put together a report on the results of this kind of workshop. Nevertheless, in the next section I make a few suggestions for improvements.

##### **4.5.2 Technical and editorial comments, queries and suggestions**

The report could be improved for the reader by a more rigorous organization, which would require some rearranging of some materials under major headings "Methods" and "Results" (with further subheadings as needed). A suggested outline is as follows:

###### **Intro**

###### **Methods**

- Estimates of numbers of breeding and non-breeding birds (as per A, p.3)





- Estimates of the influence of different design parameters and active bird control on birdspecies and their intensity (list the propositions given at the end of the report)
- Obtaining general information on migrating birds (list the questions, p. 5-7)

#### **Results**

- Numbers of breeding and non-breeding birds. (Put all the results of the questionnaires in appendices, but show the highlights in tables in the text)
- Effects of design parameters etc. (provide summaries of answers to the questions)
- Information on migrating birds (provide summaries of the answers to the questions)

#### **Research needs/ info gaps**

- Breeding birds
- Non-breeding birds
- Migrating birds

**Conclusions ?** (probably not needed and very difficult to do)

#### **4.5.3 Additional comments**

**Cover page** --- The year of the meeting is missing and the title could be "Report on..." or "Proceedings of..."

**1 Introduction** --- What is meant by "Inducement of the workshop"? (Reasons for holding the workshop?). The methods described in the introduction would better fit in a new "Methods" section that would describe the procedures followed in the workshop, including the ones for Migrating Birds.

**2. Estimation of bird numbers on a reference island** --- For clarity, add "without bird control" at the end of the heading. On p.7, point 5, bullet 3, change "lasting" to "duration"

**3. Estimation of the influence of design parameters and bird control** --- The report presents a long list of 43 conclusions. Before discussing these 43 points, mention that they also have been summarized in the next section so that hurried readers might read the summary first. I agree with all of the 43 conclusions, except for:

# 13--- If the connection allows foxes, stray dogs and cats to have access to the island they will discourage bird use

# 23.---What is the difference between a bridge running northward and a bridge running southward? Bridges run north-south, east-west, etc.

# 27--- This is a tough one (see overall comments above)

# 30 --- An amusement park (especially of the "Kermis" variety) would almost certainly draw in more gulls, because of the additional gull food, thrown away by people.

# 31 --- Rubble is certainly not very attractive to most bird species. However, many airport operators would caution against the use of rubble because of potential FOD (Foreign Object Damage) problems. Especially on an island in the North Sea (where even hard, solid objects might be blown about during storms and with curious gulls perhaps picking up small rocks and dropping them on the runway), there would be chance of FOD.



#### **4.6 Comments on report 6 "BIRD CONTROL AT AIRPORTS " (Final report phase 1)**

##### **4.6.1 Overall comments**

This report is a general compilation of bird control techniques based on a number of other compilations. Most current methods are described and commented on, albeit very briefly. There is no effort to evaluate the various methods by systematically taking into account the biological basis (if any) for the different techniques. There is no consistent effort to arrive at conclusions/recommendations for their use at airports. The report refers to the various methods in general ("generic") terms, but there is no listing and evaluation of the actual products that are currently available on the market. A few techniques used in North America are not mentioned.

The six airports for which the bird hazards and bird control operations give a reasonable idea of the approaches used, methods employed, and levels of resources dedicated to bird control. However, there is no in-depth analysis of the effects of these bird control efforts in terms of reducing bird strike rates at those airports.

I am in general agreement with the Conclusions and Recommendations, including the sections Effectiveness of bird control methods, Developing a bird control program, Bird control an airport-island, and Relevant examples.

##### **4.6.2 Technical and editorial comment, queries and suggestions**

I do not like the choice of two terms that are defined in the Introduction on page 4:

- The term "resource protection" to describe active bird control is inappropriate because it does not describe the activity (controlling birds) and it alludes to protecting natural resources something it does not do.

- The term "population management" is used to describe killing, capturing, and treating eggs to prevent hatching. This term is misleading because population control normally refers to controlling the numbers of a bird species over a large area, not just an airport.

Regarding the section Case Descriptions:

- The map for JFK should show the location of the Laughing Gull colony

- A map for O'Hare should be added

- The map for Copenhagen Airport should show nearby Saltholm Island with its large gull colony. Also, who says that Copenhagen Airport is the main airport in Scandinavia?

- The Bird Avoidance Model (BAM) used in Israel is interesting, but it really pertains only to military aviation. It is almost irrelevant to mention the BAM, unless the authors discuss how a BAM could be introduced in civil aviation.





## 5 COMMENTS ON REPORTS PREPARED BY DIRECTIE NOORDZEE

### 5.1 "Een eiland in de Noordzee: luchthaven of vogelparadijs (concept)"

#### 5.1.1 Overall comments

The report summarizes the findings of the various contractor's reports and makes a valiant effort to arrive at preliminary estimates of expected bird strike rates for a new Schiphol Airport in the North Sea (SANS). The preliminary estimates are only as good as the risk model (and its assumptions) and the air traffic and bird data used by the model. In addition, the author did not use the model in a legitimate way. The model can only be used with bird densities for airports with standard bird control in accordance with ICAO recommendations and up to 200 meter above ground level (p.15, Report 1). However in Table 2, the risks are calculated using data for SANS without bird control (and therefore invalid and an underestimation). These risk data are then reduced 90% for gulls and by a factor 3 for other birds. These final risks rates would be invalid and an underestimate.

The calculations need to be redone, preferably following a new outline for the report as suggested in the next section.

#### 5.1.2 Technical and editorial comments, queries and suggestions

The report can be better organized by separating the methods (including their assumptions) and the results, largely by rearranging some materials under new headings as follows:

- 1- introduction (leave as is)
- 2- methods for SANS (remove results) and for the other airports (= source of strike rates)
- 3- results of bird density calculations for SANS without bird management (based on the results of the workshop)
- 4- results of bird density calculations for SANS with bird management (As far as I can determine from the concept report, such estimates have not yet been made. The quickest way to get such estimates would be to hold a new workshop of knowledgeable people, as suggested in Ch 6. "Advice on further studies".)
- 5- calculation of risk at SANS using the bird density estimates obtained under point 4
- 6- comparison of **expected** strike rates for SANS (obtained under point 5) with **actual** strike rate for other airports
- 7- conclusions and recommendations

**Titel** --- Rather provocative, and not al that informative.

**Inleiding** --- Is there a need to mention the original question by ONL ("How high is the risk of a fatal strike?"), and then come back to that question in the Conclusions?

After the second question (paragraph. 4, p.4), there could be added a third question: What is the risk with maximal bird management? (see comments above)



**2.3 Risico-analyse op basis van de radarmetingen** --- What is the radar horizon at 10 km from the radar site at IJmuiden? In other words, what is the minimum height of birds in order to be detected at that range? Emphasise the urgent need to get radar data analysed and written up. If possible, that report should discuss the findings separately for high-hazard bird movements that could result in a fatal strike and bird movements that involve small and/or singly flying birds.

**3.2 Effecten van ontwerp variabelen** --- I agree with all points

**3.3 Effecten van actieve maatregelen** --- The column "bird strike per 10000 movements" has to be deleted from Table 1, and the caption of Table 1 should say that it pertains to SANS without bird management. A new Table 2 is needed to show the estimates of bird densities at SANS operating an active bird control (and the caption should say so).

A new Table 3 (instead of the old Table 2) will then show the results of the new calculations of **calculated** rates for SANS as well as the **observed** (or at least reported) rates for the 3 other airports. The column headings (or footnotes) should also give the number of the scenario number (from p. 8) for clarity.

**Bird density data** --- I have no comments on the numbers presented, but these pages should be marked as appendices and there should be reference to the section in the text where they are discussed.



## 6 ADVICE ON FURTHER STUDIES

A new Schiphol Airport in the North Sea (SANS) is not scheduled to open until 2015. It is safe to predict that during the coming 15 years technological development will continue and it is likely that new methods for dealing with bird strike problems will be developed. We can, therefore, expect that, given sufficient support and dedication in implementing new methods, we will be in a better position to deal with the bird strike problem at SANS than we would have been now.

The risk prediction model that has been produced so far (Model 1) needs to be verified and validated. Estimates have to be created of bird densities that can be expected at SANS when it operating with an optimal bird control system as recommended by ICAO. These density estimates will be used in the model. In addition, the model does not take into account three complicating factors (falls, gulls seeking shelter in bad weather, and a bird warning system), which act as limitations of the model and bias the results to an unknown extent. There is need to do studies to determine whether or not these complicating factors can be dealt with. Thus, **a large number of questions need to be addressed simultaneously in order to answer the key question by 2004.**

The recommendations for further investigations are organized around the primary questions (or fields of inquiry) that were presented in Chapter 3 "Suggestions for a comprehensive method to analyse the problem and monitor all investigations". The recommendations are briefly described below and summarized in Table 2, which also includes the planned studies mentioned in the Bijlage 1 of the "Aanpak" document.

**A--is there an adequate model or method for estimating fatal bird strike risks in general and at SANS in particular? And if not, can such a model be developed?**

### **The risk model of van Es and Smit (Model 1)**

As described in more detail in Ch. 4, Section 4.1, the report "A method for predicting fatal bird strike rates at airports" needs to be revised. The methods needs to be described in greater detail so that the assumptions and calculations can be verified. More data sets from more airports should be used to check the validity of Model 1. The revision should also have a Discussion section to discuss the findings (and their reliability) and should make suggestions on how to deal with the complicating factors that pertain to SANS and that have not been included in the model. The revised version should be reviewed by a biostatistician before it is submitted to an international, peer-reviewed scientific journal.

There is also a need to improve the data on expected bird numbers at and around SANS in 2015 (see point C below).

As mentioned There are 4 limitations to Model 1:

- (a) the fact that SANS is on an island and the model is based on data for mainland airports, This factor was taken into account to some degree (by including accidents that likely would have been fatal if they had occurred on an island airport), but it is still possible that standard bird control on an island airport has not the same effectiveness as on a mainland airport





- (b) the effects caused by the occurrence of falls
- (c) the effects of large numbers of gulls seeking shelter at SANS during bad weather
- (d) the effects of a radar bird warning system

Limitations (b) and (c) are probably the key components of limitation (a). Thus by accounting for (b) and (c), Model 1 would probably also account to a large extent for limitation (a).

**B--- What are the expected numbers of aircraft that will use SANS when it opens in 2015 or beyond ?**

Estimates on expected air traffic at SANS are available. The topic of changes in birdworthiness (described in Ch.3) need not be dealt with urgently and will not be considered here.

**C--- What are the expected bird numbers in/around SANS in 2015 when bird-unfriendly SANS is operational and operating an optimal scaring program?**

As described in Ch.3, there are three sets of questions to be addressed: what is the species composition and numerical abundance of birds that (a) can now be found in/over the sea area where the island will be constructed, (b) will be found around the island that SANS will be built upon, and (c) will be present at/around SANS when it is operational, including a bird-hostile design and optimal bird control. Basic field studies, including radar, and visual observations from platforms, ships and aircraft are needed to answer questions (a) and (b).

In order to create and operate a bird-hostile SANS, the airport should be located, constructed, and operated in such a way that the ecological needs of the expected high-hazard species are not met. Thus there is a need to study the ecological needs (including diet, nesting habitat, foraging areas, and local movements) of the high-hazard species that have been identified, and then use that knowledge in designing the airport, its ground cover and structures, and its active bird control program. Existing control methods need to be tested and improved for use against the high-risk species, and the development of new methods needs to be encouraged.

The latest risk calculations by Directie Noordzee (discussed in Ch. 5) do not use estimated bird densities for SANS with an active bird control, as is required by the model. Thus there is a need to estimate those densities and holding a new workshop for that purpose would probably provide such estimates at short notice. These density estimates can be refined in following years as more data become available.

**D--- What are the expected effects of falls at SANS on the estimates of fatal bird strike risks?**

The available information on falls, summarized in the Contract Report 4 by Lensink et al., indicates that few high-hazard species are involved. Apart from pigeons, most species involved are medium-sized songbirds (thrushes, starlings), although small songbirds are often involved in large numbers.

There is a need to learn as much as possible about falls on islands in the North Sea and a detailed study, involving radar and visual bird observations as well as meteorological data, is needed to develop methods for predicting falls and for monitoring them in real time. Can the radar system used for warning of high-



hazard birds aloft also be used to monitor the migration of small passerines and their fall on SANS during unfavourable weather?

What is needed is an evaluation of the effect of an invasion of SANS by tens of thousands (perhaps hundreds of thousands) of small and medium-sized songbirds will have on the chance of a fatal bird strike at SANS. This will depend on several factors including: numbers, weights and behaviour (fatigue) of the migrants, and the degree to which they can be "herded" away from the active runways. In case the assessment of a fall on SANS concludes a high risk, SANS will have to be closed. **By closing the airport during falls, falls as a complicating factor in the risk model, do no longer need to be accounted for in Model 1, and there would thus be no need to develop Model 2.** (From an operational point of view, the immediate question will be "For how long does the airport need to remain closed because of the birds?")

There will be a need for a workshop to bring together ornithologists, radar specialists and operational people to discuss the use of radar to monitor falls and the impact of falls on operations at SANS.

It is likely that many birds in a fall will be tired, hungry, thirsty and/or in poor condition. If the airport is designed as an essentially sterile environment with no open bodies of fresh water (as recommended, see E), then many of the birds will likely die at SANS, as they would have if they had alighted on the sea, in the absence of SANS. This offers perhaps an opportunity to gather and rehabilitate birds that are injured, totally fatigued and/or in poor condition, potentially on a very large scale. It may be possible to collect such birds by hand or by hand-held net. Such an operation would probably be welcomed by nature clubs and they might provide volunteers. This possibility can be explored in due course, if and when it has been decided to build SANS. At any rate, this topic does not pertain to estimating strike risk.

#### **E--- What are the effects of large numbers of gulls seeking shelter at SANS on the fatal bird strike estimates?**

Field studies on islands or platforms are required to learn more about seasonality, species composition, frequency, numbers, and duration of this phenomenon, and to develop a predictive model based on weather. In addition, observations are needed on the behaviour of gulls seeking shelter (Do they mill around a long time at the place where they look for shelter? Could they be "herded" to special bad-weather roosting sites? )

From an operational point of view, there is a need to evaluate the risk of a serious strike with the gulls and a need to arrive at guidelines as to the conditions under which the airport has to be closed. **By closing the airport when large numbers seek shelter, these gulls, as a complicating factor in the risk model, do no longer need to be accounted for in Model 1, and there would thus be no need to develop a new version of the model.** (From an operational point of view, the immediate question will be "For how long does the airport need to remain closed because of these gulls?")

#### **F--- What are the effects of an operational bird warning system at SANS on the fatal bird strike estimates?**

Radar-based bird warning systems have been in use in military aviation for several years, but not in civil aviation. Military training flights can be postponed due to birds relatively easily but delaying large commercial airliners





is costly and disruptive. Nevertheless, civil aviation frequently suffers from other delays, such as caused by weather, bomb threats, etc. Thus delaying flights because of serious impending bird strikes would be in line with existing precautionary procedures. The questions pertaining to a bird warning system in civil aviation are technical and operational.

The main **technical questions** are:

- how accurate is the radar in distinguishing high-hazard birds and bird flocks from small and/or individual birds?
- how accurate is the computer program in tracking the paths of several aircraft and several bird echoes, and in predicting a collision course between an aircraft and (a flock of) birds large enough to cause a major strike?
- can the information be passed on to the pilots, via ATC, in a useful format and short time frame?

The main **operational questions** include:

- will the pilots be convinced that the system has merit and can be used successfully?
- will the airline companies be convinced that the use of the system is prudent, economically sound, and operationally feasible?
- will the ATC operators be convinced that the system is beneficial for flight safety and doable?
- what will be the operational procedures to handle the radar-produced bird information?
- what will be the responsibilities (and liabilities) of the different stakeholders?

For the purpose of fatal risk calculations, there still is the need to evaluate to what extent the warning system will lower fatal strike predictions.

#### **G--- What are the results of the calculations of fatal bird strike risk?**

As already mentioned in Ch. 3, this question has the following sub-questions:

**G1** --- What are the results of the Level 1 risk calculations?

**G2** --- What are the results of the Level 2 risk calculations?

**G3** --- What are the results of the Level 3 risk calculations?

**G4** --- What are the results of the Level 4 risk calculations?

**Table 2. Research questions and recommended research activities in 2000 and beyond, by primary questions (or fields of inquiry, A-G). SANS=Schiphol Airport in the North Sea.**

RESEARCH QUESTION, BY PRIMARY QUESTION	RESEARCH ACTIVITIES IN 2000 and BEYOND
<b>A. DEVELOPMENT OF RISK MODEL</b>	
A1. Model 1 development	Verify Model 1 and expand validation
A2. Model 2 development	Create Model 2, using results from D, if needed
A3. Model 3 development	Create Model 3, using results from E, if needed
A4. Model 4 development	Create Model 4, using results from F, if needed
<b>B. EXPECTED AIR TRAFFIC AT OPERATIONAL SANS</b>	



B1. Expected aircraft movements in 2015, by type	Completed. Further refinements not urgent (see Ch. 4, Section 4.1, this report)
B2. Expected birdworthiness levels in 2015, by type	Not done. Not urgent. (see Ch. 4, Section 4.1, this report)
<b>C. EXPECTED BIRD NUMBERS AT OPERATIONAL SANS</b>	
C1. Estimates of birds now using the area of the future SANS	
C1-1. General information on bird movements, incl. migration, in area	Complete report on radar studies at IJmuiden Complete report on visual observation at IJmuiden Evaluate published radar studies
C2. Estimate of bird numbers at/near SANS, no anti-bird management	Refine existing estimates using results of C1-1, C3-1, and C3-2
C2-1 What is the effect of a bridge or dam to island (as a guiding line)?	Estimates of workshop participants available
C2-2. What is the attractiveness of island as nesting habitat?	Estimates by workshop participants are available Refine estimates using results from C3-2
C2-3 What is the attractiveness of island for migrants? (excluding D and E)	Estimates by workshop participants are available Refine estimates using radar studies, C1-1, C3-2 Refine estimates using platform study (C3-2)
C3. Estimate of bird numbers at/near SANS with anti-bird management aimed primarily at high-risk species	
C3-1. Information on high-risk species in area of future SANS	Complete literature review (report # 2)
C3-2. Risk assessment of gulls, cormorants, and other high-risk species	A large-scale field study of the abundance, distribution, ecological needs (incl. diets), local movements and migration (incl. heights) along the coast and in the area of future SANS. Methods to include visual observations from shore, ship, and/or plane and radar, installed on a platform at sea.
C3-3 Determine bird-hostile design, structures and landscaping for SANS, esp. high-risk species	Study thermal soaring and how to reduce it. Complete Report #3, section on slope soaring in gulls, and study how to reduce it. Develop bird-hostile design for SANS and for its connection to mainland. Develop bird-hostile ground cover for SANS.
C3-4 Methods for scaring, trapping, and killing of birds, esp. high-risk species	Improve existing and/or develop new control methods against expected high-hazard species at SANS
C3-5 What are expected bird densities at SANS with optimal bird control?	Develop data for use in verified Model 1 (A1). Hold workshop with bird control experts, ornithologists, airport operators to estimate bird densities at SANS using data from C2-2, C2-3, C3-1 to C3-4.
<b>D. EFFECTS OF "FALLS" ON RISK CALCULATIONS</b>	
D1. What is the species composition, frequency, intensity, and duration?	Complete literature review (Report 4)





D2 Can falls be predicted and/or monitored, and warnings be given?	Study of predictability of falls based on weather, ground and radar observations. Evaluate the potential of the bird radar (C3-2 and/or F1) for monitoring falls and for warnings.
D3. Evaluate how to cope operationally at SANS with falls of different sizes and with warnings.	Field work on platforms and islands to study behaviour and develop methods to 'herd' birds to designated roost sites. Study effect of illumination on birds' behaviour. Develop operational protocols for dealing with falls and warnings of falls.
D4. What are the effects on risk calculations?	Develop data needed to create Model 2 (A2) if necessary (that is, if a warning system, potentially including occasional airport closings, cannot be developed)
<b>E. EFFECT OF GULLS SEEKING SHELTER ON RISK CALC'S</b>	
E1. What is the species composition, frequency, intensity, and duration?	Study of predictability of events based on weather Evaluate the potential of the bird radar (C3-2 and/or F1) for monitoring events and for warnings.
E2 Can occurrences be predicted and/or monitored, and warnings be given?	Field work on platforms and islands to study behaviour and develop methods to "herd" birds to designated roost sites? Develop operational protocols for dealing with large numbers of gulls seeking shelter and warnings thereof
E3 What are effects on risk calculations?	Develop data needed to create Model 3 (A3), if necessary (that is, if a warning system, potentially including occasional airport closings, cannot be developed)
<b>F. EFFECT OF BIRD WARNING SYSTEM ON RISK CALCULATIONS</b>	
F1. Can a radar bird warning system be developed for SANS? F2. Will ATC, airlines and pilots use system and be ready by 2015?	Set up a stakeholder committee to study technical and operational feasibility of a radar bird warning system Evaluate potential use of system of RNIAF. Consider other potential radar systems, including NEXRAD radar
F3. What are effects on risk calculation?	Develop data needed to create Model 4 (A4), if necessary.
<b>G. RESULTS OF THE FATAL BIRD STRIKE RISK CALCULATIONS</b>	
G1. Level 1 calculations of risk	Redo Level 1 risk calculations using verified Model 1 and results of C3
G2. Level 2 calculations of risk	Do Level 2 risk calculations, using Model 2 (based on results of D4)
G3. Level 3 calculations of risk	Do Level 3 risk calculations, using Model 3 (based on results of E3)
G4. Level 4 calculations of risk	Do Level 4 risk calculations, using Model 4 (based on results of F3)



