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INNER THAMES ESTUARY AIRPORT FEASIBILITY STUDY 2

OPERATIONAL FEASIBILITY AND ATTITUDES TO MOVING TO AN ESTUARY AIRPORT

Prepared for

Airports Commission

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1. INTRODUCTION

This report presents the findings from a set of tasks undertaken by LeighFisher and Jacobs on behalf of the Airports Commission to address the questions set out in the Terms of Reference for the Inner Thames Estuary Feasibility Studies, published in March 2014. The Terms of Reference called for the following four studies:

- Study 1 – Environmental / Natura 2000 impacts;
- Study 2 – Operational feasibility and attitudes to moving to a new airport;
- Study 3 – Socio-economic impacts; and
- Study 4 – Surface access impacts.

This report presents the findings of Study 2 - *Operational feasibility and attitudes to moving to a new airport*. Each task is presented as a separate chapter in this report.

The Terms of Reference for Study 2 required the following topics to be addressed:

Chapter 2	The potential implications of a new hub airport on the **flood management** of the Thames Estuary and the impact future flooding events could have on the operation and resilience of a new hub airport.
Chapter 3	The impact and likelihood of **fog events** to disrupt services in the inner Thames Estuary and on the safety and resilience of operations.
Chapter 4	The impact and likelihood of **cross-winds and winds** to disrupt services in the inner Thames Estuary and on the safety and resilience of operations.
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Chapter 8	The impacts on **energy facilities**, the need to relocate them, and the feasibility of doing so.
Chapter 9	The potential issues concerning the **transition** to a new hub airport, including phasing, delivery, risks and barriers.
Chapter 10	**Attitudes** to moving to a new hub airport.

2. FLOOD RISK MANAGEMENT

2.1 INTRODUCTION

The purpose of this chapter is to explore two questions concerning flood risk management with respect to the proposed Inner Thames Estuary airport schemes:

1. What are the potential implications of a new airport on the flood risk management of the Thames Estuary?

2. What impact could future flooding events have on the operation and resilience of a new hub airport?

The chapter also explores the mitigation measures that may need to be included in the airport design to address the flood risk, and looks at international case studies as well as the schemes submitted by proposers.

The flood risk implications for the wider estuary and associated habitats and wildlife value are considered in the Environmental Study (Study 1).

2.2 OVERVIEW OF FLOOD RISK

Flood risk is an important consideration in the development of an airport on the Hoo Peninsula. There is the need to ensure that the airport is designed with an appropriate standard of protection from flooding. There is also a need to ensure that the presence of the airport does not increase flood risk to communities on the estuary by raising tidal levels. These two issues are summarised below.

2.2.1 Protection of the Airport and Associated Development from Flooding

All the potential schemes would occupy a substantial proportion of the Hoo Peninsula with significant implications for changes in the pattern of flooding: on the site to be occupied by the development and on adjacent areas of the peninsula.

In general, sources of flooding are:

- Tidal flooding
- Fluvial flooding from designated Main Rivers
- Surface water flooding: from overland flow, ordinary watercourses and surface water drainage systems
- Groundwater flooding, and
- Sewers

The airport development, together with access roads, tunnels, railway lines and ancillary services need to be defended against flooding from these sources at a suitable standard of protection.

In addition, the construction of the airport and associated development may increase flood risk in neighbouring areas in the following ways:

- The construction of large paved areas leading to an increase in storm runoff that may increase flood risk in neighbouring areas.
- The construction of the airport may impact on drainage routes through the footprint of the development, potentially increasing flood risk in upstream areas.

2.2.2 Potential Impact on Tidal Levels

Intrusion into the Thames Estuary may restrict the conveyance capacity of the Thames and airport development within the tidal floodplain area may act to increase tidal levels along the Thames Estuary thereby increasing flood risk elsewhere. These wider issues are considered in the Environmental Study (Study 1).

2.2.3 Climate Change and Uncertainty

A further consideration is the potential for an increase in flood risk caused by climate change. In general, sea level, peak rainfall intensity, peak river flow and extreme wave height are all projected to rise over this century, presenting an increase in flood risk. The uncertainty of these projections is an important consideration, particularly as the standard of protection for the airport is likely to be relatively high.

In considering any development of this magnitude, planners should be aware of the so-called 'H++' projection of sea level rise. This is discussed in the Met Office Hadley Centre Projections of 21st Century Extreme Sea Levels (November 2008). This shows that extreme sea levels in the Thames Estuary in 2100 could conceivably rise by almost 3m compared to the representative period 1980-1999. The H++ scenario represents an increase in mass loss from ice sheets of more than two orders of magnitude compared to recent observed increases in the ice sheet contribution to sea level rise. However, the possibility of these large increases occurring cannot yet be excluded based on current models or observations.

2.3 POLICY AND LEGISLATIVE CONTEXT

2.3.1 Thames Estuary 2100 Plan

There are a number of regional and local plans of relating to the issue of flood risk management in the Thames Estuary. Of particular importance to the development and operation of an airport on the Hoo Peninsula is the Thames Estuary 2100 Plan (TE2100).

TE2100 is aimed at protecting London and the people living in the Thames Estuary from flooding now and into the next century. The main focus of the Plan is the management of tidal flood risk, which forms the main source of flood risk to the communities involved. TE2100 adopts an integrated approach with climate change adaption at its core. The Plan covers the tidal Thames from Teddington to Sheerness, to the east of the Hoo Peninsula, and therefore includes the potential sites for airport development under consideration in this report. The Plan is linked to the Catchment Flood Management Plans (CFMPs) for adjacent catchments and to Shoreline Management Plans (SMPs) in Kent and Essex.

Information presented in the TE2100 Plan confirms that substantial areas of the Hoo Peninsula, on which the airport development schemes would be sited, are within Flood Zone 3, in areas presently benefiting from existing tidal defences. The Plan underlines the significance of surges in the North Sea as a major risk to the TE2100 area. The Plan anticipates rising flood levels caused by climate change and recognises the uncertainty in the predictions for sea level rise including worst case scenarios. In response the Plan adopts a managed adaptive approach, involving maintaining and improving the existing system, which defers the need for investment in a new tidal barrier to 2070. The Plan envisages the development of 876ha of new habitat to compensate for the intertidal habitat that will be lost due to sea level rise over the same period of time. Several of the identified sites for habitat creation are on the Hoo Peninsula and conflict with the proposed airport development schemes (this is addressed in the Environmental Study (Study 1).

The TE2100 Plan identifies a number of Action Zones, two of which involve the Hoo Peninsula and thus impact on the proposed airport development proposals:

- Action Zone 6 includes the North Kent Marshes policy unit, which includes the extensive areas north of the village of Cliffe forming the Cliffe and Halstow freshwater marshes. The policy adopted for this area envisages maintenance and repair of defences but no defence raising. Floodplain

management is envisaged, with improved flood forecasting and warning and a flood emergency plan for evacuation. The policy unit includes an area identified for habitat creation.

- Action Zone 7 includes the Isle of Grain policy unit, which consists of the Allhallows and Grain freshwater marshes to the west and an industrial area to the east. The policy adopted for this unit involves the raising of defences for the eastern half and a realignment for the western half by breaching the defences to create replacement intertidal habitat.

2.3.2 Legislation and National Planning Policy Framework

The Flood Risk Regulations (2009) transposed the EU Floods Directive (2007/60/EC) into English and Welsh law. These regulations require designated Lead Local Flood Authorities (LLFAs) to prepare:

- Preliminary Flood Risk Assessments, which identify Flood Risk Areas
- Flood Hazard Maps and Flood Risk Maps for main river, tidal, reservoir and other sources of flooding
- Flood Risk Management Plans

The responsibilities for the management of floods in England are set out in the Floods and Water Management Act 2010, which consolidates the provisions of the Flood Risk Regulations, and establishes the Environment Agency in a strategic overview role to coordinate the planning and management of all sources of flood risk across the country. The Environment Agency is responsible for producing a National Flood and Coastal Erosion Risk Management Strategy covering flooding from main rivers and the sea. Lead Local Flood Authorities (LLFAs) are responsible for producing local flood risk management strategies, including flooding from ordinary watercourses, surface water and groundwater. In the case of the Hoo Peninsula, Medway Council is the LLFA.

The National Planning Policy Framework (2012), as published on the Government planning portal, sets out the Government's planning policies for England and how they should be applied. This includes specific planning practice guidance on flood risk and coastal change, which defines the requirements for flood risk assessments for Local Plans and development planning applications. This presents a sequential, risk-based approach to guide development away from medium and high flood risk areas (Flood Zones 2 and 3) and other areas affected by other sources of flooding where possible. Where avoiding development within these flood risk zones is not possible, an Exception Test needs to be passed which requires demonstrable wider sustainability benefits to the community with a scheme that is safe over its lifetime with due regard to the vulnerability of its users, without increasing flood risk elsewhere, and where possible reducing overall flood risk.

Policy 10, 'Meeting the challenge of climate change, flooding and coastal change', requires that new developments should be planned to avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure. Specific guidance on climate change for planners is provided in Guidance to support the National Planning Policy Framework. This provides recommended contingency allowances for net sea level rises specifically for London and the east of England. National precautionary sensitivity ranges for peak rainfall, peak river flow, offshore wind speed and extreme wave height are also provided.

For major infrastructure plans and projects, climate change should be considered in much more detail than simply applying the recommended allowances. In particular, development of an airport on the Hoo Peninsula must address the uncertainty over the rates of sea level rise through considering different scenarios including the worst case H++ (high risk low probability scenario).

2.3.3 Baseline Flood Zones

All options for airport development involve construction in high flood risk areas (Flood Zone 3) as illustrated in Figure 1, below. This is a Zone defined by the Environment Agency as having between a 1 in 200 and 1 in 1000 annual probability of flooding. Existing tidal defences on the Hoo Peninsula are known to have a standard of protection varying between 1 in 100 and 1 in 200.

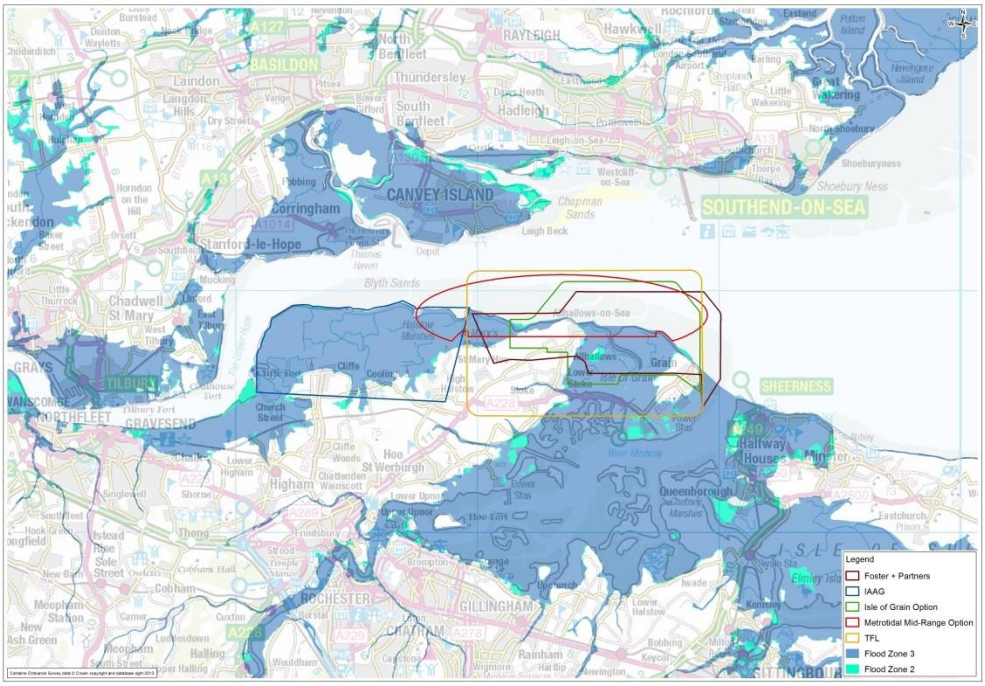

Figure 1: Map of airport schemes and Environment Agency Flood Zones

The North Kent marshes and the Isle of Grain benefit from existing tidal defences on the Hoo peninsula and within the Thames Estuary, illustrated in Figure 2, reproduced from the TE2100 plan.

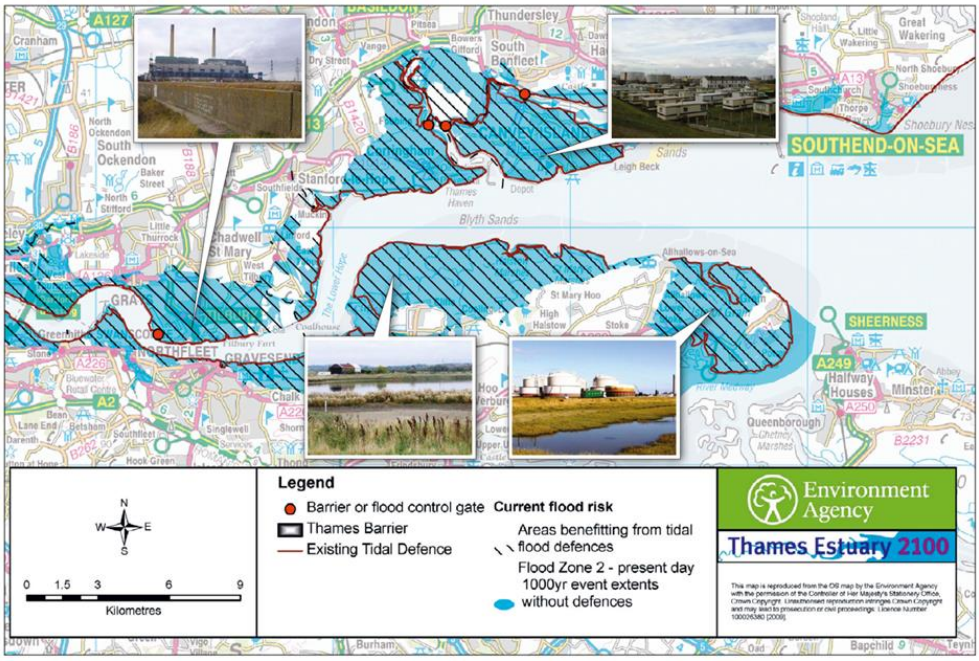

Figure 2: Existing tidal defences from TE2100 plan

2.4 FLOOD RISK MITIGATION

The airport design will need to incorporate measures to mitigate flood risk including:

- Clarification of the standard of protection against flooding to be adopted in the design for the airport site, access roads and railways and tunnels, and other assets on the site taking into account human safety, potential damage and criticality to maintaining operations.
- Measures to defend against extreme tidal flood event, including North Sea storm surges and overtopping by extreme waves such as provided by flood embankments, flood walls, wave walls, construction on a raised platform or a combination of these.
- Due consideration the effects of climate change on sea level, extreme wave heights, peak fluvial flows and peak rainfall intensity on the design of the drainage system and flood defences.
- Provision in the design to allow for the raising of tidal defences in the future with rising sea levels and wave heights due to climate change and to address inherent uncertainty in sea level predictions in line with the approach for TE2100.
- Incorporation of measures to mitigate against any increase in flood rise elsewhere in the Thames or Medway Estuaries caused by the construction of the airport. Such effects could result from a reduction in the conveyance capacity or the removal of land from the associated floodplain. Preliminary investigations by HR Wallingford (see Section 2.5), using a typical design with a significant intrusion into the estuary, indicate that the impact of the reduced conveyance on maximum tide levels and the wave climate in the estuary is relatively minor. Hence mitigation requirements for extreme flood events, which remain to be assessed for each proposal, where required, are not expected to be onerous.
- A surface water drainage system to capture and dispose of surface runoff arising from rainfall over the airport site without increasing flood risk in downstream areas. Depending upon the selected level of the airport, this may involve the need for flood storage ponds and pumping stations to discharge flood waters when tide locked.
- The surface water drainage system needs to allow for capture of pollutants that may arise from events such as spillage of fuel, de-icing spray or foams used on aircraft and runways during emergencies.
- The use Sustainable Drainage Systems (SuDS) methods within the surface drainage design incorporating source control, pre-treatment, retention and infiltration systems as appropriate.
- Provision to convey runoff from adjacent areas that drain through the airport site without risk to the airport or increasing flood risk in adjacent areas. It may be noted that there are significant areas of the Hoo Peninsula that are underlain by London Clay implying the potential for significant sources of flood risk from adjacent areas.
- Provision to mitigate the risk of groundwater flooding, depending upon location and underlying geology.
- Consideration in the design for safe evacuation routes in the event of overtopping or a breach in the tidal defences.
- Demonstrable evidence that the design of the flood defences have given due consideration to the main elements of resilience as applicable to an asset of Critical National Infrastructure within transport sector: resistance, reliability, redundancy and response/recovery.

2.5 HYDRAULIC MODELLING

Preliminary hydraulic modelling work has been carried out by HR Wallingford on a pro bono basis to investigate the impact of the Airports Commission's Isle of Grain scheme. This modelling addresses the impact on maximum water level at high spring tide. At this stage, no analysis has been carried out on the impact of airport construction on maximum tide levels during North Sea surges and extreme events as

used for the TE2100 planning such as the 1 in 200 and 1 in 1000 annual exceedance probability events. This analysis would need to be undertaken with due regard to climate change and sea level rise and address uncertainty by applying a range of scenarios. The results may be expected to vary between the airport options depending upon the extent of the intrusion into the Thames Estuary, the shape of the intrusion, and the level of tidal defence adopted. Analysis carried out for the Thames Gateway port suggests that a relatively low impact on extreme tidal levels is likely, but this remains to be confirmed.

2.6 CASE STUDIES

All of the proposals for the development of an airport on the Hoo Peninsula place the facility, to a greater or lesser degree, in Flood Zone 3 and in principle at increasing risk of flooding with climate change and rising sea levels. While this may present a challenge to designers and developers, provided that the issues are understood from the outset and taken into account in the design, this would not present an insurmountable impediment to the development of a successful airport. There are a number of examples of airports around the world that been developed under similar circumstances on reclaimed land or on low lying land close to the sea. Some of these examples are located on estuaries. However, the main issue relating to flood risk for such developments concerns the manner in which the design addresses the risk of tidal inundation, particularly in response to rises in sea level as a consequence of climate change. This risk is similar both for airports located on estuaries and on the coast. Prominent examples follow.

2.6.1 Hong Kong International airport

Hong Kong International Airport (Figure 3) is built on a platform at an elevation of 7m above sea level, on 9.4km^2 of land reclaimed between the islands of Chep Lap Kok and Lam Chau. The location of this airport was selected by the Governor of Hong Kong and the Legislative Council prior to the return of Hong Kong to Chinese sovereignty. No other options were identified within the administrative boundaries of Hong Kong at that time that would allow for construction on land without the need for reclamation from the sea. The alternatives considered were further developments at the existing Kai Tak Airport (built on land reclaimed from the sea) and a new airport in the Western Harbour between Lantau Island and Hong Kong Island (also to be on reclaimed land). Passenger numbers in 2013 were 59.9 million.

Figure 3: Hong Kong International Airport

Source: CNES / Astrium, Cnes/Spot image, DigitalGlobe, Landsat, 2014

2.6.2 Incheon International Airport, Seoul, South Korea

Incheon Airport (Figure 4) is built on 47.4km^2 of land, protected by a bund 9m high. Passenger numbers for Incheon in 2013 were 41.5 million.

Figure 4: Incheon International Airport

Source: Terrametrics, 2014

2.6.3 Changi Airport, Singapore

Changi Airport (Figure 5) is built on reclaimed land from swamp and the sea at the tip of the island. Growth in air traffic at the earlier Paya Lebar airport led to congestion problems by 1975. Two alternatives were considered: a second runway at Paya Lebar with extensive redevelopment or a new airport. Limitations of space and urban growth lead to the adoption of a new airport at Changi on reclaimed land that could be readily expanded. Flight lines over the sea avoided noise pollution issues. Changi Airport was opened in 1981 and passenger numbers for 2013 were 53.7 million.

Figure 5: Changi Airport

Source: Cnes/Spot image, DigitalGlobe, Landsat, 2014

2.6.4 San Francisco International Airport

San Francisco International Airport (Figure 6) dates from 1927 and was built out in stages on reclaimed land. It is currently considered to be at risk of flooding due to climate change and projected sea level rise. Plans for adaptation are under development and studies into the protection of the airport and the surrounding communities are in progress. The raising of the tidal defences around the airport to ensure a 1 in 100 annual probability of exceedance of the standard of protection is under consideration. Passenger numbers in 2013 were 43.8 million.

Figure 6: San Francisco International Airport

Source: DigitalGlobe, Landsat, U.S. Geological Survey, USDA Farm Service Agency

2.6.5 Schiphol Airport, The Netherlands

Schiphol Airport is constructed about 4m below sea level, but is defended by a ring dyke that provides Amsterdam, the airport and adjacent areas from flooding with a standard of protection of 1 in 10,000 annual probability of exceedance. Approximately 55% of the population of the country live on land below sea level and protected by similar dykes. There is no alternative site for an airport for Amsterdam in the vicinity that would be above sea level.

2.6.6 Flood risk and mitigation at other major airports

Flooding has posed a problem for several airports around the world in recent years: La Guardia Airport in New York was flooded by Hurricane Sandy in 2012. Bangkok Airport was affected in the major floods on the Chao Praya River in 2011. New Orleans International Airport managed to maintain operations during Hurricane Katrina which caused extensive damage to the city itself. Lessons have been learned from experiences such as these that help to inform designs for new airports such as proposed for the Hoo Peninsula.

Most recently, the US Global Change Research Program published a report in May 2014 on the results of a National Climate Assessment. This identified 12 major airports in the USA as being vulnerable to sea level rise, including San Francisco International, La Guardia, New Orleans International and JFK International. The mechanism for flooding will be storm surges superimposed on sea level rise. This is triggering investigations into assessing vulnerabilities to flooding and the incorporation of climate change adaptation in long term planning.

In New York, a range of options are under investigation including flood defence barriers together with protection for critical facilities, such as raising key electrical components and navigation equipment to be above the 1 in 100 annual probability of exceedance.

2.7 REVIEW OF PROPOSED SCHEMES

2.7.1 Issues Common to All Proposals

The four proposals provide different levels of detail into the flood defence envisaged for the various schemes. Issues common to all proposals are that:

1. These proposals are at an early stage and as such, no detailed work has been done by the proposers on the impact of the development on flood risk within the Thames Estuary.
2. No consideration has been given at this stage to surface water flooding and drainage design on the airport sites, how flood risk to adjacent areas would be managed or how the risk of groundwater flooding would be controlled.
3. Standards of protection for surface water flooding and the implications of climate change on rainfall and runoff have not been considered.

An appropriate surface water drainage design can be developed in due course for any of the options, with allowance for climate change, facilities to intercept polluted water for treatment, and giving due consideration to flood risk in adjacent areas.

The level of information offered by the proposers is varied. In the case of the individual proposals, the following points are made:

2.7.2 Foster + Partners

The Foster + Partners scheme is located on the Isle of Grain, extending out into both the Thames and Medway estuaries. The airport would be developed on a near-rectangular platform 8.7km long and 4.2km wide at an assumed level of 7m Ordnance Datum (OD).

The proposal has given good consideration to the issue of flood defence. The primary defence against flooding from high tides, storm surges in the North Sea and extreme waves is offered by the height of the platform. Although the scheme proposes a platform constructed at 7mOD, the proposers hope to be able to reduce this level at design stage. The basis for this design level is not explicitly stated.

The proposal suggests a standard of protection for overtopping of 1 in 100 annual probability of exceedance based upon a joint probability of waves and water levels. This has not been related to the concept of the airport being classified as Critical National Infrastructure within the transport sector as would be appropriate for a major international hub airport.

It is not clear that adequate consideration has been given to the issue of climate change and sea level rise in setting the platform level.

The proposal gives consideration to the issue of safety and the protection of critical facilities with the placing of the terminals and other buildings at a higher level than the platform, and upstands or actuated barriers to prevent entry of flood waters into subterranean rail and baggage systems.

The surface water drainage system is expected to be high capacity and direct, as discharge would not be tide-locked, given the airport construction on a relatively high platform.

2.7.3 Transport for London

The TfL Inner Estuary Airport design scheme would be located on the Isle of Grain, extending beyond the existing tidal defences into both the Thames and Medway estuaries with a large intrusion into the Thames Estuary.

The design concept involves the provision of flood defence embankments around the periphery of the entire airport site with the airport at an unspecified lower level. The flood defence design has been revised since the original submission in 2013: the standard of protection from tidal flooding has increased from 1 in 200 to 1 in 1000 annual probability of exceedance in recognition of classification as Critical National Infrastructure; and the flood embankment height has been raised from 3mOD to 8.8mOD. A phased approach for adaptation to climate change is envisaged, with provision in the design for raising the flood embankments in the future. Linkage with the TE2100 Plan is recognised, for which the airport scheme is expected to deliver elements that are presently not funded.

Additional defences within the airport would be provided to control residual flood risk to protect critical infrastructure and activities, although these are not described.

The need for flood storage in the surface water drainage system is recognised, with the implications of climate change on the magnitude of the storage volume required. The need for pumping stations to discharge surface runoff and seepage through the embankments is recognised. The need to control flood risk to neighbouring areas to an acceptable level is also recognised and standard of protection of 1 in 50 is indicated.

2.7.4 Metrotidal Tunnel and Thames Reach Airport Ltd

The Metrotidal scheme consists of a rectangular airport development located on the north of the Hoo Peninsula, sited within an elliptical arrangement of tidal pools to be used for flood storage and energy generation. The energy generation project would be constructed first and the airport developed within it at a later stage, the two projects being costed separately.

The scheme is to be built largely on reclaimed land north of the existing tidal flood defences with a large intrusion into the estuary. The airport is anticipated to be built at mean sea level and surrounded by a flood defence bund at a level of 8mOD, leaving the airport 2.28m below sea level during an average high tide. No standard of protection has been attached to the level of the flood defences. The need for adaptation to climate change is recognised and the potential need to raise the level of the flood defence bund around the airport and the level of the outer tidal impoundment. The height may be constrained by the Obstacle Limitation Surfaces as defined in the Civil Aviation publication CAP 168 (Licensing of Aerodromes). In order to maximise the usable length, the runways would slope up to match the level of the embankment at the ends, at a gradient of less than 1 in 100. This would tend to direct surface runoff from the ends of the platform towards the centre where the main terminal is located and would need to be given careful consideration in the design of the surface water drainage system.

The tidal energy generation scheme consists of two tidal pools which would normally be operated to deliver power generation from a combination of tidal energy and pumped storage operation, although this is not described in any detail. This scheme is also intended to deliver flood storage in the event of a storm surge in the North Sea to reduce flood levels in the estuary upstream towards London. The benefit to be gained by such operation is not stated and would require evaluation in a hydrodynamic model of the estuary. If operated in this manner, the flood defence benefit to the airport offered by the height of the tidal pool impoundment would be diminished as the pool would fill to the level of the water in the estuary. This would be clarified in the hydrodynamic modelling that remains to be carried out.

No indication of the surface water flood defence and drainage system is provided, although flood storage would clearly be required. Separate flood protection would be provided for the associated Metrotidal Tunnels. No mention is made of the secondary defence of other critical facilities and assets.

2.7.5 IAAG

The IAAG proposal is located on the North Kent Marshes to the north of Cliffe, but the footprint and the extent of any intrusion into the Thames Estuary beyond the line of the existing flood defences remains to be clarified. The form of construction and flood defence is not described in any recent documentation. The proposed level of the airport is not stated. In response to questions, IAAG refer to the use of levees

and sea walls to defend against storm surges, but no standard of protection is stated. Flood defence has clearly not been considered in any detail.

2.8 CONCLUSIONS

The brief case studies cited demonstrate that it is entirely possibly to construct a major international airport in low-lying coastal areas (including estuaries) and on land reclaimed from the sea and to provide it with effective measures for flood defence. There is a demonstrable need for incorporating adaptation to climate change and sea level rise into the design at the outset, to avoid the need for difficult retrofitting in the future, as evidenced by the recent identification of major airports vulnerable to rising sea level in the USA. There are also lessons to be learned from airports such as La Guardia Airport in New York that have suffered major flood events in recent years, regarding the protection of critical facilities, flood defence for access routes, programmes of monitoring for potential flood events, and plans for preparedness in the event of a major flood exceeding the design standard. There is an opportunity to build this learning into the development of an airport on the Hoo Peninsula.

While the level of detail provided to date for the four proposed schemes is varied, there is no reason to suppose that a successful package of measures for flood defence from all source of risk could not be developed, with mitigation elsewhere in the estuary if necessary. Hydrodynamic and wave modelling of the estuary to assess the impact of various schemes under extreme conditions and to determine any mitigation required is recommended at an early stage, taking into account climate change projections and climate change uncertainty, particularly with respect to sea level rise and storm surges. This is particularly important for the Metrotidal proposal to assess the benefit of the tidal pool system in providing flood storage and attenuating flood levels in the estuary upstream towards London.

The precise location and scale of the airport scheme will lead to very different outcomes in terms of the impact upon tidal flows in the Thames and Medway Estuaries, the impact on the TE2100 Plan proposals, and the requirement for mitigations to protect the airport itself against flooding.

3. FOG EVENTS

3.1 INTRODUCTION

The purpose of this chapter is to explore the extent to which an airport in the inner Thames Estuary would experience fog so as to cause disruption of services, and whether the likelihood and impact would differ from fog events experienced at Heathrow or Gatwick.

This chapter sets out the types of fog and their potential impact on airport operations (Sections 3.2 and 3.3), before describing the analysis conducted (Section 3.4) and our observations (Section 3.5).

3.2 TYPES OF FOG

3.2.1 Coastal Fog

Coastal fog occurs regularly along the eastern coast of the UK and is most common during spring and summer when conditions begin to warm up but the sea remains relatively cold. Coastal fog forms through advection, in which relatively warm moist air passes over a cool surface, for example when warm air moves over the cool surface of the North Sea towards the east coast of the UK. The cold air just above the sea's surface cools the warm air above it, causing the moisture it holds to condense, forming water droplets visible as fog.

Wind strength, wind direction and land temperature all have an impact on coastal fog and the length of time it takes to dissipate. On the east coast of the UK, winds blowing from the east can bring in a blanket of fog covering the coastline. If the land is warm then this will dissipate, but if it is cooler then the fog will linger.

3.2.2 Radiation Fog

Radiation fog occurs as a result of the cooling of land overnight by thermal radiation in calm conditions with a clear sky, typically in the winter. As the ground cools, the ability of the air above it to hold moisture reduces, resulting in condensation and fog. Radiation fog occurs at night and dissipates soon after sunrise as the land warms. However, under certain conditions, particularly on elevated areas, areas bounded by high ground, or where the sun's warming effect is less, radiation fog can persist for long periods. If the fog is particularly thick then it may prevent the sun from heating the surface and therefore take longer to clear.

3.3 IMPACT OF FOG ON AIRPORT OPERATIONS

The presence of fog in the vicinity of an airport can have a significant impact on operations as Low Visibility Procedures (LVPs) must be implemented, requiring the separation between aircraft both approaching and taxiing on the ground to be increased.

Instrument Landing Systems (ILS) provide precision guidance to arriving aircraft, allowing aircraft to land in very low visibility conditions. There are three categories of ILS equipment: CAT I/II/III, with CAT III having three sub-categories: IIIa, b and c. CAT IIIc theoretically allows approaches with zero visibility; i.e. no minimum height at which a visual reference must be established (Decision Height) and no visibility of the runway surface markings or lighting (Runway Visual Range). In practice, there are no certified CAT IIIc airports anywhere in the world at present, primarily because of the requirement to taxi with zero visibility.

However, even with ILS equipment in place, the distance between arriving aircraft must be increased from around 3 miles to around 6 miles. This is to ensure that the preceding aircraft has landed and vacated the runway before the following aircraft is given clearance. Aircraft are also more widely spaced when manoeuvring or taxiing at the airport.

At the other end of the route, aircraft are likely to be delayed taking off if they are destined for an airport that is currently affected by fog.

The scale of impact of fog therefore depends to a great degree on how busy the airport is at the time, its spare runway capacity and, to a slightly lesser extent, its spare taxiway capacity. During peak early morning periods with a large number of arriving long-haul flights, an airport experiencing fog will have to reprioritise its operations so as to accept the more widely spaced arriving aircraft, potentially at the expense of departing flights. These inbound aircraft are already in the air and cannot simply be rescheduled to arrive during a quieter period of the day. This has a knock-on effect through the day which frequently means cancellations of certain flights. Certain aircraft would not be able to achieve the scheduled number of rotations within the reduced time available. These impacts are amplified considerably at capacity constrained airports. At airports with spare capacity, fog still has a significant impact with the increased aircraft separation affecting scheduled arrival and departure times; however, the system is likely to be able to recover to normal operations within a shorter period of time and with fewer cancellations necessary. At an airport without night flight restrictions, it may be possible for airlines to recover from schedule perturbations more readily by extending the day, depending on factors such as operating restrictions at the destination airport and availability of crew.

3.4 APPROACH TO ANALYSIS

We have obtained historical visibility data from the Met Office with which to undertake comparisons between Heathrow, Gatwick and the inner Thames Estuary. The data extend over a ten year period, from 2004-2013.

The nearest weather station to the proposed locations of the inner Thames Estuary airport is approximately 9 miles to the north-east, at Shoeburyness. Shoeburyness was selected rather than Manston because of its proximity and its similar coastal location and shelter afforded by the surrounding coastline. Manston is located approximately 27 miles away and is positioned at 49m above mean sea level compared with 2m above mean sea level for Shoeburyness.

Our analysis examines instances in which visibility at the respective weather station is at or below 200m. The threshold for CAT IIIa operations is a Runway Visual Range (RVR) of 200m while the threshold for CAT IIIb operations is an RVR of between 75m and 200m.

The Met Office's weather data are reported hourly which means that it is not possible to determine with great precision the duration of a fog event. A recorded fog event may have lasted a few minutes or just under an hour. Two consecutive recorded fog events may represent an instance of fog that lasted just over an hour, occurred intermittently over the course of nearly two hours, or was consistent for nearly two full hours. Unless otherwise stated, a fog event refers to an hour in which the low visibility threshold was triggered.

3.5 FOG ANALYSIS RESULTS

3.5.1 Total Number of fog Events

There were a total of 1,319 fog events recorded at the ≤200m threshold from 2004-2013 across the three locations. Of these, 55% were at Shoeburyness, i.e. 2.8 times the number at Heathrow, and 2.1 times the number at Gatwick, as shown in Table 1 below.

Shoeburyness experienced fog 0.82% of the total annual hours, whereas Heathrow and Gatwick's annual hours of fog were 0.30% and 0.38% respectively.

Table 1: Summary visibility data (≤200m)

	Total Events	Percentage of Total Events	Percentage of Total Annual Hours
Gatwick	337	26%	0.38%
Heathrow	260	20%	0.30%
Shoeburyness	722	55%	0.82%
Grand Total	**1319**	**100%**	

3.5.2 Fog Events by Type

Visibility at the <75m threshold has very severe impacts on airport operations with the likelihood that the airport would be required to close. Table 2 shows that there were 70 hours in which <75m visibility was recorded in the past ten years across the three locations, of which 47% occurred at Shoeburyness. The percentage of annual hours of fog at the <75m level at Shoeburyness was 0.04%.

However it should be noted that the majority of these events occurred in the early hours of the morning. Time of day effects are examined in further detail below.

Table 2: Visibility data by threshold

	200m	<200m	<75m	Total Events
Gatwick	114 (34%)	207 (61%)	16 (5%)	337
Heathrow	101 (39%)	138 (53%)	21 (8%)	260
Shoeburyness	265 (37%)	424 (59%)	33 (5%)	722
Grand Total	**480 (36%)**	**769 (58%)**	**70 (5%)**	**1319**

N.B. Percentage data represent proportion of ≤200m visibility events for each airport separately

3.5.3 Fog Events by Month

The number of fog events experienced varies by month, though the pattern shown in Figure 7 shows the effect of coastal fog on data for Shoeburyness, resulting in a large number of fog events in spring and some in summer. Heathrow and Gatwick experience the majority of fog events in winter months, with all three locations peaking in December.

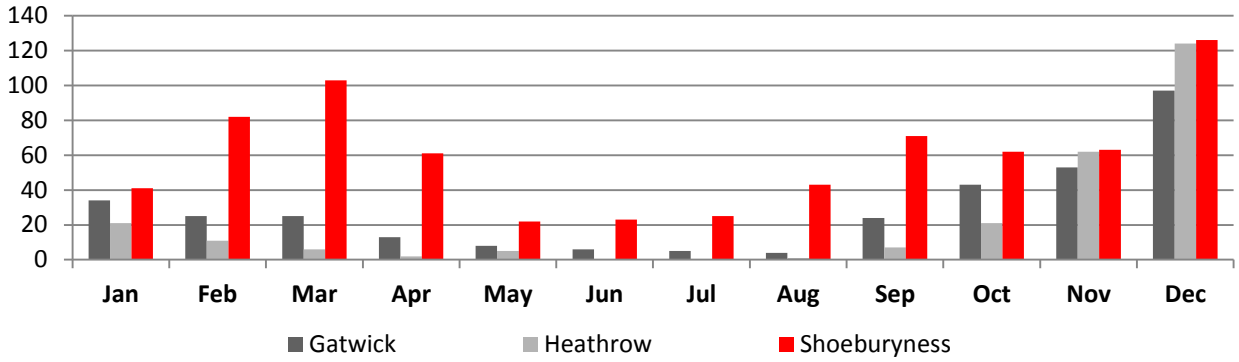

Figure 7: Fog events at ≤200m threshold by month

3.5.4 Fog Events by Time of Day

Figure 8, below, shows the profile of fog events at the ≤200m threshold by time of day. This illustrates that fog usually occurs overnight and particularly in the early hours. 51% of fog events at Heathrow and 57% of fog events at Gatwick are between the hours of 2300 and 0600. At Heathrow and Gatwick, where operating hours are from 0600 until 2300 with very few night flights, the early morning period from 0600 until 0900 experiences the most disruption. Before this time, fog has little if any impact on operations.

Shoeburyness experiences a similar profile of fog events by time of day, though notably a greater number of instances at all times of day. Importantly, the number of events diminishes rapidly after 0700.

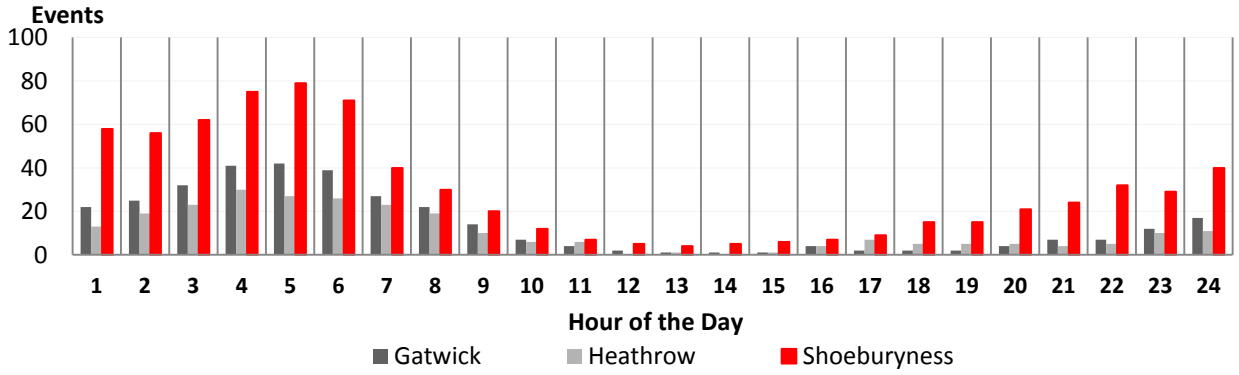

Figure 8: Fog events at ≤200m threshold by time of day

While Heathrow and Gatwick are not affected by their instances of overnight fog, a 24-hour inner Thames Estuary airport would be affected since it can reasonably be expected that at least some aircraft would be arriving and departing. However the numbers are likely to be small enough that separation distances could be increased without any significant consequential impact upon schedules.

Fog events at the <75m level would require the airport to divert all arriving aircraft and halt all departures. As illustrated in Figure 9, below, the number of occurrences of fog at the <75m level is very low over the ten year period, and these almost exclusively occurred outside core operating hours. The number of events is too small to draw out any statistical significances; however, visual inspection of Figure 9 would suggest that Shoeburyness is more likely than Heathrow or Gatwick to experience dense fog at the <75m level between 0500 and 0700.

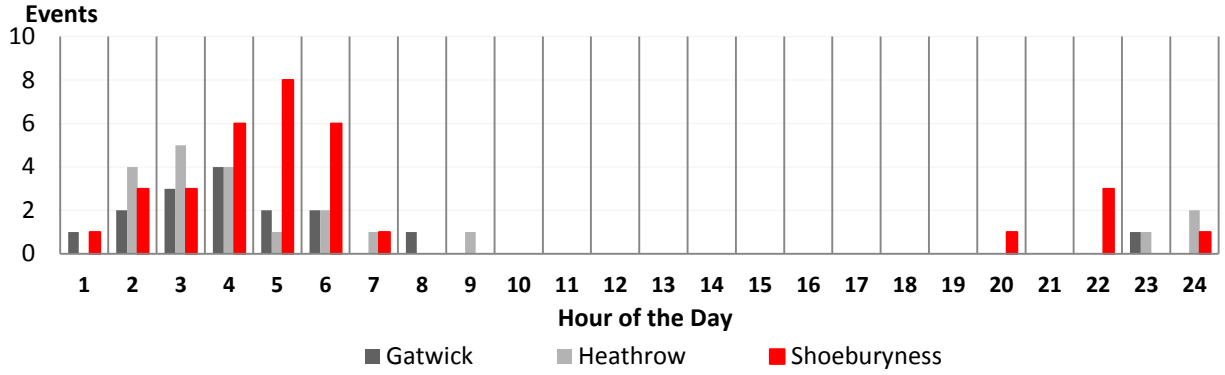

Figure 9: Fog events at <75m threshold by time of day

3.5.5 Fog Events by Duration

Short periods of fog have an important but limited impact upon airport operations, whereas long periods can have a profound impact on airlines' ability to transport passengers and cargo, with full recovery sometimes taking days. We have examined the durations of fog events over the period 2004-2013 for each of the locations.

Between 40% and 50% of all occurrences of fog at Shoeburyness, Heathrow and Gatwick lasted one hour or less. There were seven occurrences of fog lasting more than 10 hours in the ten year period, of which four were at Shoeburyness, two at Heathrow (December 2006 and November 2010) and one at Gatwick (November 2011).

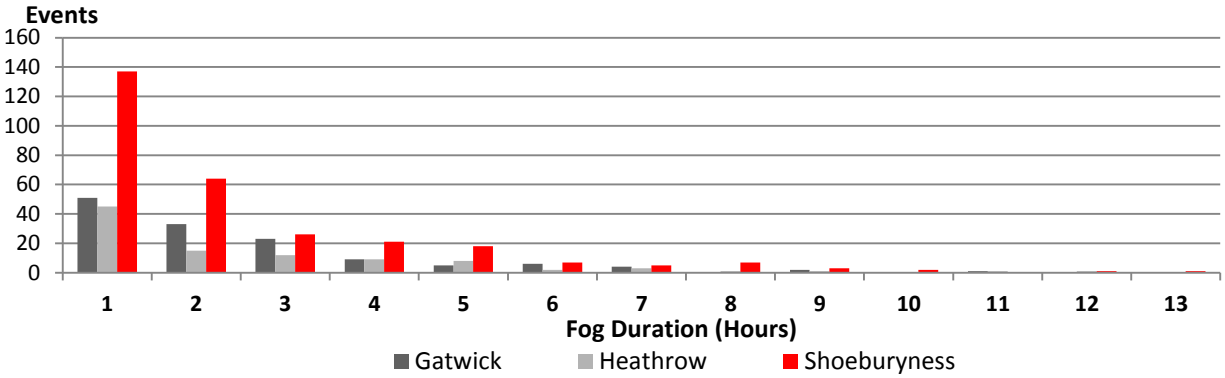

Figure 10: Fog events at the ≤200m threshold by duration in hours

3.6 CONCLUSIONS

Fog events have the power to cause immense disruption to airport operations, resulting in large numbers of cancelled flights especially where a lack of spare runway capacity hampers resilience and recovery. Fog resulting in visibility of 200m or less is very rare, accounting for only 0.30% and 0.38% of annual hours at Heathrow and Gatwick respectively and 0.82% at Shoeburyness. Although Shoeburyness is more than twice as likely to experience events of visibility at or below the 200m level than either Heathrow or Gatwick, the overall proportion of annual hours is very low. The majority of those fog events (around 55%) occur overnight, outside core operating hours, and are therefore much less likely to cause significant disruption.

While there are more instances of fog at Shoeburyness, there is no evidence to suggest that the duration of these instances is materially longer than at Heathrow or Gatwick.

The capability of an inner Thames Estuary airport to operate night flights carries advantages and disadvantages. On the one hand, it means that queues of early morning long haul arrivals could be dissipated to some degree, and the capability exists to extend normal hours of operation into the evening or night time to 'catch up' when required. On the other hand, the Estuary location will inevitably experience occasional periods of severe fog in the night and early hours, to a greater extent than Heathrow or Gatwick do between 0400 and 0700, and aircraft that operate at those times may experience some disruption. However, given technological advances in aircraft navigational equipment and airport ground radar equipment, it is reasonable to assume that CAT IIIc or similar capability will be in more widespread existence than currently, enabling aircraft to approach, land and taxi with little or no visibility. At certain times of the day, the new airport may also be expected to have sufficient spare runway capacity that increased separation between aircraft could be accommodated with minimal perturbation to airline schedules.

4. CROSS-WINDS AND WINDS

4.1 INTRODUCTION

The purpose of this chapter is to explore the extent to which an airport in the inner Thames Estuary would experience winds and cross-winds so as to cause disruption of services.

This chapter sets out the importance of wind speed and direction to aircraft operations, before describing the analysis conducted (Sections 4.3 and 4.4) and our observations (Section 4.5).

4.2 BACKGROUND

The runway alignments for each of the proposed inner Thames Estuary schemes are east-west, similar to both Heathrow (270°) and Gatwick (260°). With the prevailing wind in the UK being south-westerly, and since aircraft take off and land into the wind, the airports operate with a westerly preference.

Aircraft can tolerate a certain crosswind component, i.e. wind that is perpendicular to the runway or direction of intended travel, and larger aircraft typically have much greater tolerance than smaller aircraft. However, operations in crosswind conditions require consideration of a number of factors including the Reported Braking Action of the runway, the runway's co-efficient of friction, and the resulting maximum recommended crosswind. In very wet or icy weather conditions, or in the event of surface contamination, the maximum crosswind limits may have to be reduced because of reduced runway surface friction.

During certification, aircraft are given a 'maximum demonstrated crosswind' level. This is the maximum crosswind condition experienced during the certification process and the level that aircraft manufacturers recommend operators should not exceed. Depending on aircraft type, crosswinds of 25-38 knots (including gusts) can be tolerated. Maximum tailwinds of 10-15 knots are acceptable depending on whether the aircraft is landing or taking off.

To understand whether an inner Thames Estuary airport would be affected by crosswinds, it is necessary to examine historical weather data.

4.3 APPROACH

We have obtained historical weather data from the Met Office for the period 2004-2013. The data take the form of monthly wind roses which illustrate the typical wind pattern for the selected period. Wind roses showing seasonal summaries and overall summaries were also provided. Data were obtained for Shoeburyness weather station, located approximately 9 miles to the north-east of the inner Thames Estuary schemes. The weather station is 2 metres above mean sea level.

The wind rose has 12 arms representing 30 degree bearings. North is at the top. The length of each arm shows the percentage of time that the wind blew from that particular bearing. Each arm comprises a number of bars, which illustrate different wind speeds. Therefore it is possible to determine the percentage of time that any given wind speed and direction was experienced within the applicable time period.

4.4 RESULTS

4.4.1 Shoeburyness Wind Rose Data, 2004-2013

The wind rose in Figure 11 contains all observations for Shoeburyness from January 2004 to December 2013: 86,651 in total.

Simple visual inspection shows a clear effect of the prevailing wind. Westerly wind (210° to 330° inclusive) accounts for 60% of the time. Easterly wind (30° to 150° inclusive) accounts for 26% of the time. Winds blow from the north and from the south 7% and 6% of the time respectively.

The data show, at a high level, that stronger winds (i.e. above 17kts) occur only a very small percentage of the time. The closer these are to the perpendicular, the greater their potential significance, since the crosswind component of wind depends on its direction relative to the runway alignment. For example, compared to a runway oriented east-west (090-270), a 20kt wind speed at 240° has a crosswind component of 10kts, whereas a 20kt wind speed at 210° has a crosswind component of 17kts. There are a small number of instances of higher strength wind from the south and south-west illustrated in the wind rose which require further examination within the seasonal data in Section 4.4.4.

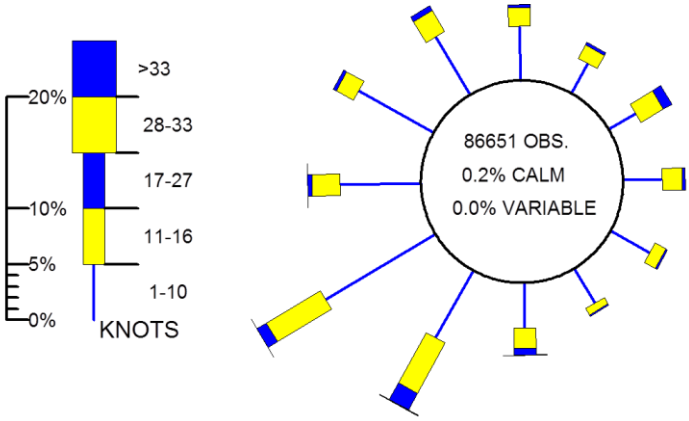

Figure 11: Wind rose data for Shoeburyness, 2004-2013

4.4.2 Heathrow Wind Rose Data, 2004-2013

The wind rose in Figure 12 contains all observations for Heathrow from January 2004 to December 2013: 85,593 in total.

Wind blows from between 180° and 270° approximately 50% of the time. Observations are evenly distributed between 210°, 240° and 270°, each bearing accounting for around 15% of readings, although winds from 210° and 240° tend to be stronger. Heathrow experiences slightly more crosswind than Shoeburyness at speeds of up to 16kts cross-wind component. Cross winds with a higher average speed (classed as Fresh to Strong) occur slightly more frequently at Shoeburyness than at Heathrow but the differences are too small to measure accurately.

Instances of higher strength wind (above 27kts) appear to be no more frequent at Shoeburyness than at Heathrow.

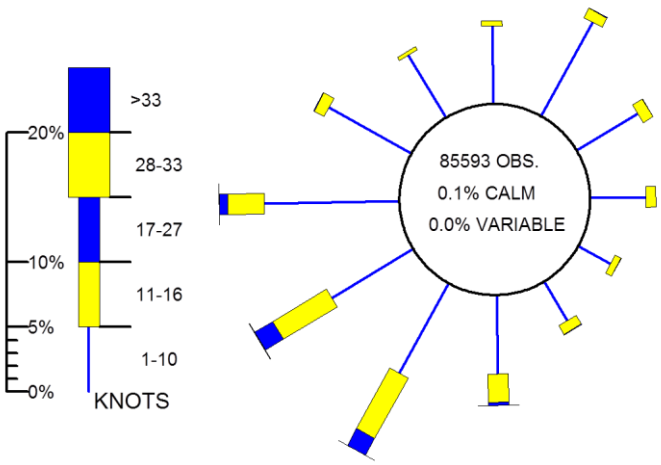

Figure 12: Wind rose data for Heathrow, 2004-2013

4.4.3 Gatwick Wind Rose Data, 2004-2013

The wind rose in Figure 13 contains all observations for Gatwick from January 2004 to December 2013: 86,977 in total.

The pattern of wind direction is more pronounced at Gatwick; bearings of 210° and 240° account for around 22% and 17% of observations respectively and wind speeds are generally lower. Instances of higher strength wind (above 27kts) appear to be much less frequent at Gatwick than at Heathrow or Shoeburyness and there are no instances in which a significant cross-wind component would be observed.

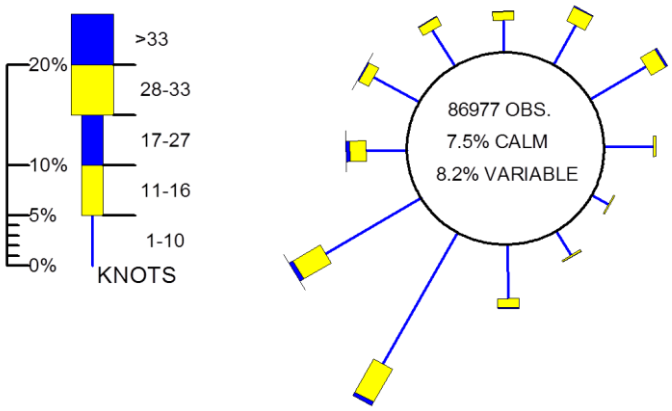

Figure 13: Wind rose data for Gatwick, 2004-2013

4.4.4 Shoeburyness Seasonal Wind Rose Data from 2004-2013

Closer analysis of wind rose data for Shoeburyness by season shows that there is some variation between seasons, with March to May appearing to experience more instances in which the wind comes from the north, north-west and north-east than in other months. Between 21,000 and 22,000 data points are recorded each season.

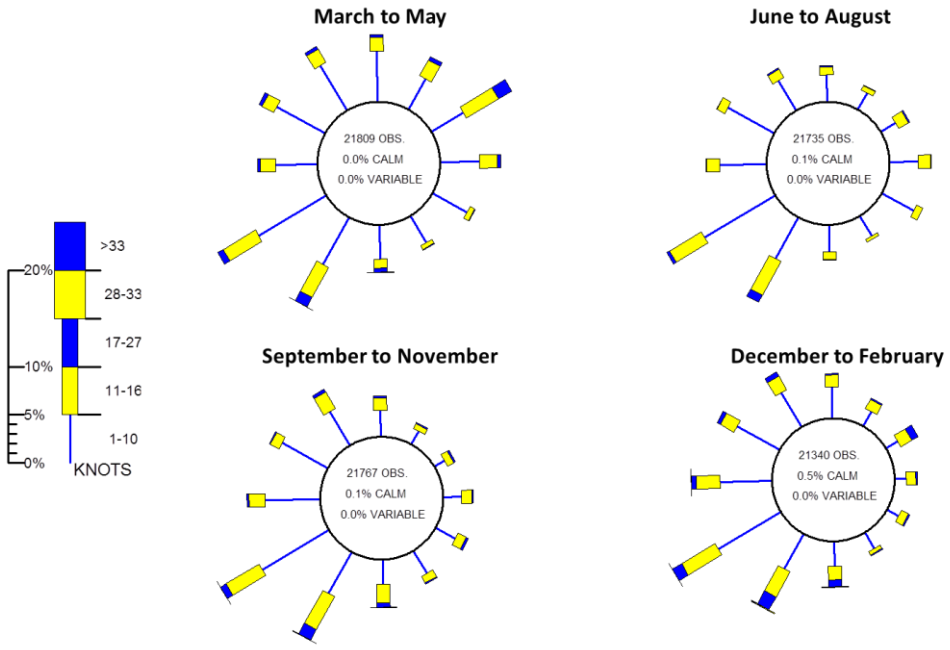

Figure 14: Wind rose data for Shoeburyness, 2004-2013 by season

Some stronger wind events (i.e. above 27 knots) are from the south and south-west and therefore contain a strong crosswind component. However, their number is very low in all seasons and only represents a very small percentage of the time.

4.5 CONCLUSIONS

Wind becomes a material concern to aircraft operations during approach and departure phases when it contains a crosswind component exceeding the maximum demonstrated crosswind for the particular aircraft type. Analysis of ten years of data from Shoeburyness, which gives a reasonable approximation for conditions at the inner Thames Estuary, has found that the instances in which the crosswind component exceeds 27 knots are very few. Where these instances do occur, data on the precise wind speeds are not available but it is likely that many of them are within the accepted maximum demonstrated crosswind for aircraft that would operate from the Estuary airport.

From the analysis performed to date, there is no evidence to suggest that crosswind or strong winds in general would be significantly worse than at Heathrow or would be a material concern for an inner Thames Estuary airport, assuming that a broadly east-west runway alignment is adopted.

5. BIRD STRIKE RISK

5.1 INTRODUCTION

The purpose of this chapter is to explore in greater detail the extent to which aircraft operating from an Inner Thames Estuary airport location would be exposed to bird strike risk and the impact on safety and resilience. The scope of the study does not include implications for designated areas and species although relevant issues are noted. The wider implications for birds and their habitats are considered in the Environmental Study (Study 1).

The assessment has been prepared by Dr John Allan, Head of National Wildlife Management Centre, Animal Health and Veterinary Laboratories Agency, Sand Hutton, York.

5.1.1 The Author

Dr John Allan is Head of the Wildlife Department at the UK Government's Animal Health and Veterinary Laboratories Agency (AHVLA). He has worked as a specialist in wildlife management on airports for the past 26 years and was Chairman of International Birdstrike Committee (the main professional body for specialists in the field) from 2005 - 2012. He received the Mike Khuring award for achievements in birdstrike prevention in 2003. His main research interests are the objective assessment of risk from birdstrikes to aircraft and development of audit and best practice standards for bird management on and around airfields. He has carried out risk assessments and developed bird management protocols for a variety of new build and existing airport developments including Heathrow Terminal 5, Stansted Second Runway, Chek Lap Kok airport Hong Kong, Incheon Airport Korea, Dubai International Airport etc. He also led the AHVLA input into the birdstrike risk assessment for a 4th London Airport on the Hoo Peninsula in 2003.

5.2 BACKGROUND

Collisions between wildlife and aircraft have been a recognised hazard to aviation since the development of the first powered flight in 1910. Whilst all wildlife has the potential to cause damage to a aircraft during a collision, in the context of the Thames Estuary the vast majority of the hazard arises from birds. Hence the remainder of this document will refer only to the birdstrike risk at the proposed new airport sites.

The first human fatality caused by a birdstrike occurred in 1912, and to date birdstrikes have been responsible for the loss of at least 108 aircraft and 276 lives in civil aviation (Thorpe 2010). As well as a threat to life, less severe birdstrike incidents result in significant operational costs to the industry, either directly, in terms of the costs of damage to aircraft, or as a result of delays and cancellations arising from the need for precautionary checks or emergency return to an airport after a strike has occurred. Allan (2002) used data from a major international airline to show that the average cost of a birdstrike, including consequent delays and cancellations if the aircraft had to be taken out of service for repair or inspection, was around US$40,000 per incident. The delays and cancellation costs suffered by the airline outweighed the actual repair costs by a factor of almost 8 times, showing that even non-damaging birdstrikes can be very expensive if they lead to precautionary turn-backs for safety checks. When extrapolated to the world aviation fleet, these costs are estimated to total a minimum of $1.2 billion per year. Other cost estimates exist (e.g. Cleary et al, 2000 estimated an annual cost of up to US$ 391 million for birdstrike damage to civil aircraft in the USA) but most of these concentrate on recording costs of damage and exclude the cost of delays and cancellations.

As well as the costs to the airlines, there are the on-going costs to airport operators of habitat management and bird deterrence operations that are needed to reduce the numbers of birds on and around the airport to acceptable levels. For example, managing the airfield grassland to make it unattractive to birds which is the most common method of airfield habitat management in the UK and

recommended by the CAA (CAA 2008) is estimated to cost around US$ 75,000 per year, and a fully staffed bird harassment programme around US$ 130,000 per year to implement (Allan 2002).

In order to control the birdstrike risk, the International Civil Aviation Organisation (ICAO) has implemented a series of standards and recommended practices (SARPS) that require states to ensure that airports under their control manage the birdstrike risk effectively. In the UK, the Civil Aviation Authority (CAA) implements the ICAO SARPS by requiring airport license holders to manage the birdstrike risk as part of their licensing procedures CAA 2010). The CAA provides guidance on how this should be carried out in their publication CAP 772 Bird Control on Aerodromes (CAA 2008) which is currently undergoing revision.

There is no definition of what is an 'acceptable' level of birdstrike risk at an airport. The CAA carries our regular safety audits of UK airports as part of its licensing procedures and could, in theory, withdraw an airport's operating licence if it deemed the birdstrike risk to be unacceptably high. Similarly, a new airport in the Thames Estuary will require a licence from the CAA before it can operate, but there is no definition of what levels of birdstrike risk the CAA would deem acceptable at a new build site. The normal process would be to work to As Low As Reasonably Practicable (ALARP) as a target for managing the birdstrike hazard. There therefore needs to be a recognition that requirements for bird control need to be balanced against, cost, logistical feasibility and conservation issues. The fundamental question for an airport in this location is whether what is reasonably practicable in the Thames Estuary will result in a birdstrike risk level that is both acceptable to the regulator and can be sustained operationally in terms of costs to the airport and the airlines operating from it.

Whilst the actions needed to control the birdstrike risk at existing aerodromes are well understood (e.g. Allan 2006, CAA 2008), processes for assessing the likely future birdstrike risk at new aerodromes are less well established. Detailed birdstrike risk assessment may also be hampered by a lack of suitable data. Most environmental survey techniques concentrate on counting birds at specific locations to assess the ecological importance of particular sites and often focus on species with conservation designations or other protected status. For the assessment of birdstrike risk, however, it is often the movements of the birds from place to place that are the most significant, because it is only when birds are in the active airspace that they actually pose a risk to aircraft.

It is also the case that most birdstrikes are caused by common bird species. The UK CAA birdstrike database shows that the 10 most commonly struck bird species in the UK in 2013 were Swallow, Swift, Woodpigeon, Skylark, Common Gull, Black-headed Gull, Herring Gull, Kestrel and Starling (CAA Unpublished). These are common species that are abundant around most airfields, both inland and on the coast, but they are frequently not recorded in ornithological surveys designed to assess conservation impacts of developments.

Given that the majority of the species of conservation concern in the Thames Estuary are likely to be waders and waterfowl, it is unlikely that there is sufficient information available on the species in the area that are not of conservation concern to allow a comprehensive risk assessment to be carried out.

For example, even at Liverpool John Lennon Airport, which is immediately adjacent to the Mersey Estuary, a site that supports many thousands of waders and waterfowl, the most frequently struck species groups are Gulls (22%) pigeons (22%), Swallows and Swifts (21%) and small passerines (mostly skylarks and Meadow Pipits) (18%). Waders and waterfowl account for only 10% of the birdstrike sample at Liverpool. It is important to note, however, that this sample represents the residual risk after the airport has implemented habitat management and bird control measures. It is not the same as the background risk that exists at a new airport prior to bird management being implemented nor does it reflect the strikes that might occur if the airport's birds control programme was not in place. It is also the case that not all birdstrike incidents carry the same risk. Strikes with small passerines and Swallows and Swifts are highly unlikely to damage an aircraft whilst strikes with larger waterfowl species or flocks of gulls are more likely to cause a serious incident. An airport's bird control programme is therefore designed as far as possible to deter the most hazardous species and to largely ignore those which pose

minimal risk. Identifying these species is therefore most important in assessing the risk for a new airport and designing a bird management process to control it.

This document provides an overview of the likely birdstrike risks that will arise from developing an airport on the Inner Thames Estuary and the type of data that need to be gathered in order to allow a detailed comparison of risk levels for different airport proposals. It outlines the basic principles for assessing birdstrike risk and describes the likely additional ecological impacts that will arise from steps that may need to be taken to mitigate the risk, particularly outside the airport footprint.

5.3 PRINCIPLES OF BIRDSTRIKE RISK ASSESSMENT FOR NEW AIRPORTS

Assessing birdstrike risk at existing airports is well established using published methods (e.g. Allan 2006, Soldatini et al 2010, CAA 2008). These methods rely on the fact that there is a relationship between the size and flocking tendency of different bird species and the likelihood that a collision with that species will damage an aircraft or cause an accident (Allan 2006). In risk assessment terms this equates to the severity of an incident. Counting either the number of strikes that have occurred at an airport with a particular species in the past, or counting the number of birds of that species on or near the airport, can then be used to estimate the likelihood of a strike with that species occurring in the future (the probability of an incident). A simple multiplication of the probability by the severity gives a measure of the risk of a damaging strike and this can, in turn, be crudely extrapolated to the probability of an accident occurring in a given time (Bell et al. 2003).

For new airport sites the problem is more complex, because the site prior to the development of the airport may bear little resemblance to the site after the airport, and all its associated infrastructure, is built. There is also no history of birdstrikes at the airport to draw on. It is also the case that many birdstrikes arise from birds transiting the active airspace rather than birds actually on the airfield itself. Understanding the movement of birds across the proposed airfield and its approaches is therefore key to developing an accurate estimation of the likely risk at a new site.

Examples of the development of bird management strategies for new-build airports are relatively few, but two examples with some similarities to the Thames estuary situation are Chek Lap Kok (the new airport for Hong Kong) and Incheon airport in Korea. Chek Lap Kok was built on an island which was extended using reclaimed land, whilst Incheon was built in a estuarine area comprising mudflats and lagoons. In both cases extensive bird surveys were carried out prior to finalising the detailed design of the airport and elements of the designs were modified to either remove potential bird attraction or to leave those that were unlikely to generate a significant risk. Appropriate habitat management (selection of ground cover planting, bird exclusion netting from lagoons, choice of ornamental planting around terminal buildings etc. was all carried out and the specifications for bird control equipment, manpower and training all put in place in advance of the first operations beginning. The high background risk at the Thames Estuary means that controlling birdstrike risk will need to be considered in all parts of any proposed airport design.

Most ornithological survey methods, which count birds on the ground at particular sites, do not provide the data needed for this purpose, either because they do not record bird movements in sufficient detail or because they concentrate on bird species that are of high conservation importance e.g. they are rare, threatened or are subject of site protection designations such as SPAs or SSSIs. For example, a recent report submitted by the British Trust for Ornithology (BTO) (Wright et al. 2014) in relation to this Feasibility Study listed the following objectives:

1. Assessment of the importance of the Thames Estuary and Marshes Special Protection Area (SPA), the Medway Estuary and Marshes SPA and relevant adjoining sites for bird populations from published sources;
2. Assessment of the key species and potential numbers that may be impacted by the proposed Thames Hub (note this can only be very approximate as detailed designs are not yet produced);

3. A review of the ability of bird populations to respond to the loss of habitat associated with large scale developments, using examples taken from around the world;
4. A high-level review of potential habitat creation mitigation / compensation measures available and associated issues, and the approximate costs per unit area or bird of such mitigation measures.

The BTO report also provided data on the number of birds on the airport platform area for each of the species that it was reviewing.

The BTO report is typical of most of the data likely to be available for the local area in that it provides count data rather than movement data and focuses on species of conservation concern or for which there is a protection designation at the site.

The majority of birdstrikes are caused by common birds which are not usually recorded in sufficient detail by surveys undertaken to assess impacts of airport developments on conservation interests. The BTO report, for example, does not provide data on any of the top 10 birdstrike species, although it does provide location and count data on a number of the species identified by Bell et al (2003) as posing a high risk on this site. Note that this is not a criticism of the BTO report in itself, as it has been written for a different purpose, but this is a good example of the problems faced when assessing the likely birdstrike risk at new airport sites.

For an airport proposal that involves significant night time operations, there is also a need to assess bird distribution and movements at night. This requires specialist techniques, such as thermal imaging, radio telemetry and, in particular, bird detection radars to be used. This is especially important if, as is the case for the Thames Estuary, other factors such as tide state and wind strength and direction can cause birds to move in less predictable ways during the hours of darkness (Allan & Milsom 1992).

Undertaking a detailed assessment of the likely birdstrike risk at a proposed new airport site therefore requires specialist fieldwork to be carried out. The movement of hazardous birds (i.e. large and/or flocking species) over and around the site needs to be monitored at different times of day/night, throughout the year and, in this case, at different states of the tide and in different weather conditions. Once this information is gathered, it can be compared with other airports in similar environments and an estimation of the likely birdstrike frequency with different species developed.

This exercise was carried out in 2003 to investigate the likely birdstrike risk at a proposed airport site on the Hoo Peninsula (Bell et al 2003). The data available were collected specifically in relation to that proposal and, because suitable techniques were not available at the time, did not include much information about bird movements at night. Despite the fact that the data were also collected some 11 years ago and features in the landscape that may have attracted birds at that time may no longer be present and new ones may have arisen, it is possible to draw some broad indicative conclusions about the proposals being considered in this report. Using the data gathered for the Hoo Peninsula assessment would not, however, produce a comprehensive or an up to date assessment of birdstrike risk.

The 2003 work was specifically designed to assess birdstrike risk. Fieldwork was carried out between 30th September 2002 and 28th February 2003, to identify flight-lines, regular and irregular movements of birds around the Peninsula and to collect information on those species for which information was lacking in the historic analysis (particularly pigeons and corvids). Work was also carried out to establish if there were any changes in behaviour, activity or habitat use at night.

Note that the survey work only covered the 5 month period between October and February and although the methodology included observations made at night, these were restricted to visual and auditory detection as bird radar systems were not available in the UK at the time. It is also important to note that the study covered all species present on the Hoo Peninsula, not just those of conservation concern. Indeed, the species posing high risk to aircraft were found to be: Lapwing, Herring Gull, Oystercatcher, Wigeon, Shelduck, Curlew, Great Black-backed Gull, Cormorant, Mute Swan, Greylag goose, and Redshank. Those with a moderate risk rating were; Black-headed Gull, Common Gull, Starling, Thrush

sps., Brent goose, Bewick's Swan, Canada Goose, Grey Heron, White-fronted Goose and Red-throated Diver. Only a proportion of these species are likely to be monitored by surveys primarily concerned with assessing conservation impact.

The 2003 study concluded that *'the environment around the Cliffe airport option contains substantial numbers of birds hazardous to aircraft. Without a comprehensive and aggressive bird management programme in place, incorporating careful and considered airport design, appropriate habitat management and active bird control, an airport could not operate safely in this location. Even with such world class management and mitigation measures in place as identified in this report, it is not considered possible to reduce the risk to a level similar to that experienced at other UK airports. The risk posed by birds at the proposed Cliffe airport is likely to be greater than at any operational airport in the UK.'*

The report acknowledges that with good airport design proper habitat management and effective bird control, even the high levels of risk encountered could be managed, but not to a point where the risk would be comparable with other airports in the UK. What the report did not consider, however, was the possibility of removing additional bird attracting habitat outside the airport footprint. Also, a number of bird detection and deterrent techniques such as bird radars, lasers and long range sound generators were not included in the assessment as they were not available at the time. It may also be the case that the different design options being considered in this report could, because they would remove more habitat that would otherwise support hazardous birds, have a lower overall risk than the option being considered in 2003. However, because of the lack of up to date information of the type needed for birdstrike risk assessments, this review can only produce an outline assessment of the likely birdstrike risk and potential mitigation methods in the most general terms. At present it is not possible to provide detailed comparisons of the birdstrike risk associated with the different proposed designs shown in Figure 15.

5.4 SCHEMES UNDER CONSIDERATION

Figure 15 shows the outline footprints of the options being considered in this review. There is one option to the western end of the peninsula and three to the eastern end. All of the options have runways orientated east to west, and options at each end of the peninsula have broadly similar approach and departure corridors (Figure 16). The principles used for assessing the probable birdstrike risk are described below and the different options evaluated insofar as is possible given the limitations of the data available.

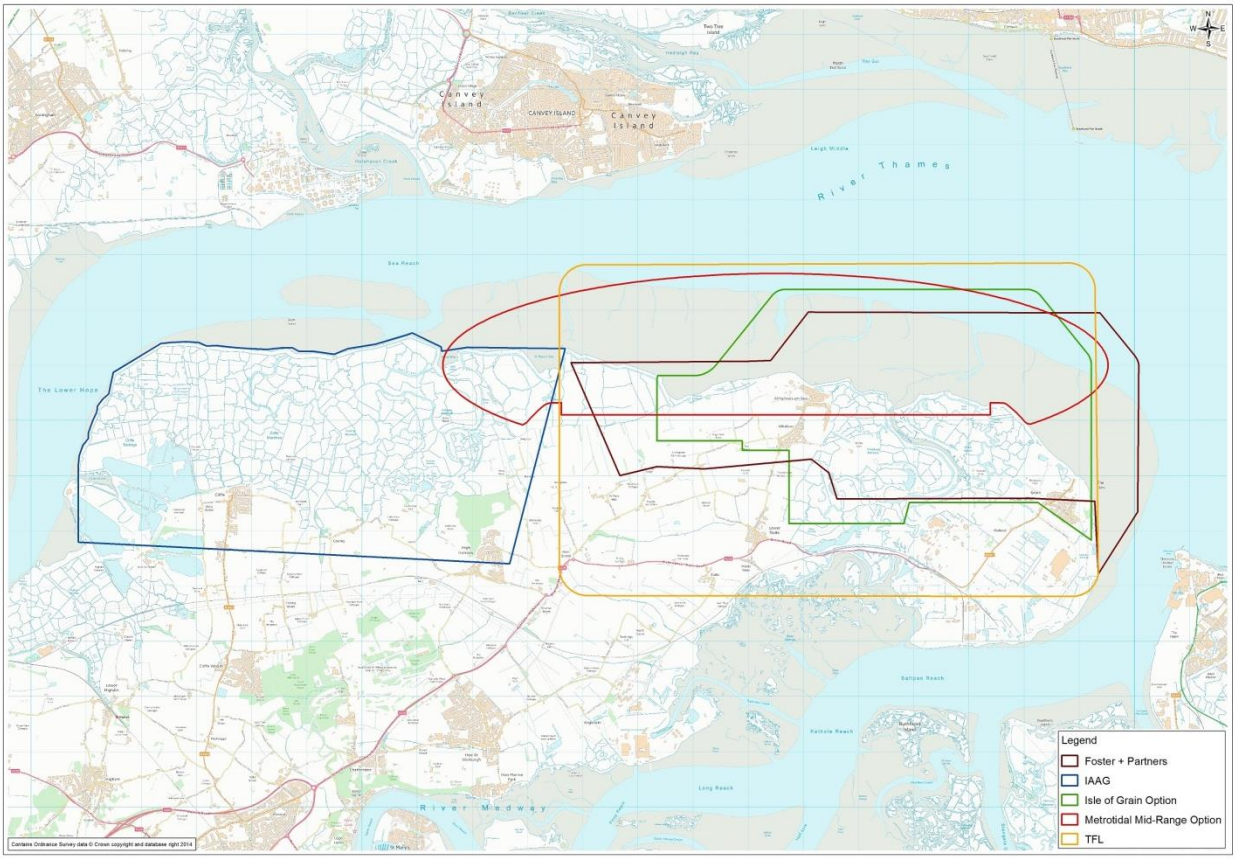

Figure 15: Potential airport design footprints being considered

5.4.1 General Birdstrike Risk for any Airport Located on the Thames Estuary

The Thames and Medway Estuaries provide a variety of habitats that support large numbers of hazardous bird species. Exposed mudflats support waders, gulls and waterfowl, all of which may attempt to move inland when forced off feeding areas by high tides or strong onshore winds. The extensive saltmarsh areas offer nesting and/or feeding sites for similar species, as well as starlings, corvids and pigeons. The freshwater lagoons at Cliffe support gulls, waders and waterfowl as well as Grey Herons, and pockets of local woodland provide breeding sites for corvids, pigeons etc. All of these were recorded by Bell et al (2003). There are also substantial urban and industrial areas nearby which provide feeding, breeding and roosting opportunities for gulls, corvids, pigeons and starlings. All of these species may attempt to use airfields as feeding or roosting sites, and all can, at different times of year, create additional hazards when transiting operational airspace as they move between breeding, roosting and feeding sites. These movements will be influenced by tide and weather as well as time of day or time of year, and the interaction of these factors, combined with the high number of individual birds present, means that the Thames Estuary is a high risk environment in which to build an airport from the birdstrike point of view.

5.4.2 Factors Affecting Birdstrike Risk at a Coastal Airport

Whilst the overall numbers and movements of hazardous birds in the local area mean that the background birdstrike risk is likely to be high, there are a number of factors that can influence the risk for a particular design footprint.

Relationship to known bird flightlines

Some bird species that use consistent roosting or feeding sites may transit to and from them along 'flightlines', sometimes using roads or rivers as landmarks for navigation. A classic example is gulls moving from a feeding site on a landfill to a roosting site on water, usually on a lake or reservoir, or at sea. If the flightline crosses an airfield it can result in a severe birdstrike risk around dawn and dusk that will occur

on a daily basis at times of the year when the birds are present (e.g. during the winter in the case of gulls). If such movements are triggered by the incoming tide they may occur far less predictably (e.g. only when a high spring tide coincides with strong onshore winds) making them harder to predict and to manage (Allan & Milsom 1992). The Thames Estuary has a considerable tidal range, which means that extensive mudflats that have been replenished with food by the incoming tide are revealed twice a day all along the estuary when the tide goes out.

Assessing bird flightlines is further complicated by the fact that by the time the airport is built the potential feeding and roosting sites may have changed (landfills may be closed, mudflats reclaimed and build upon, reservoirs drained, and others created), so assessments of risk from flightlines may over or under-estimate the risk at the time of construction. Bell et al (2003) found flightlines of gulls and waders that crossed the Hoo Peninsula as birds moved between the Thames and Medway estuaries and very strong flightlines of gulls to and from local landfills, but it is unknown if these flightlines still occur. In the event that construction of an airport in this location proved likely, it would be advisable to impose planning restrictions at the earliest opportunity in order to safeguard the development site against anything that could compromise air safety in the future. This, in turn, could impact on the development potential, and hence value, of land surrounding the proposed airport site.

Approach and departure corridors in relation to bird concentrations

As well as the movement of birds to and from sites off the airfield, any areas close to the airport and its approach and departure corridors that attract large numbers of birds will also lead to an elevated risk of birdstrikes. Saltmarsh, grazing marsh or mudflats can all support concentrations of hazardous birds, and the closer that these are to the active airspace the more likely it is that birds using these sites will fly at altitudes that bring them into conflict with aircraft. Thus, any bird attracting habitat on the airfield itself should be avoided in any proposed airport design, and proposals where the areas adjacent to the runway thresholds in particular have attractive habitat for hazardous birds should be avoided if possible. Figure 16 shows outline approach and departure routes for the different options under consideration. It is not possible to compare the options in detail because of the lack of appropriate bird movement and distribution data, but the general principle that approach routes that avoid crossing habitats known to attract hazardous birds are less risky can be applied.

In the event that approach paths have to cross areas of bird attracting habitat, it may prove necessary to manage or remove the habitat or to apply bird deterrence to it in order to control the risk. This in turn will increase the potential ecological impact of the development. In general, designs that utilise the space beneath the airport approaches for uses such as car parking or similar developments will be less risky, and proposals where the approaches are over open water without exposed mud at low tide will also offer less risk.

Developments that utilise the areas beneath the approaches as conservation areas or other bird attracting developments should be avoided. Because of the large size of the airport footprints proposed, it is likely that different runways will have approaches crossing different types of habitat and consequently suffer different levels of birdstrike risk. Once appropriate bird movement data is available, a detailed assessment, carried out runway by runway, for each option would be needed to properly compare the birdstrike risk and consequent management needs of each.

It is impossible to be precise about what level of habitat management or bird deterrence would be needed without more data on the bird numbers and distribution, but a broad assumption that deterring birds from areas in the approaches out as far as the point where aircraft arriving on a 2 degree glideslope pass through 1000 feet in altitude would be reasonable (see Figure 16).

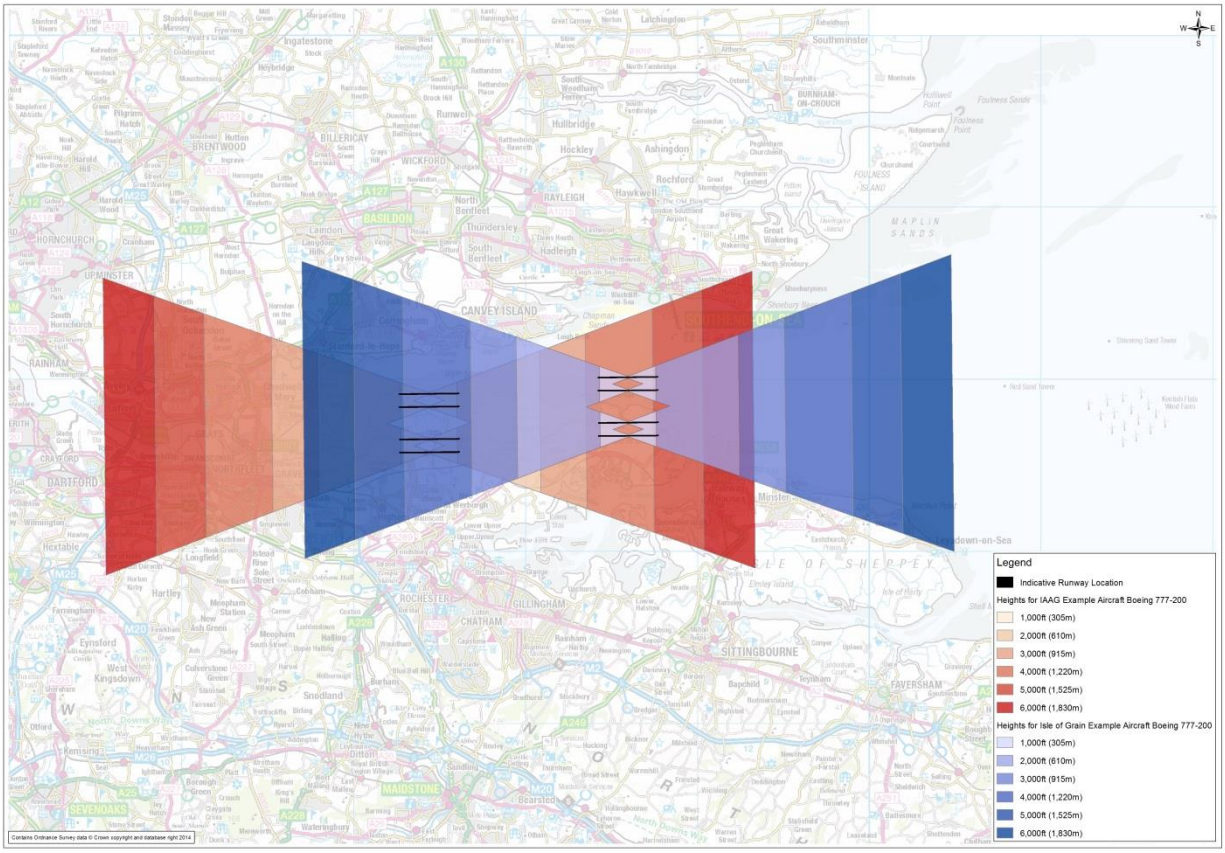

Figure 16: Example approach and departure corridors for a Boeing 777-800 for an eastern and a western airport location

Quantity of bird attracting habitat removed

The quantity of habitat that an airport design removes is an important consideration in terms of assessing birdstrike risk, as well as the relationship of a proposed design to any remaining bird attracting habitat. In general, most developers, and planning authorities, prefer designs with the minimum of environmental impact and try to avoid destroying valuable natural habitats if at all possible. Good practice in terms of birdstrike risk runs counter to this, and designs that remove habitat that can attract hazardous birds, especially from areas close to the approach and departure corridors should be preferred.

Designed-in greening or nature conservation areas

All airport designers and planners are conscious of the environmental impact that a large airport can cause, and any proposal that is sited in an area with high nature conservation value, such as the Thames Estuary, will put pressure on designers to make their proposals as 'green' as possible. As a general principle, designs that include nature reserves, conservation areas or extensive areas of woodland near the site should be avoided. Such areas are likely to increase the birdstrike risk at the airport and make it very difficult for airport operators to argue against the development of bird attracting features in the surrounding environment, or to justify bird management actions off the airfield (see Section 5.6.2), if they are operating their own nature reserves on the airport property.

5.5 OUTLINE EVALUATION OF THE PROPOSED SCHEMES

5.5.1 IAAG

The location of the IAAG scheme has the advantage that it removes large areas of grazing marsh and has its western approaches over open water rather than mudflats. It retains large areas of mudflat to the north of the site, and movements of hazardous birds to and from these mudflats could cause significant

problems. The eastern approaches are above grazing marsh and mudflat, although the latter is probably far enough from the runway thresholds that the aircraft will be too high to encounter large numbers of birds.

The supporting documentation suggests that the proposal will include the creation of woodland, wetland and other conservation areas to the south of the airport footprint. This is likely to result in a significantly elevated birdstrike risk compared to other options. It is not advisable to deliberately create habitat that can attract hazardous birds so close to a major airport development.

5.5.2 Foster + Partners

The Foster + Partners option removes areas of grazing marsh and also significant areas of mudflat in the eastern approaches. This means that the eastern approach will largely be over open water which reduces the risk. The supporting information provided indicates that the area beneath the western approach will be used for ancillary development which will remove areas of grazing marsh. The proposed footprint does not remove all of the mudflats to the north west of the site, however, and birds transiting from the Medway Estuary to the remaining mudflats may result in significant problems that require further mitigation.

Additional information submitted with this proposal recognises the need to engineer habitat on and around the airport footprint to deter hazardous birds and to provide any compensatory habitat elsewhere. The outline approach to developing a bird control programme that is fit for purpose at the site is sound, and includes provision for necessary data gathering in order to inform both habitat management and bird deterrence programmes in advance of the airport becoming operational.

5.5.3 Metrotidal Mid-Range

The Metrotidal Mid-Range option removes mudflat to the north of the site and has the eastern approaches over open water, but the western approaches are over a combination of mudflat and grazing marsh. Wading birds are likely to be concentrated on the shoreline beneath the western approaches by high tides and this presents a significant potential risk that may require additional off-airfield management to control. Significant areas of marshland to the south of the proposed footprint may also attract hazardous birds.

The supporting information includes a ‘bird strike protection zone’ which takes the form of an ellipsoid shape around the airport platform, but little information was provided on what habitat management or bird deterrent activities would be carried out within this area.

5.5.4 TfL

The TfL option removes almost all of the grazing marsh at the eastern end of the peninsula, but leaves a small amount of exposed mudflats in the eastern approaches. It also removes all of the mudflats from the north of the airport. There is the potential for both the eastern and western approaches to be over mudflat and/or grazing marsh, requiring further management actions to be considered.

The supporting evidence from TfL provides a sound assessment of birdstrike issues, but is heavily biased towards bird detection radars as a solution to the problem. Three of the four examples quoted describe airports that have used radars to enhance their bird management processes. Bird detection radars are useful tools in airport bird control, but are currently used at very few airports around the world with varying success. The vast majority of airports do not use bird detection radars in their bird control, nor are there any generally accepted methods for how the radar data can be integrated into airport operations.

One of the examples cited by TfL at the new Durban airport in South Africa illustrates this point. Here, a specific hazard was identified which was a very large roost of Swallows in a nearby wetland. Rather than destroy the wetland the airport opted to install a bird radar system to detect when the swallows were present and which allows air traffic patterns to be adjusted either by delaying departures or changing

departure and landing directions, to avoid them. This process works well when the timing and location of a hazard, and the steps that need to be taken to avoid it are well known. There is a clear action to be taken when the hazard is detected and its timing is broadly predictable in terms of time of year and time of day. This may not be the case at a coastal airport where combinations of season, time of day, weather and tide may result in hazards arising at unpredictable times and locations. At present air traffic controllers are proving very reluctant to accept the responsibility for interpreting the outputs from bird detection radars and then implementing ad hoc adjustments to air traffic patterns to avoid hazardous birds. This is not to say that such a system would not be useful at a new airport on the Thames Estuary, especially in informing bird controllers of the location of high risk situations, as has been described in two of the other case studies described by TfL, in Riga and Warsaw, but considerable further study is required before such a system can be reliably integrated into air traffic management processes.

5.6 LIKELY MITIGATION REQUIREMENTS

5.6.1 On Airfield

Providing that birdstrike is considered when developing airport designs, it should be possible to control the presence of birds on the airport itself effectively whatever the overall birdstrike risk in the surrounding environment. The airport operator has control over what happens on its property, and techniques are available to manage airfield habitat and buildings to make them unattractive to birds and then to scare away any birds that remain. It is important to note, however, that if an airport design is adopted that includes significant areas designed to attract wildlife the effective management of the birdstrike hazard may become impossible. Any mitigation for habitat loss should be carried out well away from the airport.

All major UK airports have specially trained staff continuously patrolling the airfield to deter birds. If the birdstrike risk is elevated it is simply a question of deploying more staff and resources until the point is reached that the birds are expending more energy avoiding the bird controllers than they are gaining from being on the airfield, at which point they will move elsewhere.

In the case of an airport with 24 hour operations in an environment where birds will be highly active at night, as is the case here, additional detection and deterrence methods such as bird detection radar and lasers may be needed to maintain safe operation. In general, bird control at night is less well understood than for daytime operations, and for many airports the only night time bird control that is done is periodic patrols to clear birds from the runway itself without any effort being made to detect or disperse birds from the grass areas. This approach is normally adequate for those airfields where the majority of the bird species are not highly active at night (e.g. pigeons or corvids which roost in trees). On these airfields the nocturnal risk is consistently low. In contrast, for airports with species that are commonly active at night (waders, waterfowl and gulls for example) as is the case here, the risk at night or when tide and weather conditions combine to cause birds either to cross the airfield or attempt to use the airfield to feed or roost, can be high (Allan & Milsom 1992) and the airport design and bird management processes will need to be adapted accordingly.

5.6.2 Off Airfield

The control of birdstrike risk arising from off the airfield is far more problematic, and given the large numbers of hazardous birds in the broad Thames Estuary area, this risk is potentially impossible to manage effectively. Figure 17 shows the various airport proposals plus the associated 13km bird safeguarding circle. This is the area within which the UK planning regulations require any new planning application to be referred to the airport for possible objection, and within which the lethal control (by approved means) of otherwise protected birds is permitted under license issued by natural England. Note that these licences give no access rights to land not owned by the airport so any control actions cannot be carried out without the landowner's permission.

Birdstrike risks that arise from land that is not owned by the airport and which may have a number of layers of legal protection because of its conservation value, may require significant intervention to modify

habitat, scare away birds or remove the habitat altogether. As well as requiring the owner's consent, such actions may be in contravention of UK and/or EU legislation and thus impossible to achieve. The UK Air Navigation Order makes it an offence to carry out any action that imperils air safety, but this has never been tested in court in relation to birdstrike issues and it is unclear if allowing wildlife to naturally colonise land under your control would be covered by the Order. It may, therefore be impossible to require landowners to cooperate with necessary birdstrike risk management around the new airport without either enacting new legislation, or the airport taking control of potential bird attracting habitat in the local area by means such as compulsory purchase.

The need to control bird hazards around the airport also limits the possibilities for creating new compensatory habitat close to the site. There is the possibility that any new bird attracting habitat that is developed will attract additional hazardous birds to the area, or change the behaviour of existing populations such that they become a bigger risk (e.g. by creating new flightlines or diverting existing ones. Creating bird attracting habitat within the safeguarding circle also makes it very difficult to argue that other developments that might attract hazardous birds should not proceed, or to justify asking landowners to take action to manage birdstrike hazards on their property. The airport development needs to be an exemplar of good practice in terms of controlling the birdstrike risk, and developments that include significant conservation areas within the 13km bird safeguarding zone risk compromising that principle.

Figure 17 shows the 13km safeguarding circles within which off-airfield bird management can be carried out under general license with landowners' permission.

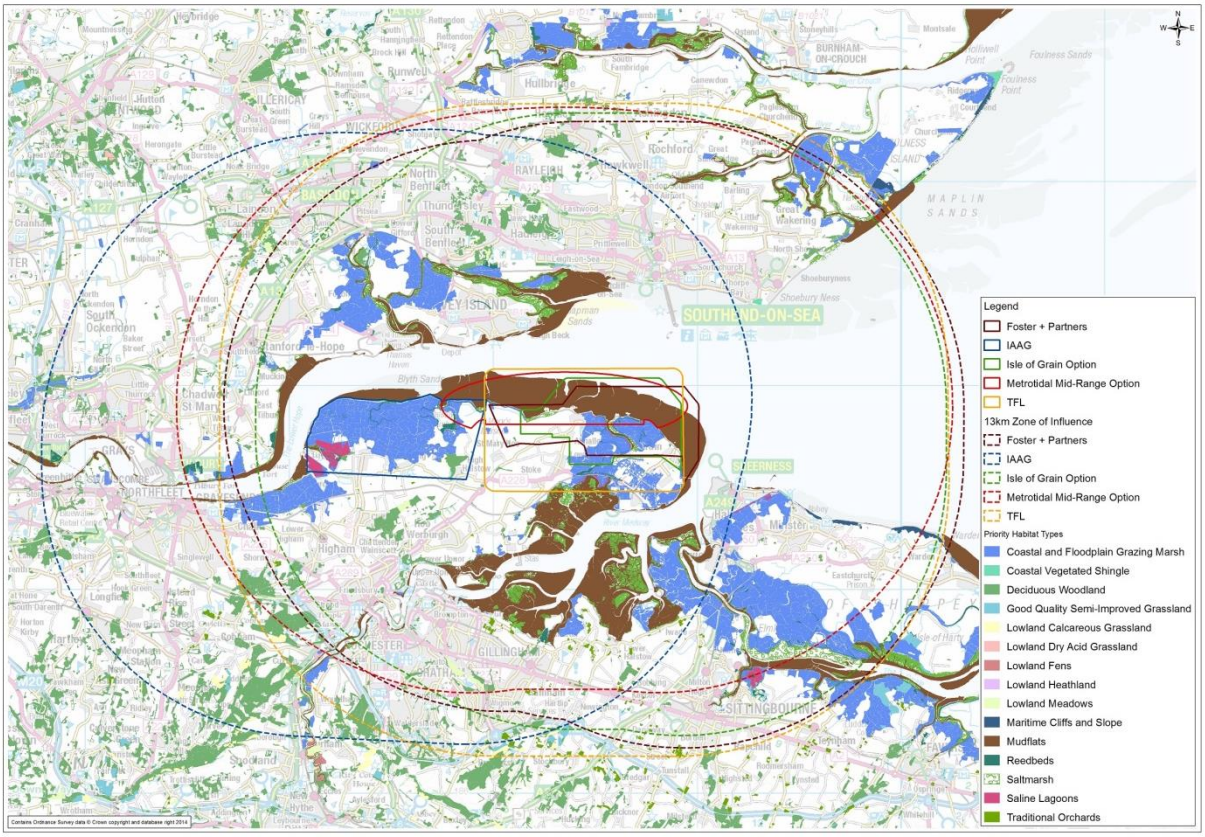

Figure 17: 13km safeguarding circles

In its response to the Call for Evidence, the RSPB notes that the potential impacts of active bird hazard management both inside and outside the airport perimeter would be to increase greatly the effective "bird free" area, compounding the environmental devastation of international and national conservation interests that would be caused by the construction of the airport itself. It also observes that, "depending on a detailed assessment of the bird strike risks, it is possible that the effects of bird hazard management

might extend throughout the 13km safeguarding zone, affecting several other internationally important wetlands".

5.6.3 Compensation for Habitat Lost

Given that the airport footprint itself may destroy habitat of high conservation value and require the removal of bird attractions outside the airport's footprint, the obvious solution is to create compensatory habitat to replace that which has been lost. The opportunities for habitat creation within the airport design are limited by the need to control the birdstrike risk, so off-site compensation is the obvious solution. The conventional approach is to create new habitat as close as possible to the site from which it has been lost. Unfortunately this has the potential to create significant additional birdstrike risk for the reasons described above. In the case of airport developments, compensation for the loss of habitat that is attractive to hazardous bird species should be carried out as far from the airport as possible, ideally a minimum of 20km from the airport perimeter and certainly outside the 13km bird safeguarding circle.

5.7 CONCLUSION

The 2003 study on the potential safety risks from birds at and around Cliffe Marshes, prepared by the Bird strike Avoidance Team, Central Science Laboratory and British Trust for Ornithology on behalf of the Department for Transport, described a previous proposal to site an airport on the Hoo Peninsula as 'possibly the most problematic location in the UK to site an airport'. All of the proposed airport designs for the Thames Estuary will encounter similar problems and elevated birdstrike risk because of the high numbers of hazardous birds in the area. The problems are not insurmountable, as bird management on the airfield is a question of resources and manpower, but controlling the birdstrike risk from sites off the airfield will require the management or removal of additional habitat or the imposition of additional off-airfield bird control, which will significantly increase the ecological impact of the development.

Although all of the proposals in this report will suffer from the same broad set of problems, the individual proposals have greater or lesser levels of risk and requirements for off airport bird control depending on the detail of the airport design and relationship between bird attracting habitat and the airport footprint and active airspace. On this basis, the IAAG scheme at Cliffe appears to present the greatest birdstrike risk as a result of the scale of bird attracting habitat retained to the north and east of the Isle of Grain. However, it is not clear at present how many hazardous birds use these areas and what their movement patterns are. More detailed information relating to bird movements as well as numbers on the ground, covering the full range of hazardous birds found in the area at different times of day, year and in different weather and tidal conditions, will be required to fully evaluate the merits and risks of various airport layouts and runway positions, and to determine the on airport and off airport mitigations that would be required.

6. SS RICHARD MONTGOMERY

6.1 INTRODUCTION

The purpose of this chapter is to describe the assessment of the extent to which the construction and operation of a new hub airport in the inner Thames Estuary could impact upon the overall stability of the SS Richard Montgomery wreck.

The chapter does not seek to collect further data on the current state of the SS Richard Montgomery and its cargoes or its likely future state, rather to explore the risks posed by the development of an airport in the vicinity of the vessel and the courses of action that might be required. The opinions and conclusions expressed in this report are based upon the opinions and conclusions stated in the referenced studies.

The section begins with a description of the history of the wreck and its current state (Sections 6.2 and 6.3) before discussing the various risks associated with the wreck (Sections 6.4), the implications for construction and operation of an airport (Sections 6.5 and 6.6), possible mitigation (Section 6.7) and presenting summary conclusions (Section 6.8).

6.2 HISTORY

The SS Richard Montgomery is a US Liberty Ship, built in 1943 in Florida. The vessel was carrying a cargo of munitions to support the war effort, travelling from the USA to Cherbourg, France via the UK in August 1944 when it sank off the coast of Sheerness. The vessel was at anchor when it drifted on to a sandbank running east of the Isle of Grain, approximately 250m north of the approach to the River Medway, and suffered major structural damage causing it to take on water.

At the time the vessel ran aground, it is understood to have been carrying between 6,000 and 7,000 tons of munitions. A salvage operation was launched a few days later and continued for a month but was abandoned before all the cargo had been recovered. The vessel subsequently broke into two parts. Around 1,400 tons (Net Explosive Quantity) of munitions is understood to remain on board.

The wreck remains on the sandbank where she sank and her masts are visible above the water level at all states of the tide. Figure 19 and Figure 20 show the location of the wreck in relation to the Isle of Grain.

Figure 18: SS Richard Montgomery soon after running aground

Figure 19: Location of SS Richard Montgomery

Figure 20: Location of SS Richard Montgomery in relation to the Isle of Grain

6.3 CURRENT STATE

The SS Richard Montgomery is administered by the Receiver of Wreck, a department of the Maritime & Coastguard Agency (MCA), an executive agency of the Department for Transport which has overall responsibility for the vessel.

The wreck is designated under Section 2 of the Protection of Wrecks Act 1973 due to its munitions cargo and is subject to an exclusion zone which is marked and guarded by Medway Ports. The wreck and its exclusion zone are marked on nautical charts. Large vessels in any case avoid the area of the wreck because it is in shallow water.

The Maritime & Coastguard Agency undertakes annual surveys of the SS Richard Montgomery to monitor the condition of the wreck and the seabed. MOD divers assess the hull every ten years. Various technological advances have enabled more detailed analyses to be conducted in recent years, including

sonar surveys and hull thickness measurement using ultrasound. The results of the multibeam sonar survey in 2002, shown in Figure 21, illustrate the features of the sea bed around the wreck; deeper water is shown in blue.

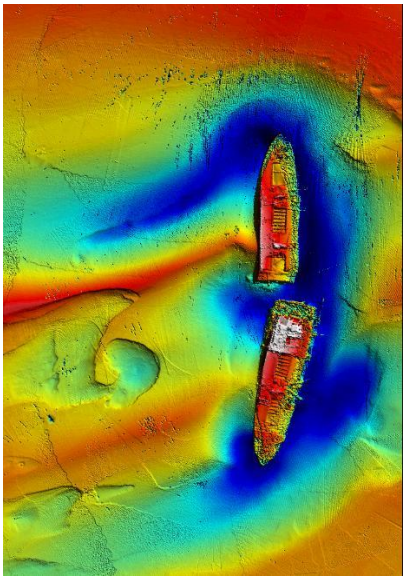

Figure 21: Multibeam sonar image of the SS Richard Montgomery in 2002

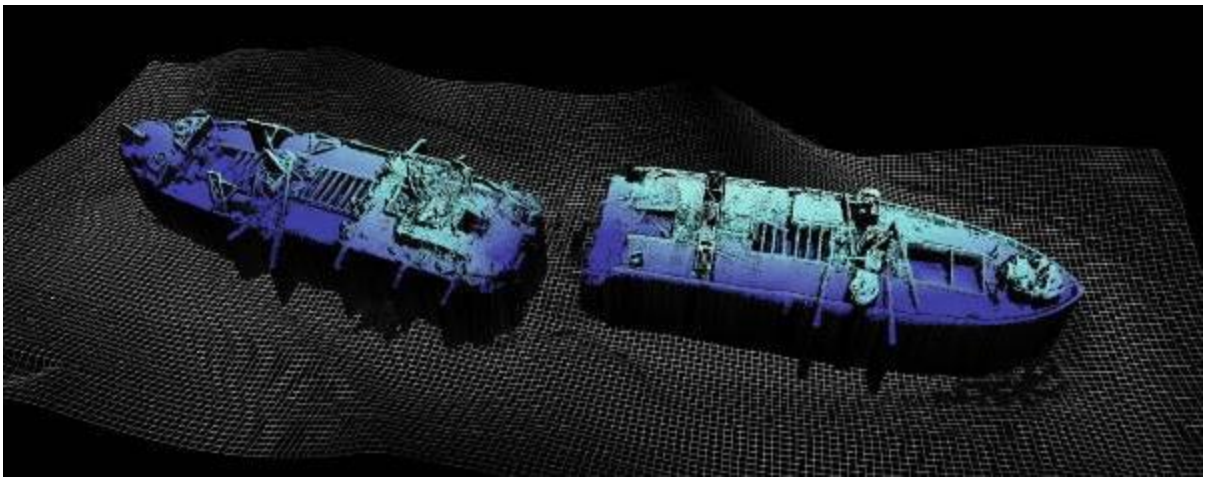

Figure 22: Multibeam sonar image of the SS Richard Montgomery in 2012

The most recent published survey was undertaken by NetSurvey Limited in October 2012 and encompassed a sonar survey of the area within a 400m radius of the wreck. Successive recent surveys have observed gradual changes in the condition of the wreck.

Figure 23: SS Richard Montgomery, masts visible above the waterline

The vessel list and orientation have been found not to have changed in the past three surveys, the erosion of the sea bed (scour) having already taken place over many years to the extent that the vessel is now believed to rest on a London Clay bedrock, most probably with no significant quantity of sand beneath it. Some erosion of the sea bed continues to occur and a particular feature located 40m from the wreck is observed to be moving closer by around 1m each year.

The surveys in recent years have been conducted remotely using equipment that assesses the condition of the hull but technology has not allowed further sonar beam penetration to assess the condition of the munitions. The munitions are understood to comprise fused cluster bombs, standard unfused TNT bombs and smoke bombs. Any fuses that remain on board may no longer be functional, but it is believed that the munitions would retain their explosive power and the phosphorous contained in the smoke bombs would be capable of spontaneous ignition if exposed to air.

Excerpts from the MCA survey in 2012

- The crack on the port side of hold 2 shows a vertical increase of approximately 16cm since 2011. The horizontal measurement remains unchanged.
- The deck plating at hold 2 has dropped by 30cm since 2010 (2011 survey data could not be accurately measured in this area, although a small drop in deck plating was noted in the 2011 report).
- No change noted in the aperture in the bulkhead at hold 3.
- Buckling of the hull plating on the port side of hold 2 remains in a similar condition to that found in 2011.
- One of the two stays on the forward mast is now detached at deck level but remains suspended from the masthead.
- Scour on the port (west) side of the wreck has shown a gradual increase in size.
- The orientation, list and pitch of the wreck remain unchanged.

- Over much of the wreck, no changes were noted.
- As recommended in 2011, a smaller survey vessel was used to survey the wreck and this has resulted in much improved data.
- The seabed survey re-located all 38 seabed features that have previously been identified.

6.4 RISKS ASSOCIATED WITH THE WRECK

As stated in the Maritime & Coastguard Agency's 1998 report, there are three broad areas of risk associated with the SS Richard Montgomery:

- Collision
- Capsize
- Breaking up

Collision with the wreck is considered a remote possibility, though collision with the masts rather than the main part of the vessel would be more of a possibility. While larger vessels would naturally keep away because of the shallow waters, recreational vessels do pose a threat. However, the area is clearly marked with navigational buoys and other markers and no near misses have been recorded to date. Were a collision to occur, the conditions may be produced for an explosion.

If the wreck were to capsize, perhaps because of sea bed erosion, mass detonation could result or munitions could escape and be dispersed by the tide. Similarly, if the wreck were to break up as the structure continues to disintegrate then either mass detonation, partial detonation or dispersal of individual munitions could result.

The effect of mass detonation has been the subject of much press speculation, but very little data exists from which the scale of impact could be confidently derived. Based on the MCA's 1998 survey report, which cites some work carried out by the Defence Evaluation and Research Agency (DERA; now the Defence Science and Technology Laboratory), it is reasonable to assume that local property and population would be put at risk if mass detonation were to occur.

The dispersal of munitions would be likely to result in some washing ashore. Once ashore, they would dry out which would render some more volatile and those containing phosphorous to spontaneously combust.

6.5 RISKS RESULTING FROM AIRPORT CONSTRUCTION AND OPERATION

Limited detail on the proposed construction methods for an inner Thames Estuary airport is available at present. However, it can be reasonably assumed that construction will involve extensive pile driving into the London Clay and chalk estuary and sea bed and that considerable volume of infill material will need to be transported to the site and deposited.

Tunnelling (proposed by Metrotidal Tunnel and Thames Reach Airport Ltd) and pile driving for the construction of the airport will cause local vibration; however it is considered somewhat unlikely that vibrations of any significance would reach the location of the wreck.

Construction may involve large amounts of material being transported by ship. The Thames and Medway Estuaries are already very busy shipping routes and therefore it is unlikely that the additional traffic would have a material impact on the wreck.

The airport is expected to have an impact on the tidal flows of the Thames Estuary and possibly the Medway Estuary. The scale of the impact is not comprehensively understood at present but small

changes to the movement of water around the wreck and the resulting scour and movement of sands cannot be ruled out.

Once the airport is in operation, aircraft on westerly approaches (i.e. the majority of the time) would pass over the site of the wreck at a height of over 1,000ft, possibly much more depending on the precise location of the runways.

While the wreck has been subjected to the forces of nature, including tidal flows, storm surges, and high winds, to which the wreck has been subjected for nearly seventy years, the construction and presence of the airport could lead to certain vibrations and changes in tidal flows and the sea bed which could potentially affect the stability of the decaying wreck.

Overall, any authority would need to give careful consideration to the risk that construction and operation of the airport may change the likelihood of the SS Richard Montgomery's munitions detonating or being dispersed.

6.6 RISK POSED TO THE AIRPORT

The SS Richard Montgomery, if left in its current state, poses three main risks to an inner Thames Estuary airport:

- Unplanned mass explosion
- Munitions washing up on shore
- Disruption during planned disposal

Depending on the selected location for the inner Thames Estuary airport, the SS Richard Montgomery could lie within as little as 5km of the airport perimeter. The airport and its associated infrastructure could therefore be within the range at which an unplanned mass explosion of the munitions would likely cause damage to people and property. The events that might lead to an unplanned explosion are described above.

There are very few recorded, relevant comparative examples upon which to assess the impact. One example is the Kielce, a munitions ship which sank in 90ft of water around 4 miles off the coast of Folkestone in 1946. In 1967, efforts to clear the wreck resulted in an explosion with an equivalent yield of 2,000 tons of TNT. The majority of the energy was carried seismically, rather than acoustically, with vibrations felt nearly 5,000 miles away, though the blast was reportedly heard 7 miles away. Some minor damage to property was reported. Differences between the SS Richard Montgomery and the Kielce make it difficult to draw comparisons. The SS Richard Montgomery is believed to carry a smaller quantity of munitions (equivalent to 1,500 tons of TNT rather than 2,000 tons); the design and construction of the ships is different; the SS Richard Montgomery is one or two kilometres closer to shore; and the Kielce was lying in much deeper water than the SS Richard Montgomery. Given these factors, it is reasonable to assume that an unplanned explosion could result in sufficient release of seismic and acoustic energy to cause damage to airport infrastructure and potentially cause harm to people within the radius of a few kilometres.

Munitions washing up on shore have the potential to cause disruption to airport operations even in the absence of detonation. It may be necessary to curtail airport operations while the munitions are examined and disposed of, and while searches are made for any other munitions that might be dispersed in the area. The extent to which small quantities of munitions might cause risk of harm to people and damage to airport infrastructure cannot be assessed at present.

Therefore, while the construction and operation of the airport are unlikely to increase the likelihood of the SS Richard Montgomery exploding, the presence of an airport would introduce several thousand people within the potential range of a mass explosion. The impact of the explosion would therefore be much greater and so the overall risk profile is raised.

6.7 POSSIBLE RESPONSES

The Maritime & Coastguard Agency's 1998 report presents a range of possible responses to the risks posed by the SS Richard Montgomery:

- Do nothing
- Monitor
- Containment
- Entombment
- Removal

The 'Do nothing' option was ruled out by the report since the wreck is continuing to degrade and the risk of capsize, significant movement and dispersal of munitions increases with time.

Monitoring, which involves routine surveys of the wreck to examine any changes that would suggest a change to the level of risk, was identified as the safest option and has been adopted as the policy to date.

Containment would involve placing a carefully designed bund around the wreck with the aim of preventing dispersal of munitions and possibly supporting the structure. Surveys to determine the appropriate construction and location would be necessary with respect to the sea bed and tides. Monitoring would need to be continued to examine the condition of the bund and the wreck itself.

Entombment would involve placing a rigid structure around and over the wreck to completely enclose it. Both entombment and containment are thought to carry a certain amount of risk during the construction phase. They cannot be considered permanent solutions since the structures would need to be monitored, maintained and at some stage replaced. Replacement could be a particularly hazardous exercise.

Removal would entail either complete removal of the wreck or just its munitions, with the former bringing to the end entirely the risks and costs associated with the wreck. At the time of the report, in 1998, the removal option was considered unfeasible as the technology did not exist to carry out the work safely.

Planned disposal of the wreck, or indeed planned containment or entombment, would probably involve extensive disruption to operations if an airport were located in the inner Thames Estuary. The findings of the report prepared by DERA in 1998 suggested that entombment or disposal would elevate the risk of detonation while the works were taking place. If the wreck were to be disposed of, consideration would need to be given to an evacuation zone with a radius of several kilometres to be implemented for the duration of the disposal works, which could take weeks or months. It is therefore feasible that during this time, at least part of the airport would fall within the evacuation zone and in any case over-flight of the zone would likely be prohibited, requiring substantial curtailment of operations or even full closure. If this were to occur during the construction phase, the schedule for delivery of the airport could be put at risk and costs could significantly increase.

Disposal would carry immense safety risk for those working on the wreck. In recent years, the safety risks of undertaking a detailed physical inspection of the munitions and the storage areas have been assessed to outweigh the benefits of doing so. Disposal of underwater explosives is extremely hazardous and it is reasonable to assume that the risk to human life could be substantial.

Given the safety risks, the lack of detailed information on the state of the wreck's holds and of the munitions held within them, and with few if any comparable reference points nationally or internationally, it is not possible to assess costs at this stage. However, any cost estimate would also need to account for the disruption to the areas evacuated. Costs could be much higher during construction and once the airport opens because of the potential disruption to operations resulting from any requirement for an evacuation zone.

6.8 CONCLUSION

The SS Richard Montgomery poses a low risk to people and property today, as it has done for nearly seventy years. The approach adopted by the Maritime & Coastguard Agency has been to continue to monitor the wreck for any changes; the safest option in the meantime being to leave the wreck undisturbed.

The construction and operation of the airport itself is not thought to increase the risk to the SS Richard Montgomery significantly, particularly given the elements and forces of nature to which it is continually exposed. However, an airport would introduce several thousand people who would be within the potential range of a mass explosion; thus the impact of an explosion would be much greater.

While the change in stability of the munitions is not fully understood, i.e. whether they pose more or less of a risk of explosion now than before, the structural condition of the wreck can only continue to worsen. It is almost inevitable that the time will come for the wreck to be conclusively treated, perhaps through containment or disposal. It may be that technological advances, coupled with sufficient data collection and analysis, will allow the munitions to be safely neutralised, removed or contained so as to eliminate the risk of explosion. Even then, some period of elevated risk can be foreseen while works are being carried out.

The greatest risk to the airport is therefore that the time will eventually come for the wreck to be treated and that the treatment itself may require construction work to be halted or, if the airport is already open, requires full or partial closure or some other curtailment to operations for an extended period of time.

Therefore, because the costs and operational disruption of interventions to eliminate the risk posed by the SS Richard Montgomery could be prohibitive once the airport is being built or is operational, it would seem necessary for full treatment and/or removal and disposal of the munitions to be undertaken prior to construction of the Estuary airport.

7. AIRSPACE IMPLICATIONS

This chapter was prepared by NATS under direct contract to the Airports Commission and is reproduced in Appendix A – NATS Support to the Airports Commission: Input to Thames Estuary Studies.

This builds upon previous advice provided to the Airports Commission by NATS, whilst considering the potential impacts of more advanced airspace 'technologies' not currently in use that may be available in 2030.

8. ENERGY FACILITIES

8.1 INTRODUCTION

The purpose of this report is to assess the impacts of the Inner Thames Estuary Airport scheme on the energy facilities on the Isle of Grain, the need to relocate them, and the feasibility of doing so.

The report begins by describing the energy facilities located on the Isle of Grain and the planned developments at those sites and in the local area (Sections 8.2 & 8.3). The report then explores the Grain Liquid Natural Gas (LNG) facility in further detail (Sections 8.5 to 8.8) before examining the risks resulting from a new airport development (Section 8.9). Grain LNG's role in importing and storing LNG is examined in Section 8.10, along with potential alternatives (Section 8.11). The conclusions consider the risks presented by co-locating the energy facilities and an airport, and the feasibility of relocating the Grain LNG facility if it were necessary to do so (Section 8.12).

8.2 ENERGY FACILITIES ON THE ISLE OF GRAIN

The Isle of Grain is home to several energy facilities including:

- Grain power station, an oil-fired power station owned by E.on (now decomissioned)
- A Combined Cycle Gas Turbine (CCGT) and Combined Heat and Power (CHP) station at Grain, owned by E.on
- Medway power station, a CCGT owned by Scottish & Southern Energy (SSE)
- Kingsnorth power station, a dual-fired coal and oil power station owned by E.on (now decomissioned)
- Grain LNG port and storage facility, owned by National Grid
- Pipelines forming part of the National Gas Transmission System

The Isle of Grain also houses a High Voltage Direct Current (HVDC) converter station, connected to a 260km, 1000 megawatt subsea cable link to the Netherlands. A joint investment between National Grid and TenneT in the Netherlands, operated by BritNed, this cable provides one of only two electricity interconnectors with continental Europe.

These facilities and the proposed airport locations are shown, on the next page, in Figure 24.

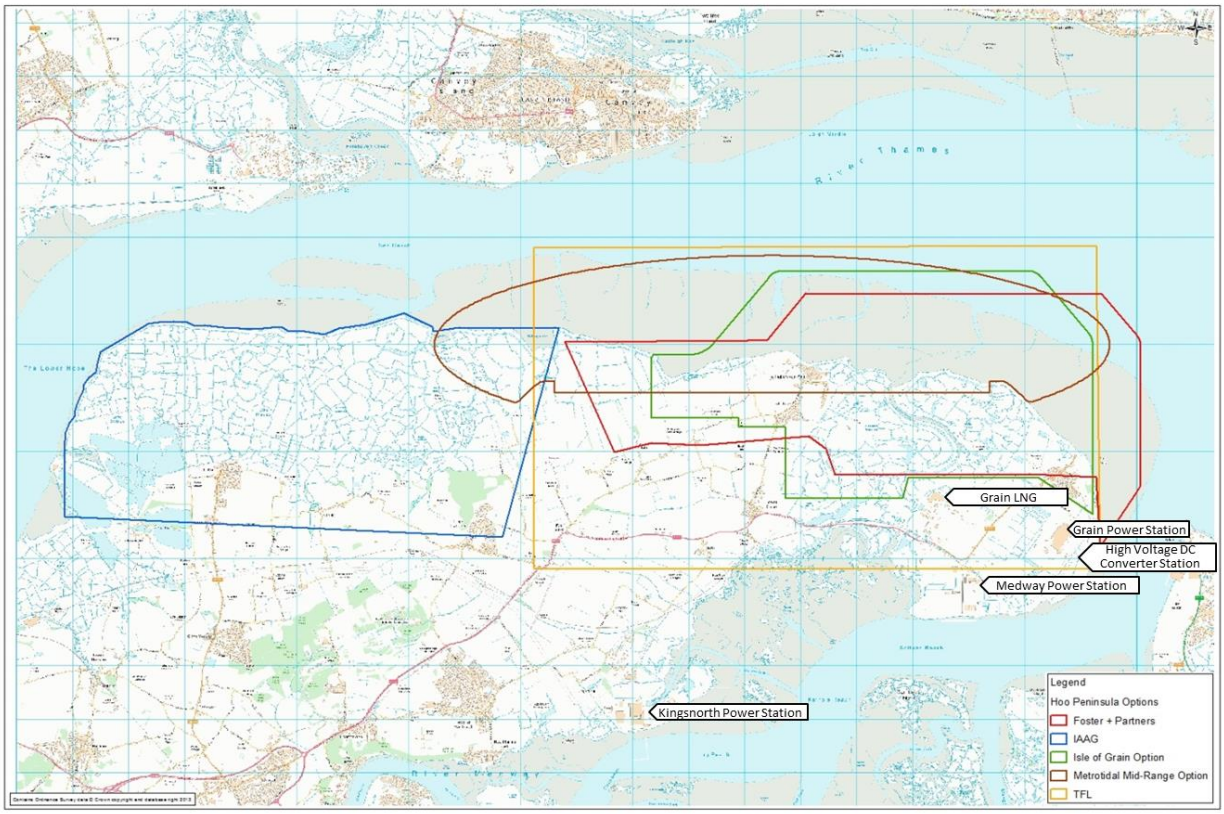

Figure 24: Location of Isle of Grain energy facilities

8.3 POWER STATIONS

8.3.1 Current Status and Future Plans

There are two operational power stations on the Isle of Grain: Grain CCGT and Medway CCGT. Grain CCGT has three stacks of height 93m and one remaining Open Cycle Gas Turbine stack of height 63m. Medway has two gas turbine stacks of height 65m and one black start stack of height 52m.

The oil-fired power station at Grain was decommissioned at the end of 2012 and is being removed, together with its 244m chimney.

The dual-fired coal and oil power station at Kingsnorth was also decommissioned at the end of 2012 and is being demolished, together with its 198m chimney.

E.on, as owners of the Grain and Kingsnorth sites, consider that both sites are well placed for electrical power generation, being sited close to demand in London and the southeast, and to the electricity grid.

According to E.on, future developments at the Grain site could require chimneys up to 105m in height, subject to the choice of generation equipment and environmental modelling.

SSE is undertaking a strategic review of its thermal generation sites with a view to future developments potentially including Medway power station. A second plant at Medway would, subject to planning consultation, require construction of several tall buildings including heat recovery steam generators, boilers and stacks to accommodate the new gas turbines.

Grain CCGT has an output of 1365MW and Medway power station has an output of 700MW (DUKES, 2013). Together they account for approximately 2.5% of the UK's domestic electricity generation and 6.7% of the UK's CCGT electricity generation capacity. Both facilities are considered to be of importance

to the UK's energy security. As coal and nuclear power stations are being forced to be decommissioned for reasons of emissions and asset age respectively, the contribution of existing gas fired generation is becoming more important. The impact of early closure of these facilities, if required in order to accommodate the Estuary airport, would have a damaging effect on overall electricity security of supply. Similarly an aircraft accident resulting in the loss of one of these gas fired power stations could have an impact on the integrity of the electricity grid, particularly in the south east.

8.3.2 Impact of Airport Development

Airports are subject to Obstacle Limitation Surfaces (OLS) which define the limits to which objects may project into the airspace for safety reasons. Figure 25 illustrates the various surfaces in three dimensions. Taking the example of an airport with a runway aligned east-west, the TakeOff/Approach surfaces extend to the east and to the west, while the Transitional surface extends to the north and south.

The surfaces extend beyond the boundaries of the airport and so all tall buildings within the Inner, Conical or Outer surfaces (Figure 25) must be studied to determine whether they are below the height limit for their location. The Transitional surface is angled quite steeply so buildings to the north or south, in the case of the Isle of Grain, are less likely to have a material impact. However, buildings to the east or west potentially fall within the TakeOff/Approach surfaces. The TakeOff/Approach surfaces specify an inner edge that diverges from the runway centreline at an angle of 15°, meaning that facilities located, for example, at a compass bearing of between 75° and 105° from the runway end might conflict with the Take Off/Approach surfaces. Infringement of the Inner, Conical or Outer surfaces may be deemed to present a lower operationally risk than infringements of the Take Off/Approach surfaces, however, all infringements would be considered on their merits and depending upon the extent and location of infringement may be acceptable, subject to appropriate lighting and marking, or alternatively may not be able to co-exist with the airport.

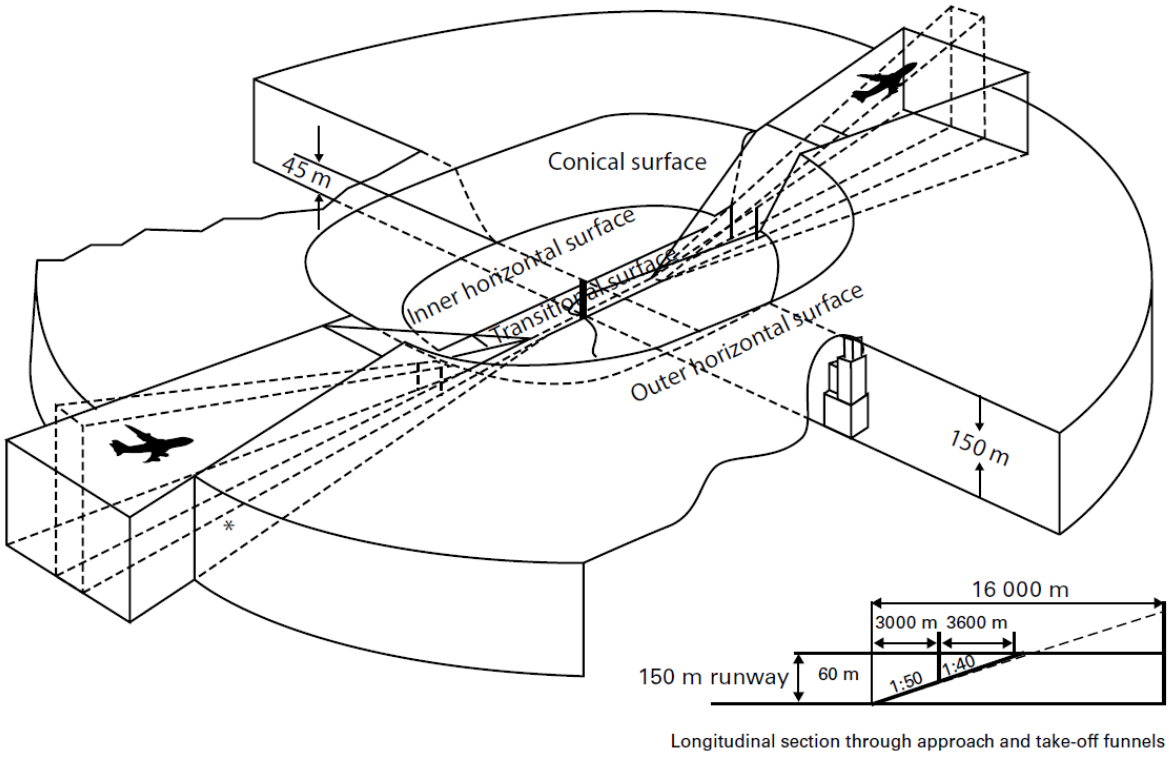

Figure 25: Obstacle Limitation Surfaces
(Source CAP 168: Licensing of Aerodromes)

Figure 24, above, shows the location of the power stations and LNG facility on the Isle of Grain in relation to the proposed airport sites. At this stage, and without detailed assessment, it appears that the existing operational facilities, Grain CCGT, Medway Power Station and Grain LNG, may be in conflict with the OLS for the airport schemes located to the east of the peninsula with the exception of the TFL scheme (which requires their removal), because they are sited within the Inner Horizontal Surface which extends 4km from the runways. These facilities are located some distance from the Take Off/Approach surfaces and therefore although they breach the Inner Horizontal Surface it may be possible to accommodate them. However, if new chimneys were to be constructed at the site of Grain Power Station then a conflict may arise for the schemes, because the chimneys might extend into the Transitional surfaces of the southern runway.

The energy facilities pose a more significant issue for the IAAG scheme, located to the west of the Isle of Grain. Here, it is possible that new and existing chimneys at Grain Power Station would conflict with the TakeOff/Arrival surfaces.

Any proposed developments at Kingsnorth are not thought to be material to any of the schemes because of its southern location.

Consideration will also need to be given to the emission of smoke from chimneys and the impact on visibility at the airport.

8.4 ELECTRICITY INTERCONNECTOR

The Isle of Grain is the landing point for a 260km, 1000MW electricity interconnector with the Netherlands, a €600m investment by National Grid and TenneT in the Netherlands, operated by BritNed. The subsea cable surfaces near Grain village and is routed underground to the High Voltage Direct Current (HVDC) converter station adjacent to the Grain LNG facility.

The development of an airport in proximity to the HVDC converter station is understood to introduce a number of potential risks, though further examination would be required to determine their materiality and the extent to which they could be mitigated:

- Aircraft collision with the HVDC would have an impact on electricity supply security in the short-medium term until the facility could be repaired. The buildings are not thought to impact upon the Obstacle Limitation Surfaces beyond those of Grain CHP or Grain LNG.
- The HVDC converter station emits electromagnetic fields (EMF) which could theoretically interfere with aircraft communications and navigation equipment. The range and altitude at which interference might be observed are not known at this stage.

Overall, the electricity connector does not appear incompatible with the siting of a hub airport on the Isle of Grain.

8.5 GRAIN LNG

8.5.1 Background

Grain is home to the largest LNG importation terminal in Europe in terms of capacity, and the eighth largest in the world.

Grain LNG is a facility for the importation, storage and regasification of Liquefied Natural Gas, owned and operated by National Grid.

The site opened in 2005 as an LNG importation and storage facility with the capacity to receive and process up to 3.3 million tonnes of LNG per annum.

Since then, the capacity of the terminal has tripled to 9.8 million tonnes of LNG per annum with the construction of three above-ground storage tanks, each with a capacity of 190,000 cubic metres.

The facility can supply up to 20% of the UK's natural gas demand. Approximately £1 billion has been invested in developing the facility to date.

Several companies have the rights to import LNG and utilise the capacity of the facility:

- BP/Sonatrach
- Centrica
- GDF SUEZ
- E.on Ruhrgas
- Iberdrola

The LNG terminal has two jetties which can berth LNG vessels simultaneously. The second jetty opened in 2010 and can accommodate the world's largest LNG vessel type, the Q-Max, operated by Qatar Gas. Q-Flex vessels can also be accommodated.

- Q-Max vessels measure around 345m, with a breadth of 54m, a height of 35m and a draft of around 12m. They have an LNG capacity of 266,000 cubic metres.
- Q-Flex vessels measure 315m, with a breadth of 50m, a draft of around 12m, and LNG capacity of between 210,100 and 217,000 cubic metres.

8.5.2 Location of the Site

Grain LNG is located on the south-east of the Isle of Grain, 35 miles east of London. The site occupies approximately one square mile and currently has four of the world's largest above ground storage vessels, each with a of volume of 190,000m^3, height 50m and diameter of around 90m. Four smaller vessels with a volume of 50,000m^3 from the original development in 2005 remain and are in use.

To the north of the site, land is predominantly agricultural with mudflats, creeks and marshland. To the east is the site of the Grain oil-fired power station (now decommissioned) and CCGT plant, both owned by E.on. To the west are Medway CCGT, operated by SSE, and Kingsnorth dual-fired coal and oil power station, owned by E.on and now decommissioned.

The River Medway and its approach by sea are deep enough for the largest LNG vessels, the Q-Max and Q-Flex.

Grain is connected to the National Gas Transmission System via the Grain-Shorne gas pipeline.

8.5.3 Planned Development of Grain

A major expansion of up to 6 million tonnes per annum of LNG importation capacity is planned. The project, valued at over £300 million, consists of one further 190,000m^3 tank (located between the existing tanks and the B2001 Grain Road), associated process equipment (in the same vicinity) and a second cryogenic unloading line (running from the jetties to the tanks and running parallel to the existing unloading line). With planning consents in place and an exemption from regulated Third Party Access requirements received from Ofgem and the EU, some construction has already commenced including ground clearance and drainage works associated with the tank.

Construction of the cryogenic line is well advanced and is due for completion in 2014. The additional storage tank is planned to be available from 2018. Timing of the final investment decision on the remainder of the plant is dependent on market appetite.

In the longer term, National Grid is considering further expansion of the facility, shown in Figure 26, to develop three further 190,000m^3 storage tanks, liquefaction plant, and a power generation facility making use of boil-off gas. TfL's submission states that a significant proportion of the storage facilities will

be nearing the end of their life by 2029; however, the majority of the storage tanks were constructed since 2005 and could be expected to have a longer operational life than 24 years. National Grid's future development strategy indicates that the entire facility is expected to have a much longer lifespan.

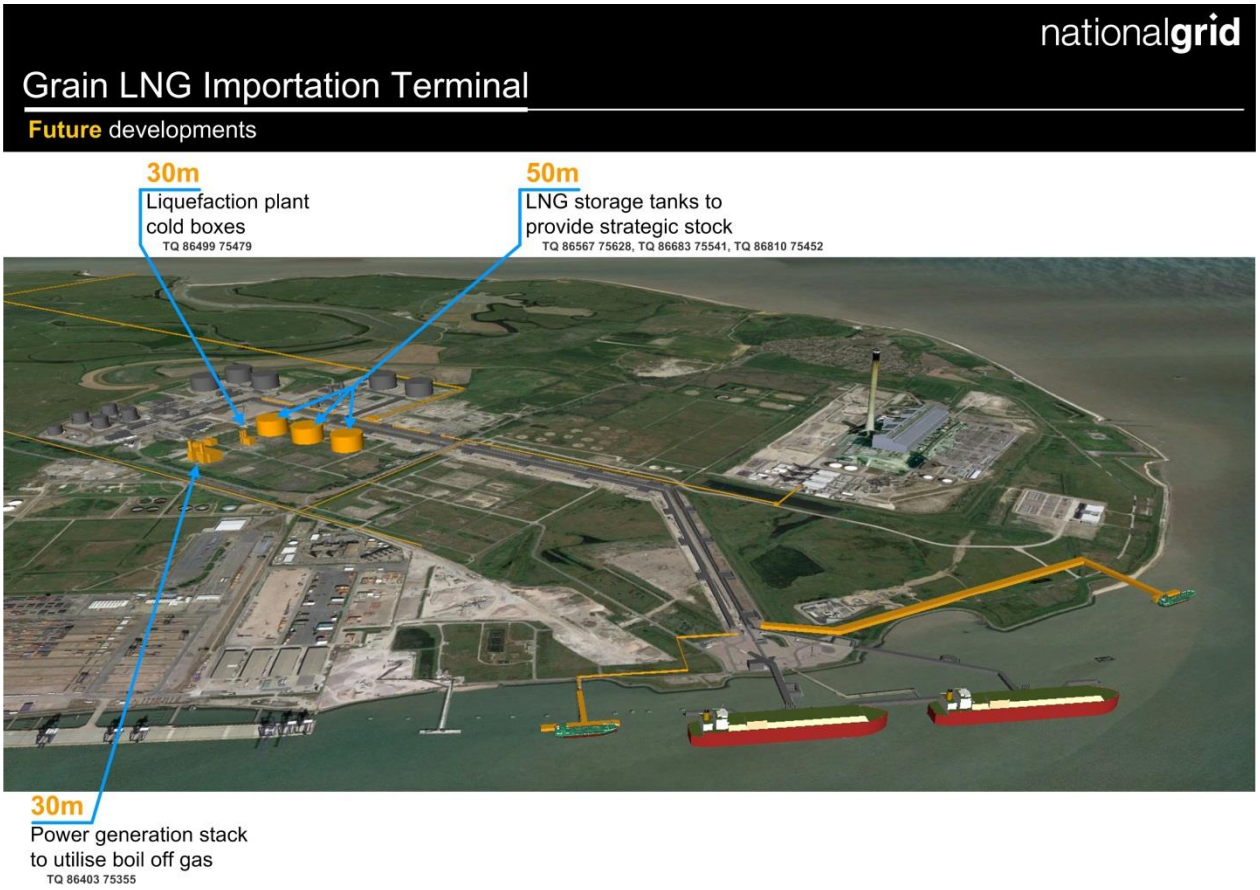

Figure 26: National Grid's long term expansion plans for Grain LNG

National Grid has recently announced that it is developing a road tanker loading facility at Grain LNG to cater for commercial, industrial and road tanker markets. Demand for LNG as a road fuel in the UK is forecast to grow significantly and has Government support. Grain LNG is well positioned to become one of the most important distribution facilities for LNG road tankers.

8.6 BACKGROUND ON LNG

Liquefied Natural Gas is natural gas that has been cooled to -162^{o}C, shrinking its volume so that it takes up 600 times less space, making it economically viable to transport over long distances.

LNG is transported to the UK in dedicated vessels, typically of membrane type with double-wall metal containers, which require navigation and berthing in deep water ports. From the berth, the LNG is extracted using compressors into cryogenic storage tanks where it is stored at -162^{o}C.

LNG is stored in tanks specially designed to maintain the very low temperature of the liquid and to mitigate the risk of loss of containment. A full containment design is employed, comprising an inner tank made of a nickel alloy and an outer tank made of pre-stressed concrete with a reinforced concrete base slab and roof. The outer tank provides containment in the event of a leak from the inner tank. A certain amount of warming of the liquid occurs due to less than 100% thermal efficiency of the insulation material. This gas is collected and used by the nearby Combined Cycle Gas Turbine power generation facility at Grain.

According to demand, the liquid can be extracted from storage tanks and returned to gaseous state at around 5^{o}C at a regasification plant before being fed into the National Gas Transmission System. The

regasification process can require the addition of nitrogen to ensure the product meets UK gas quality specifications.

8.7 LNG'S SAFETY RECORD

LNG has an excellent safety record during transport, offloading, storage and regasification. According to the International Group of Liquefied Natural Gas Importers (GIIGNL, 2011), there have been no instances of LNG ships experiencing major accidents or safety or security problems in over 45 years and 135,000 voyages.

There have been very few accidents related to the storage and transmission of LNG. The most significant accident occurred in 1944 in Cleveland, Ohio, USA, when a tank failed and spilled its contents into the street and storm sewer system. The resulting explosion and fire killed 128 people. The accident was found to be due to the materials used to construct the inner tank, and the lack of fire resistance of the legs supporting the adjacent tank. Since then, significant advances in the design, construction and safe operation of LNG facilities have been made.

Where accidents have occurred involving pipelines or other infrastructure, such as steam boilers, the resulting impact has tended to be very localised although fatalities and casualties have resulted. LNG, as a liquid, will not explode or burn. When it leaks, it sinks to the ground (being denser than air), where it begins to vaporise. It is flammable within an approximate concentration of 5-15% gas in air. Outside this range, it does not burn. The circumstances in which LNG presents the greatest risk are when LNG leaks, vaporises, and gases are allowed to build up in such a way that they reach a flammable concentration.

The most recent LNG accident occurred on 31st March 2014 in Washington State, USA. A gas pipeline adjacent to an LNG storage tank of a similar scale to those at Grain LNG exploded and the resulting shrapnel caused a breach in the tank walls. LNG leaked from the tank and vaporised, but it did not ignite or explode. A two-mile evacuation zone was set up as a precautionary measure.

Research undertaken for this study has not identified any instances of an LNG storage tank igniting or exploding, even in the event of an adjacent pipeline explosion and fire.

8.8 GRAIN LNG SAFETY

Grain LNG falls under the Control of Major Accident Hazards (COMAH) regulations and is a top-tier registered establishment. The aim of the regulations is to prevent major accidents involving dangerous substances and to limit the consequences of any accident to people and the environment. The regulations cover the unloading equipment at the jetty, the site itself, and the feed up to the National Gas Transmission System.

Grain LNG is overseen by the Competent Authority, which comprises the Health & Safety Executive (HSE) and the Environment Agency (EA). The Health and Safety Executive (HSE) is responsible for scrutinising the site in relation to Planning Advice for Developments near Hazardous Installations (PADHI) guidance which advises on planning decisions within hazardous areas. The local authority, Medway Council, is responsible for giving Hazardous Substances Consent. Consent for the site to store an increased quantity of LNG and gas following Phase 4 expansion was awarded in early 2013.

The HSE has defined a Land Use Planning (LUP) Consultation Distance (CD) around the Grain site, based upon a detailed assessment of the hazards and risks associated with the site. Three zones within the CD are defined: inner, middle and outer, derived from an assessment of the probability of a 'dangerous dose' occurring. A 'dangerous dose' is defined as an incident resulting in severe distress to all; a substantial number requiring medical attention; some requiring hospital treatment; and about 1% fatalities.

The Consultation Zones for Grain LNG are shown in Figure 27 and Figure 28, below. Note that the zones have been derived from an assessment of the existing infrastructure and storage capacity, including that

which is currently in development. They do not reflect the additional capacity that forms part of the longer term plans for expansion.

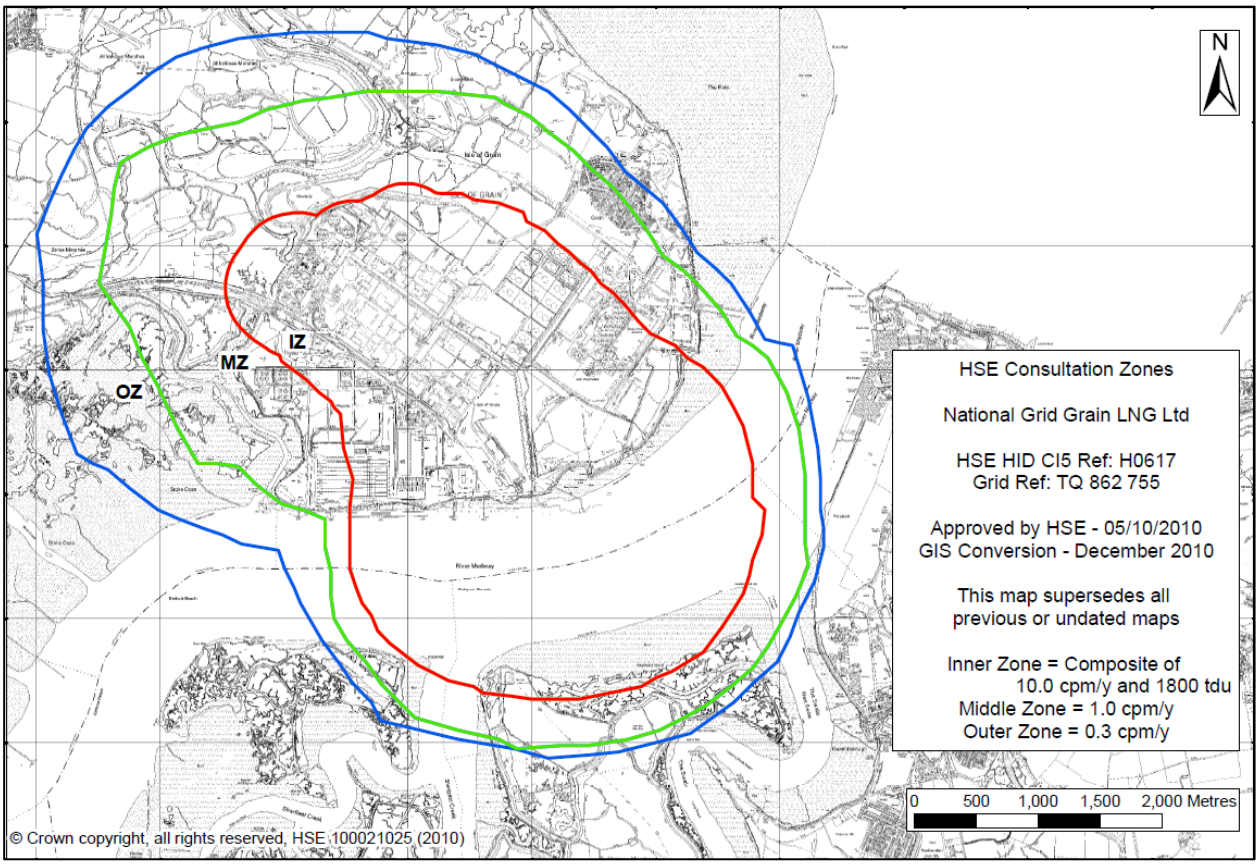

Figure 27: Grain LNG HSE Consultation Zones

PADHI is a methodology that gives Land Use Planning (LUP) advice on proposed developments near hazardous installations. The approach takes into account the zone in which the proposed development is located, and the 'sensitivity' of the proposed development:

- Sensitivity 1 includes people at work and parking
- Sensitivity 2 includes the general public (e.g. housing, transport links, indoor and outdoor facilities)
- Sensitivity 3 includes developments for use by vulnerable people (e.g. institutional accommodation, education, prisons)
- Sensitivity 4 includes very large and sensitive developments (e.g. football ground, large hospital)

A matrix, shown in Table 3, is used to decide the type of advice that the HSE would give to the Local Planning Authority in relation to the scheme.

Table 3: PADHI risk matrix

Level of Sensitivity	Inner Zone	Middle Zone	Outer Zone
1	Don't advise against development	Don't advise against development	Don't advise against development
2	Advise against development	Don't advise against development	Don't advise against development
3	Advise against development	Advise against development	Don't advise against development
4	Advise against development	Advise against development	Advise against development

The HSE uses the above table to determine whether it would advise against development or not. The HSE has an advisory role rather than the power to refuse consent or a planning application. It provides advice to the local planning authority which will make a planning decision weighing Health & Safety against other considerations.

The absence of substantive data on the probability of an incident occurring means that the focus of a risk assessment shifts towards assessing impact rather than likelihood. The specification of the LNG facility is designed to manage the likelihood of an incident to a level that is As Low As Reasonably Practicable (ALARP). Further mitigations are focused on reducing impact, i.e. reducing the number of vulnerable people within the vicinity and reducing the risk of a 'domino effect' in which an explosion could be triggered at a neighbouring facility.

There is currently little or no housing within the Grain LNG Inner Zone, and only a small settlement of 1,648 (2011 census data) within the Middle and Outer Zones.

8.9 RISKS RESULTING FROM POTENTIAL AIRPORT DEVELOPMENT

The development of an airport adjacent to the Grain LNG facility introduces reciprocal risks:

- The risk of a fire or explosion at Grain LNG resulting in loss of life, casualties, damage to property, and/or causing disruption to airport operations; and
- The risk of an aircraft colliding with part of the Grain LNG infrastructure, causing fatalities, casualties, loss of availability of critical infrastructure, and potentially a fire or explosion.

The complexity of these risks means that they require thorough investigation by the HSE. An airport development of the scale of an inner Thames Estuary hub does not readily fit into the PADHI model. Informal advice from the HSE suggests that the main development, the airport terminal and all associated buildings (those for indoor use by the public) may be sensitivity level 3 in the PADHI system, while other areas such as runways and taxiways could be level 2 or 3 depending on the number of people present and the length of time they are present. The precise location of the facilities will then form a material part of the decision-making to determine which facilities, if any, fall within the Consultation Distance.

Recognising the shortcomings of the PADHI system for this application, HSE would have operational concerns about the close proximity of the airport to the terminal and its presence could lead to HSE revising its LUP zones, which could place the Estuary airport scheme within HSE's consultation distance.

Figure 28, below, shows the location of the existing Consultation Zones in relation to the proposed airport locations.

Figure 28: Grain LNG HSE Consultation Zones and proposed airport locations

Historical data suggest that if a fire or explosion were to occur at Grain LNG then it would not have an immediate impact on the airport and terminal buildings (i.e. it is unlikely that they would be immediately damaged by an explosion); however, the airport would likely fall within an evacuation area that would be set up, and were the incident to develop into a full LNG facility fire then damage may be caused to airport infrastructure. The evacuation itself would result in significant disruption to airport operations as some or all of the airport would probably be required to close. Facilities that fall outside the exclusion zone would be unlikely to be able to be operated independently from those that fall within it.

The risk of an aircraft colliding with part of the Grain LNG infrastructure cannot be calculated; nevertheless it is recognised to exist. The flight phases that carry the greatest risk are departure and approach. The inner Thames Estuary airport schemes propose an east-west parallel runway alignment to the north of Grain LNG, therefore an incident following aircraft departure would be extremely unlikely. With Grain LNG located potentially less than a mile from the southern runway, only a small course deviation for an arriving aircraft would be necessary for a collision with the LNG facility to occur. It must be emphasised that this would be an extremely unlikely event and that we are not aware of any incidents in which a commercial aircraft has made a controlled or uncontrolled flight into terrain at such a deviation from intended course. Additionally, the go-around procedure for an aircraft on a westerly approach to the southern runway would ordinarily take it over Grain LNG; such an event might occur as frequently as once per day and may therefore present a material risk.

LNG tanks are designed to withstand ground movement, blast overpressure and missile impact. It is reasonable to assume, however, that neither the tanks nor the adjacent pipelines and other infrastructure would withstand an aircraft impact and that a fire and/or explosion would be likely to occur as a result, potentially on a scale never witnessed in any other LNG accident to date.

It cannot be ruled out that an aircraft might be deliberately flown into the LNG facility. Its proximity to the proposed airport means that it would present both an attractive target to terrorists and a target of opportunity. In common with safety risk assessment methodologies, given that it is not possible to assess

the probability of such an event occurring, security risk assessment methodologies tend to focus on establishing the scale of the impact and on implementing measures to reduce the risk to people and property as far as reasonably practicable.

Importantly, it may not be necessary for an actual incident at Grain LNG to take place in order for disruption to result. An increased risk of an accident, perhaps because of a small local fire, or the threat of an explosion, for example from a suspect package or coded bomb warning, could be sufficient to result in substantial disruption to normal airport operations.

8.10 ROLE OF GRAIN LNG IN IMPORTING AND SUPPLYING NATURAL GAS TO THE UK

8.10.1 Grain LNG's Importation role

The UK has four LNG importation facilities which, in 2011, provided up to 47% of the UK's total natural gas imports:

- Grain (20.4bcm/yr);
- Dragon LNG (7.6bcm/yr) and South Hook LNG (21bcm/yr), both located at Milford Haven in Pembrokeshire, are importation and storage facilities; and
- Teesside GasPort (4.1bcm/yr) is an importation-only facility which uses regasification equipment onboard the ship to deliver natural gas into the onshore pipeline and into the National Gas Transmission System.

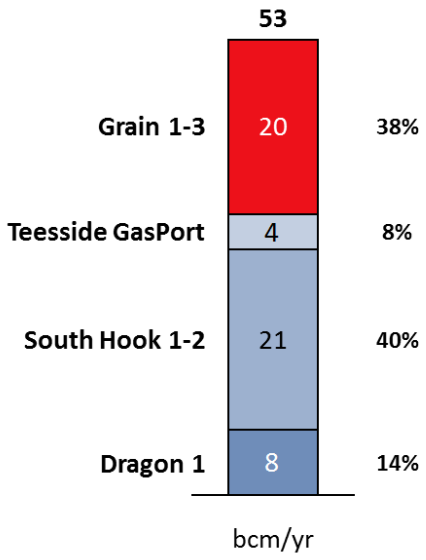

Figure 29: Contribution of each LNG import facility capacity

(Total = 53.1 billion cubic metres per year)

Grain provides up to 38% of the UK's LNG import capacity and 13% of total natural gas import infrastructure capacity. It has the capacity to supply around 20% of the UK's requirement for natural gas.

In 2012, 97% of the UK's LNG imports were supplied by Qatar, with Norway, Algeria, Nigeria and Egypt supplying the remainder. The nature of importing LNG by ship means that the UK's terminals are, in effect, connected to any LNG supplying country, providing much greater purchasing flexibility. In terms of energy security, the facility provides access to ship-borne gas on global markets, which means that in the event of pipeline failure (or geopolitical dispute such as has been observed recently between Russia and Ukraine), LNG can be sought from a wide range of global producers.

LNG import volumes were much lower in 2012 (14.0bcm) than 2011 (24.6bcm), principally because higher demand in Asian markets caused prices to rise above European levels. The UK's gas demand was therefore met to a larger degree in 2012 by gas pipelines from Norway, the Netherlands and Belgium.

Domestic North Sea production continues to be the UK's largest single source of natural gas at 54% of 2012 demand. However, North Sea gas production from the UK and Norway is forecast to decrease over time. At the same time, the UK will become less reliant upon coal-fired power stations and more reliant upon renewable sources such as wind. CCGT plants are typically used to produce on-demand electricity generation to supplement renewable sources.

Therefore, although the Department for Energy and Climate Change forecasts a gradual decline in gas consumption over the period to 2030, a greater proportion of the UK's gas will be met by imports. These imports will be met by a combination of LNG imported by ship and natural gas imported through interconnectors with Belgium and the Netherlands.

There are also some plans to construct additional LNG importation infrastructure, including a regasification plant at Teesside, a floating storage and regasification facility (similar to that currently operating at Teesside), and a facility to take LNG from sea tankers at Amlwch, regasify it and distribute it by pipeline for storage at Preesall in Lancashire. These projects would provide less capacity than Grain and would be developed to meet an already identified need. There is also no confirmation that these projects will materialise.

TfL's submission to the Call for Evidence states that both the LNG shipping terminal and the link to the underground national LNG pipeline structure outside the perimeter fence of the airport could be retained. This would appear to overlook the requirement to regasify the LNG before it is pumped into the National Gas Transmission System, which distributes natural gas rather than LNG.

Grain, therefore, continues to form a key component of the UK's current plans to meet the UK's gas needs over the forecasting period.

8.10.2 Grain's LNG Storage Role

The UK uses a combination of gas storage and LNG storage to meet its gas demands. The various gas storage facilities shown in Table 4, below, offer not only a very wide range of capacities but also differ in their role.

- Depleted gas fields are typically injected with gas in the summer which is withdrawn in the winter, since they have slow injection and withdrawal rates (Long Range)
- Salt caverns can be used to store gas and offer high injection and withdrawal rates, enabling them to be refilled and emptied several times a year (Medium Range)
- Peak shaving is the name given to highly deliverable storage such as LNG which can be used to meet very high demands for short periods of time (Short Range)

Table 4: UK gas storage facilities (Source: National Grid, June 2014)

Type	Site Name	Type	Accessibility	Maximum Capacity (kWh)
LNG Storage	Isle Of Grain	Peak Shave	Short Range	6,450,197,230
	South Hook	Peak Shave	Short Range	5,220,000,000
	Dragon	Peak Shave	Short Range	2,066,359,801
Gas Storage	Rough	Depleted field	Long Range	40,256,100,000
	Aldbrough	Salt cavity	Medium Range	1,498,319,536
	Holford	Salt cavity	Medium Range	2,383,571,904
	Hill Top	Salt cavity	Medium Range	417,000,000
	Humbly Grove	Depleted field	Medium Range	2,772,360,852
	Hornsea	Salt cavity	Medium Range	2,855,555,546
	Holehouse Farm	Salt cavity	Medium Range	492,000,000
	Avonmouth	LNG	Short Range	551,506,679
Total				64,962,971,548

As Table 4 shows, the only short range source of gas is from LNG storage. Salt caverns provide medium range, while Rough, a partially depleted gas field in the North Sea, provides slow access to a very large supply of gas. One of the reasons that access to gas stored in salt cavities and depleted fields is slow is that the gas must travel some considerable distance before being processed and introduced into the National Gas Transmission System. LNG, on the other hand, needs only to be regasified and to have nitrogen added so that it reaches the required specification – a comparatively quick process.

8.11 POTENTIAL ALTERNATIVES TO GRAIN LNG

Grain LNG fulfils a number of criteria that make it ideally suited to its LNG importation and storage role. It has a very low local population, it is sited on a large area of brownfield land for development; it has a deepwater port, an existing connection to the National Gas Transmission System, and it is close to the main source of gas demand in the south east.

The examination of Grain LNG's role for both importing and storing gas demonstrates the significant challenge that would be faced if it were necessary to relocate the facility. Despite an appetite to develop further LNG importation facilities in the UK, few suitable alternative locations have been identified either by the National Grid or by other energy companies, and indeed none that combine both importation and LNG storage. Alternative approaches can be envisaged, such as using onboard regasification ships, feeding natural gas directly into the National Gas Transmission System, and cooling it for storage elsewhere (as at Avonmouth). However, this would incur operational inefficiencies by being limited to smaller vessels equipped with onboard regasification equipment, and the operating costs of re-condensing the gas for storage as LPG on land. Market position would also be weakened by constraining the market to only those suppliers equipped with onboard regasification vessels. A key constraint remains the access to a deepwater port, able to accept the largest LNG vessels, that is within reasonable reach of the National Gas Transmission System. Were an alternative site to be found, the National Grid's view is that it would be necessary to construct and commission the new site before decommissioning Grain LNG, so as to retain the supply which has strategic importance for the UK's energy security. The Department for Energy and Climate Change has also highlighted the importance of the UK remaining in compliance with the EU security of gas supply regulation (EU 9994/2010).

The storage tanks used at Grain LNG are understood to take 42 months to construct. According to National Grid's submitted evidence, the costs of rebuilding Grain LNG would be significant and the site would take 10 years to replicate. Therefore, if the Grain LNG site were to be vacated in favour of part of the airport development then a strategy to replace Grain would be required with some urgency. National

Grid is not aware of another suitable site available in the UK that meets all of the requirements of the Grain LNG facility.

According to National Grid, over £1bn has been invested in Grain LNG and a further £300m is committed. Given the investment, it seems likely that the facility's operational life will continue well beyond 2029, and some asset renewal can be foreseen. It is reasonable to assume that a replacement facility would cost at least as much as has been invested at Grain LNG, potentially much more once land acquisition and any works required to enable access by deepwater vessels were carried out.

8.12 CONCLUSIONS

The Isle of Grain is home to a number of energy assets of strategic national importance as well as some brownfield sites with redevelopment potential as electrical power generation facilities. At present, the energy facility that poses the greatest potential barrier to airport development on the Isle of Grain is the Grain LNG terminal.

Current HSE advice is inconclusive as to whether Grain LNG and an airport could satisfactorily co-exist and if so, the specific location of the airport that would be acceptable. The current risk assessment is based upon the existing facility, taking into account the short-term development work but not the longer term planned expansion. The reciprocal risks that the airport might introduce are not readily accommodated within existing risk assessment frameworks.

From a security perspective, the co-location of the facilities could provide an attractive target to terrorists with a significant impact upon the UK's energy security and the operation of the UK's hub airport. Indeed, the threat of a safety or security incident would most probably be sufficient to cause major disruption to the airport and surrounding service providers.

Even if it were decided that the energy facilities and the airport could coexist, their location would inhibit the expansion of the airport in a southerly direction, undermining the attraction of the Isle of Grain as a site that provides relatively unconstrained airport expansion opportunity. Similarly, the existence of an airport would be likely to deter or prevent further energy infrastructure development on the Isle of Grain.

The energy facilities at Grain potentially impinge upon the Obstacle Limitation Surfaces of the IAAG airport scheme located to the west of the peninsula; given the height of the power station stacks, they may also have an impact on the airport locations to the east.

Grain LNG is a facility of strategic importance, providing nearly 40% of the UK's LNG importation capacity, storing the equivalent of around 600mcm of natural gas, and able to supply 20% of the UK's gas demand in a short range, peak shave capacity. Given the UK's forecast growth in demand for imported gas and its desire to maintain a competitive position with regard to gas pricing, it would be necessary to find an alternative site that provides similar capabilities. However, suitable sites with deepwater berthing, space to develop a large scale facility away from residential areas and with reasonable access to the National Gas Transmission System, are not readily available.

It can be expected that the scale of investment into Grain LNG, which will total £1.3bn once the current development phase is complete, would be exceeded by the costs of locating, obtaining approvals, and developing a replacement facility.

9. TRANSITION TO A NEW HUB AIRPORT

9.1 INTRODUCTION

The purpose of this chapter is to outline certain key issues if the UK's hub airport were to transition to a new location in the inner Thames Estuary. It also examines the issues that might arise if it were necessary to close either or both of London City Airport (LCY) and London Southend Airport (SEN). It is assumed that it would be necessary for the Government to purchase or otherwise acquire Heathrow, while the development of the new airport may be either through a private or government owned entity.

The scope of the chapter is confined to major strategic issues, and to cover only the transition involving the termination of services at Heathrow and the inauguration of similar levels of service at the Estuary airport. It does not cover the post-airport use of the land at Heathrow, nor the inherent risks involved in the construction and opening of the new airport, except in the context of the relocation of existing services from the closed airports.

The chapter considers the issues presented by existing commercial agreements with airports, airlines and related entities before going on to consider the the transition from the perspective of existing employees. The next section considers, by way of comparison, global examples of airport closure and transition. Finally, other issues outwith these subject areas are considered.

9.2 COMMERCIAL AGREEMENTS

9.2.1 Agreements with Airports

A decision to proceed with the Estuary airport concept would have critical implications for Heathrow Airport Limited (HAL), as well as potential implications for London City (LCY) and London Southend (SEN) airports. Given that the scheme would almost certainly require substantial public funding for construction, and to compensate or acquire at least HAL, it is clear that the decision involves a major financial commitment by the Government. The Government would have to consider whether to negotiate with HAL to arrange a satisfactory transition to the Estuary airport, or whether to legislate to acquire the airport (within the limits of EU law and international trade law).

Government may consider that there are risks in adopting a Compulsory Purchase Order approach, as they can undermine confidence by foreign (and UK) investors in the UK and could damage efforts to attract wider private investments as well as investment into the airport sector.

We are not aware of examples of nationalisation of profitable businesses in OECD countries with the sole purpose of closing the business, and all other examples of airport closure and relocation in recent years have been undertaken by the airport owners themselves (Hong Kong, Denver, Oslo, Berlin, Munich and Athens).

It is more likely that the Government would wish to negotiate with HAL and it could be expected to enter into confidential discussions in anticipation of a final decision, with a commercial negotiation strategy prepared in advance, to gauge HAL's reaction and how it would wish to work with the Government.

HAL is likely to have a range of concerns about the announcement of a decision in favour of the Estuary airport scheme, but its highest priority would be to ensure shareholders are not disadvantaged. It would decide whether strategically it wishes to remain involved in the London airport market.

HAL will be aware that it has considerable leverage to extract value for its shareholders, tempered by the risk that Government could legislate to achieve its objectives. Agreement with one airport may require agreement with other airports in potentially similar positions (notably the owners of London City and Southend airports).

In developing its negotiation strategy, the Government will require clarity of legal issues around compensation and its ability to legislate for closure of airports, given competition law considerations, as well as wider UK and European Union law on state aid, among others. Legal challenge could also arise in a sale scenario, if HAL were to successfully negotiate a price above a fair market price; HAL's competitors and those companies that may wish to bid to own and/or operate the Estuary airport may raise concerns about unfair behaviour.

HAL's shareholders would appear to face a number of options:

- retain ownership of Heathrow until closure, but with both charges and service standards regulated over that period in exchange for compensation/acquisition at closure;
- Crown acquires Heathrow, but allows HAL to be retained with a management contract for the airport, with the Crown setting charges and determining capital investment strategy until closure;
- Crown acquires Heathrow, and lets out a management contract with another company to operate Heathrow, with the Crown setting charges and determining capital investment strategy until closure;
- Crown acquires Heathrow from HAL, and operates company as fully state owned enterprise.

In any scenario which retains Heathrow (and potentially London City and Southend airports also) in private ownership, there are significant risks that would need to be managed around maintaining, operating and renewing busy airports that are to be closed at a specified date. The key issue is that the owner of an airport that is to be closed is not incentivised to maintain and renew the infrastructure to the same level that it would if it were going to continue to remain open. This creates a number of issues concerning cost and service quality that would be contrary to the wider policy objectives of government in ensuring the UK retains its position as an aviation hub in the interim.

These issues are principally:

- Airport equipment and infrastructure that would otherwise have been replaced would not be cost effective to do so and would need its life extended through short-term investment to maintain services. This would be expected to create reliability and efficiency issues, as increasingly obsolete equipment is more prone to breakdowns and errors, and with some systems (e.g. mechanical, computerised equipment) it may prove difficult to obtain spare parts or customer support from suppliers;
- With higher reliability and efficiency issues, the costs of operating the airport would likely rise and create consequential costs for airlines that may face delays or customer service issues due to systems failures or poor performance;
- Airlines could be reluctant to pay higher airport charges for poorer service quality;
- The increased unreliability and poorer customer service from the airport would worsen the end users' experience. The level of service may act as disincentive to use Heathrow potentially encouraging airlines and passengers to use alternative airports.

The challenge therefore is to manage ongoing investment in Heathrow so as to not undermine achievement of the policy goal of promoting hub airport capacity until the Estuary airport was opened.

Regardless of whether or not Heathrow remains owned by HAL, one avenue would be to implement a performance monitoring regime with appropriate regulatory sanctions to ensure that an adequate level of service is provided to airlines. Nonetheless, irrespective of the compensation package for closure, it would appear commercially appropriate to "sweat" Heathrow assets rather than renew or replace them. Safety critical systems must be protected; however, it is likely that some facilities would need to be retained or refurbished depending on the timescales between decisions on closing Heathrow and the date for closure. A full analysis of the lifecycle requirements and capacity/reliability issues for airport systems for passengers, cargo and aircraft (and also some surface access elements) would need to be

carried out. This may require a broader mandate for economic regulation than is currently provided for through CAA and may necessitate a monitoring trustee role.

Whilst it is likely that Heathrow in such a condition would have higher operating costs than would otherwise be the case, the critical factor is in maintaining reliability and ensuring the airport functions safely. There may be short term options to vary operating procedures at Heathrow to improve reliability and resilience (and consequentially lower costs to airlines), and so assist in gaining greater support from airlines for increases in charges. Whilst airport charges may be lowered, such a response would raise accusations among competing airports of unfair subsidies (particularly since competing airports are likely to see the period before the Estuary airport is opened as an opportunity to attract new airline business).

While most of the engineering risks of airport closure are based on Heathrow, there are similar risks with London City and Southend airports, although both these airports have comparatively newer infrastructure.

Summary

Given that a significant cost of the Estuary airport scheme is likely to be the compensation for/acquisition of Heathrow as a going concern, the negotiations over this are expected to present a significant risk in inflating capital costs for the wider programme. Since such negotiations would be of fundamental importance to the Government and the airports' owners, it is difficult to envisage the timescales that would be needed to reach satisfactory conclusion. However, it is likely that the costs of professional services for advice and strategy development for this stage would be significant, and that misjudgement in negotiations could add substantially to the total cost. Airport companies will be aware that the longer such negotiations take and the higher the perceived political cost of abandoning the project, the greater may be their scope to extract more concessions from Government, increasing the costs of the project, but also the risk of legislative intervention to implement policy on terms that are less favourable than those they may negotiate. If the legislative option is pursued by Government, it could also face judicial review, but nevertheless could impose considerable delay and costs upon Government and the private airport owners, through consultation and challenges, as well as impacting negatively on international perceptions of the UK as a location for investment in airports and possibly infrastructure more generally.

9.2.2 Agreements with Airlines

The announcement of an Estuary airport may generate mixed responses from airlines. Whilst, in principle, some airlines may be expected to support additional capacity at a more flexible and efficient, modern airport, the results of the Attitudes survey undertaken for the Commission (see Section 10) indicate that some airlines would have major concerns if they were expected to relocate from Heathrow.

These concerns include the costs and risks around the relocation itself, the likelihood of higher airport charges (especially given Heathrow's charges are already among the highest in the world) affecting the competitiveness of services from the Estuary airport compared to other airports in the London area, and the relative shortage of regular travellers within the Estuary airport's catchment in the short to medium term. In addition, there is concern that the longer journey times many passengers would experience travelling to the Estuary airport compared to Heathrow may increase the attractiveness of other airports (e.g. Gatwick, Luton and Stansted), thus weakening the competitive strength of services at the Estuary airport.

Airlines with substantial operations at Heathrow (and potentially London City and Southend airports) will have particular concerns regarding relocation of equipment and staff. While it may be expected that parallel to the Estuary airport's development, some businesses (including airlines' suppliers and customers) would relocate nearby and housing would be developed to accommodate staff near the airport, such development would take place over a period of many years, extending long after the Estuary airport opens. There are likely to be challenges in demonstrating to airlines that the new capacity, the more flexible operations and potentially more efficient airport layout would offset these negative factors,

particularly in the absence of indications over airport charges. The Attitudes survey provides further evidence of airline perceptions about the Estuary scheme (see Section 10.3).

There are a number of non-trivial issues that will need to be addressed in consultation and negotiation with airlines at various stages:

Business case: The Estuary airport is a different proposition for airlines and their customers compared with Heathrow. The location means that the airport serves a different catchment to Heathrow, and it is likely that airport charges will exceed those at Heathrow. These and other factors mean that it cannot be assumed that all services in their current shape and size would transfer from Heathrow to the Estuary. Through the Attitude Survey, some airlines indicated that they would be unlikely to transfer their operations from Southend or London City airports, given the different airport proposition (perceived lower convenience, more remote, and higher airport charges). Furthermore, if presented with a flight from the Estuary airport, a passenger may well also consider flights from Gatwick and Stansted which, in some cases, may involve similar or shorter travel times.

Air Services Agreements: Whilst the EU has a single aviation market and has open skies agreements with a number of countries, there are other bilateral Air Services Agreements (ASAs) that are quite specific about capacity and airport access on both sides. This includes maintaining minimum levels of access at Heathrow (and reciprocal access at the foreign jurisdiction's primary hub). Although the trade in aviation services is likely to be further liberalised, some ASAs will probably retain some airport specificity and so these ASAs may need renegotiating to enable Heathrow to be closed without breaching the existing ASA, and to ensure continuity for airlines after Heathrow is closed. As it would be the UK initiating such a renegotiation, it would be both an opportunity and a risk to the existing rights of access to each other's markets. Such negotiations would be undertaken at the intergovernmental level and may take some time to resolve.

Heathrow ATM slots: Since Heathrow is designated as a Co-Ordinated Airport[1], the question arises as to how slots would be allocated at the Estuary airport. Whilst the least complex approach might appear to be to allow airlines to use comparable slots as incumbents (and incumbent airlines are likely to prefer this in many cases[2]), it may be that such transferability of rights is not automatic if the Estuary airport does not have co-ordinated status (which under existing EU law would only be determined once there was a clear indication of genuine demand for slots). EU law does not presently allow for "grandfather" rights, which are based by time at a single airport, to be transferred across airports.

If the Estuary airport could not have co-ordinated status, then existing and new airlines may be able to seek slots at the Estuary airport according to a "first come first served" basis.

If it could have co-ordinated status (because of peak time congestion) and if slots were allocated at the Estuary airport based on existing EU law, then it would have to afford some priority to new market entrants (airlines with fewer than five slots a day at the Estuary airport). This is likely to give cause for concern to British Airways (BA), Virgin Atlantic and a number of other existing Heathrow operators.

Even if agreement among over 70 airlines at Heathrow, London City and Southend airports could be achieved, it is likely that there would be new entrant interest in the Estuary Airport upon its opening.

1 Under EEC Reg 95/93.

2 Although there is anecdotal evidence of some airlines being interested in additional slots or shifting to early morning arrival slots.

This creates a new challenge of accommodating airlines that were not operating at Heathrow, London City or Southend airports at the time. During the period of transition, there may be no legal method to restrict new entrants from taking favourable slots equivalent to those held by airlines encumbent at Heathrow. In addition, some existing operators are likely to want to introduce new services immediately, or to change the times of their existing services, making the transition more complex than simply replicating the existing flights from the existing airports.

Terminal and ground infrastructure design: Major airlines and the three airline alliances are likely to seek early involvement in informing the design of the Estuary airport, if confirmed, which presents both opportunities and risks around cost and project timelines. Dedicated terminals for some airlines/alliances may present opportunities to attract new capital investment from airlines, although airlines may be reluctant to invest if their recent investments at Heathrow have not been fully depreciated or compensated. Although airline alliances may loosely commit to the new airport so as to be involved in terminal designs, airlines themselves may not commit until much later in the construction programme.

Airport charges: It would be important for airlines to understand as early as possible the future airport charges at airports marked for closure, as well as the prospective charges at the Estuary airport. It is probable that this would be a balance of interest between the Government seeking to maximise revenue to recover the costs of the new airport, and setting charges so as to compensate for, or increase the appeal of, relocation to the Estuary airport for a transitional period. Charges may be seen as a tool to facilitate the transition process, but there would appear to be limits to this to avoid accusations of anti-competitive bias. There is a considerable risk that owners of competing airports, such as Gatwick and Stansted, but also even Schiphol, may seek to challenge charges that are below the long run capital costs of the airport.

Airline relocation sequencing: If it were decided to stagger the transition to the Estuary airport, airlines are likely to have mixed views about whether to relocate early or later. Given that over one-third of passengers at Heathrow are transferring between flights, it seems unlikely that most members of the existing three big airline alliances would shift in advance of their partners.

Airlines that base aircraft at the airports overnight would be expected to relocate them the following day when operations shift. These relocations in themselves appear to be much less complicated than the issues of wider staff relocations and the business decision about relocation of services more general.

In the timelines concerned, there is also the likelihood that some airlines will cease operations at Heathrow, either due to mergers, acquisitions or financial concerns, whilst other new ones may emerge. Some foreign carriers with limited (and marginal) operations may choose to cease operations rather than relocate to the Estuary airport.

Agreements should be simpler with airlines at London City and Southend airports, given the smaller scale of operations, and in any case many airlines operating at London City airport also operate at Heathrow. However, evidence from the Attitudes survey suggests that some airlines at London City and Southend airports would not see their business model being compatible with the Estuary airport, given higher charges, a more remote location and potentially a more complex operation (e.g. longer taxiing), and they may therefore move their services elsewhere.

Summary

The critical issues are likely to be around the price of access to the Estuary airport, and how competitive the overall proposition is, as to how airlines would approach commercial negotiations on relocating from Heathrow (and potentially London City and Southend airports) to the Estuary airport. There is a considerable risk that airport charges, surface access and the catchment area of the Estuary airport will be seen as inferior to the airports it is replacing, by airlines and their customers. Competition from other airports and airlines could mean that some airlines choose not to relocate some services to the Estuary airport.

Individual airlines have critical commercial imperatives which are largely driven by short-medium term decisions about where to allocate aircraft and staff, and some longer term decisions on fleet purchases. Assuming the critical interest in development of the Estuary airport is around maintaining and expanding the range of destinations, frequencies and airlines serving London, then there will need to be considerable effort taken to make the proposition to airlines sufficiently compelling. There is a considerable risk that such negotiations could mean measures that directly or indirectly involve additional costs to taxpayers, including delayed or deferred airport charges. Any such measures are likely to be challenged by competing airports as being anti-competitive.

9.2.3 Agreements with Other Entities

Airport ancillary services: Ground handling agents, airline caterers, retail outlets, cargo agents and fuel companies are all likely to be interested in the Estuary airport in terms of design, layout, costs of doing business and timescales for transition. Whilst major business decisions on relocation may not be taken until the airport is well under construction, for some businesses there is a strong strategic interest in maximising commercial positions through contributing to the Estuary airport design in advance of that. One key matter will be to avoid commercial agreements that monopolise certain services or disadvantage or unnecessarily limit new market entry. For some businesses, the relocation will change capital investment programmes to avoid the deadweight costs of shifting equipment that may be better to operate past obsolescence (e.g. ground vehicles).

Businesses reliant on airport generated demand: For those businesses that are ancillary to the airport itself, but which gain significant revenue from airport users, it is likely that the key concern is adequate land/building/planning scope to re-establish at the Estuary airport. Such businesses include hotels, rental car companies and logistics companies. This is likely to be best addressed through the planning process for the Estuary airport and demand around land use adjacent to it. Once there is certainty about the land footprint of the Estuary airport, and related transport links, such investment is more likely to be made. It appears unlikely to be a priority for Government to enter into formal agreements with such businesses, although there is a risk that some may lobby for compensation.

Train Operating Companies: Rail franchises would need to be renegotiated to cover the termination of services at Heathrow and to serve the Estuary airport.

TfL: TfL would be expected to reconfigure Piccadilly line services and bus routes once Heathrow is closed. However, given the development of new routes and infrastructure for the Estuary airport, it may be that compensation will not be needed, although decisions on replacement rolling stock (likely to be partly funded by central government) for the line may be altered according to what future use the Heathrow branch line is planned. TfL would also need to consider the service pattern of Crossrail.

Local authorities: Local authorities at Heathrow and the Estuary airport will all need to be involved in infrastructure planning and co-ordination for the logistics involved in the transition. Relocation of equipment may involve considerable planning of road closures and disruptions, which will also involve the Highways Agency (or successor).

Other government agencies: Amongst others, UK Border Force, HM Revenue and Customs, Police forces, the Home Office will have to duplicate operations during a transitional period. CAA and NATS would clearly need to be involved throughout the planning and transition.

Summary

The wider business community adjacent to Heathrow and also the other airports will require extensive consultation and involvement in the process to transition from the existing airports to the new one, as it is difficult to envisage all of the key issues that are likely to arise. The sheer diversity of businesses and the lengthy timescales mean that programme planning for the transition would need considerable provision for engagement with a wide range of stakeholders.

9.3 WORKFORCE RELOCATION

9.3.1 Existing Airport Workforces

More than 75,000 employees work at Heathrow, of whom 6,475 work directly for the airport company. According to HAL's figures, a further 50,000 off-airport employees are directly or indirectly dependent on the airport. These include companies such as cargo handlers, catering suppliers, engineering companies and airline office staff.

Southend airport has approximately 1,000 staff working on the airport campus, of which 290 work for the airport directly. London City airport currently has 2,100 on-airport staff and forecasts this to increase to 3,500 subject to realising its growth plans.

According to HAL's 2014 employment survey, which represents all staff working on the airport campus, 54% of employees live within one of the five boroughs local to the airport. 59% of staff have a journey time of less than 45 minutes to the airport, including 38% who travel for less than thirty minutes. More than 50% of staff travel to Heathrow by private car.

At Southend airport, 86% of staff live within a Southend postcode area, and at London City around 65% live within five miles of the airport.

If Heathrow were to close, a large population would be faced with the decision of whether to take up employment at the new Estuary airport, if offered, and whether to commute or relocate. London (Heathrow) Airline Consultative Committee (LACC) raised concerns over the willingness of staff to move to a new airport, noting that 'the scale of any migration is unprecedented in any modern urban planning scenario'. Medway Council commented that as Heathrow Airport's support services staff are largely low wage workers, 'it is inconceivable that they would relocate or commute to a new hub airport to the East of London'. Unite the Union stated that 'individuals that work in the aviation industry are often highly trained in their chosen field and in a role which is in demand globally. Consequently if the hub airport was to relocate there is no guarantee that these staff would wish or were able to move their family to the east of the capital or would, or could, entertain commuting from their current home to their new place of work'.

At present, commuting time by public transport from the Heathrow vicinity to the Isle of Grain is not viable, but even if the proposed surface access infrastructure were built, it is unlikely than any Heathrow staff who do not live adjacent to key rail corridors to the Estuary airport would find the commute feasible without access to a car. Even for car commuting, existing travel times by road using the M25 and A2 from the vicinity of Heathrow to the Isle of Grain are around 1 hour and 45 minutes, which is unlikely to be considered acceptable on a time or fuel cost perspective for most workers. To achieve car commuting travelling times of less than one hour to the Estuary airport site (given current peak traffic conditions), an employee would have to live in middle to outer east and south-east London, within easy access of the M25, A2, A20 or A13 (i.e. Bromley, Bexley, Romford, Ilford, Woodford and Chingford). Much of south London except those locations close to the M25 east of Coulsdon, would involve car commutes of longer than an hour, with similar conditions from locations in north London west of Enfield and Walthamstow. It is unlikely that such employees would choose to be employed at the Estuary airport and remain living in their current homes if they had to face such time and commuting cost penalties. It is also unlikely that substitute public transport services could be provided (e.g. by express coach) to offset this, given the diverse employment times for shift workers and wide catchments of employees (making it difficult to service by public transport).

The Mayor's proposal for surface access for the Estuary airport under the Optimal scenario is to provide a range of new public transport links. Of those, the proposed high speed rail connections to St. Pancras and Waterloo stations, with limited stopping services, could reasonably be expected to be priced at premium levels similar to the Heathrow Express and express airport rail links elsewhere, and so would be unaffordable for most employees at the airport site. While a proposed extension of Crossrail from Abbey Wood, and local rail connections to lines in south Essex and north Kent (leading to Fenchurch St and

London Bridge/Charing Cross/Cannon St respectively) would be useful for employees who live near such lines, at present the residential locations of the vast majority of those who work at Heathrow are not conveniently located to stations on such lines. None of the highway proposals would improve car commuting times or allow for express bus commuting times that would be an improvement on travel times today, using existing technology, as the highway proposals primarily focus on access and providing capacity approaching the Isle of Grain.

9.3.2 Issues with Transition

The selection of the Estuary airport option would mark the beginning of a period of workforce transformation that could be expected to last for several years or even decades. The current decision-making phase is believed to have created uncertainty for businesses and staff that is already affecting decisions regarding office locations, property leases, expansion and investment. That uncertainty may only diminish once tangible commitment is made by the government and various construction programmes for the airport and surface access commence.

For employees, the transformation can be expected to increase rapidly towards the date of transition to the Estuary airport. During this time, employees would start to consider whether alternative employment may exist for them in the area post-transition; whether they would seek employment at the new airport; and whether they would commute or relocate to the new airport.

Our interviews with airport businesses suggest that few staff would be prepared to relocate in order to take up employment at the new airport for various reasons including: family ties, community and cultural ties, expense (assuming relocation costs would not be met), availability of housing of the type desired, and location.

In the latter years before transition to the new airport, we can therefore expect some staff to seek alternative jobs, taking advantage of opportunities to move ahead of the unemployment that could result from the closure of the existing airports. This creates a resourcing challenge for airport businesses, which must then recruit and train replacement staff on a non-permanent basis in addition to replacing those staff that retire or leave through natural attrition. The opportunity to migrate at least part of the workforce onto temporary contracts (94% of staff are currently on permanent contracts) may be attractive to employers since it would save redundancy costs, but this would probably be offset by recruitment, training and wage rate costs.

At the Estuary airport, businesses would need to begin the process of developing talent, recruiting and training staff well in advance of the airport construction being completed or facilities opening.

This in itself presents a significant challenge in terms of recruiting large numbers of staff with the required levels of skills and experience which, according to Kent County Council, Medway Council and the local enterprise partnerships in the region, would not be met by the current pool of available labour within the region.

Any business setting up at the new airport, from duty free retailers to aircraft ground handlers, may intend to recruit a sizeable proportion of its workforce either from its own current employees at Heathrow or from those employed by another business at Heathrow. It appears to be unrealistic to assume that they could build an entirely new workforce without operational experience gained at an airport of similar size.

Businesses might meet this challenge by recruiting staff for the Estuary airport from the local catchment area and training them at Heathrow, if the business already operates there. This would require those staff to travel to Heathrow for a period of time instead of travelling to their future place of work, the Estuary airport. It may take weeks or months for staff to gain sufficient operational experience. It would also require some cooperation on the part of Heathrow which would be needed to provide access to the airport. These employees, even if recruited more locally to the Estuary airport, would require housing within a reasonable commuting distance.

Alternatively, businesses might choose to bring across experienced staff from Heathrow to the Estuary airport, to whom it might be necessary to provide an incentive or to pay relocation costs. Businesses expressed in the Attitude Survey that relocation costs for their staff would place an unaffordable burden on them. These staff would require a pre-operational period of familiarisation at the new airport, leaving the Heathrow operation understaffed or requiring the companies to employ more staff to back-fill.

The pre-operational phase would require the majority, if not all, staff to gain familiarisation in the new airport and a comprehensive set of trials of equipment and processes can be envisaged, as for the recent opening of Heathrow Terminal 2. Airports have large numbers of fixed staff, i.e. staff that are required regardless of the number of passengers handled. This means that during the transition period, to a large extent, a dual operation would be required.

Running a dual operation inevitably results in significant cost and inefficiency. However, added to this could be the complexity of developing a substantial workforce at Heathrow that would ultimately migrate across to the Estuary airport. The locations of the two airports and their workforce catchment areas would mean total commutes of between 3 and 4 hours per day for many staff during this period of workforce development, with the cost of time and travel potentially falling to the new airport businesses, and reducing the pool of available workers to those who may consider the travel requirements.

The distance between the airports, or more importantly the time and cost to travel between them, creates perhaps the greatest challenge. It would inevitably be seen by a significant proportion of staff as a barrier to them taking up employment at the new airport. For others, it would introduce significant cost, time and journey time risk that may make commuting unsustainable. Long and expensive commuting times are much less compatible with part-time working, while shift-workers need to be able to access transport at times of the day when services may be infrequent or not operating, or when road congestion is particularly severe (e.g. the Highways Agency reports that the probability of congestion on at least one segment of the M25 during peak periods is 90% between Junctions 10 and 15, and 50-80% between Junctions 5 and 10)[3].

At the same time, it may not be practicable to relocate large numbers of people to areas within reasonable commuting distance of the Estuary airport. Evidence submitted by Kent County Council and Medway Council suggests that there are not enough housing sites to meet the baseline forecast demand, without the additional housing demand that airport workers would pose. In addition, recent house building activity peaked at 2,454 houses completed in 2008/9, which is less than half the number that would need to be completed per annum to meet the additional demand. House-builders would be unlikely to complete developments of houses, schools, medical facilities and other services in advance of the demand arriving, since it would be financially unviable to do so and carry risk, so would likely need guarantees of public funding of social infrastructure and would seek finance to support development of housing. Kent County Council and Medway Council suggest that housing development would therefore lag behind demand, resulting in a long period during which airport employees would have to commute long distances, and the significant demand for housing near the Estuary airport would be expected to fuel house price escalation. It is possible that given the lead time for the Estuary airport, central government intervention to liberalise planning regulations and to release brownfield (and more controversially greenbelt) land for housing development could help ease constraints on market led development of housing to minimise pressure on prices and supply, but this is likely to be controversial with local authorities and existing communities. A pro-active approach to develop the vicinity and promote it may

3 London Orbital and M23 to Gatwick Route Strategy Evidence Report Technical Annex, Highways Agency, April 2014, p31.

be needed, which would impose further costs and risk challenges from residents and businesses that may be negatively affected.

Meanwhile, house prices in the Heathrow area may not perform well in the absence of the airport. This is likely to be dependent on how development of the brownfield Heathrow site is managed, and how this affects perceptions of living and working in the area. Until there is some certainty of private and public investment in the site, it could hinder property values in the vicinity, making it difficult for staff that own homes convenient for commutes to Heathrow to sell and relocate for a more convenient commute to the Estuary airport, presenting a further cost and recruitment challenge to airport businesses. However, the anticipated reduction in aircraft noise around Heathrow could result in an upward pressure on house prices, adding to the uncertainty for homeowners who need to move house, for example, to work at the Estuary airport.

9.3.3 Summary

The Estuary airport will need a substantial workforce and there may be a period during which a full or near-full complement of staff would be required at both airports. Taking the staff costs for Heathrow Airport Limited alone, this could mean between £190m-£200m annualised additional costs[4]. Given staff costs for contractors, airlines and other service providers at the airport, this could be as much as double this over the period of transition and would be likely to attract calls for compensation.

Airport businesses anticipate a lack of willingness among staff to transfer to the new airport, in view of the costs and disruption of relocating or commuting. The lack of housing stock, the difficulty in finding sites for and constructing housing within the time period, and the potential for housing around Heathrow to lose attractiveness, means that there could be a significant shortfall in housing within reasonable commuting distances of the Estuary airport. This would force airport workers to commute for longer or seek alternative employment nearer home, potentially exacerbating resourcing difficulties for new airport businesses. The transition period from Heathrow to the Estuary airport would entail significant time, cost and inconvenience for staff while they commute to Heathrow for operational training and/or to the Estuary airport for operational testing and familiarisation. Overall, the transition of airport operations from Heathrow to the Estuary airport would entail a number of practical challenges that would result in a significant cost burden for airport businesses that may ultimately be passed through to passengers as well as considerable risk to delivery.

9.4 INTERNATIONAL EXAMPLES OF TRANSITION

9.4.1 Overnight Transfer

There is an inherent attraction and simplicity to transferring all operations, so that on a predetermined day flights arrive at the Estuary airport instead of Heathrow and potentially London City and Southend airports, and that all staff and aircraft based at the previous airports are relocated so that services can commence. In all of the more recent cases of new airports being opened to close older ones, the transitions happened entirely or predominantly overnight. Hong Kong, Munich, Oslo, Denver and Athens all transferred either entirely overnight or within a few days. While some of them experiences some teething issues with systems that did not work as expected (e.g. Hong Kong had baggage handling difficulties for several weeks), these were largely considered to have been weaknesses in the testing and

4 Source: Heathrow Airport operating costs spreadsheet for final proposals, October 2013, CAA.

commissioning of the new airport, rather than a factor of transition. These issues can happen with the opening of any new facility, let alone one that takes over the activities of a previous one.

However, in all cases the scale of operations being transferred was a fraction of that which would be involved if an Estuary airport was to replace Heathrow, London City and Southend airports, and over a shorter distance as seen in the table below.

Table 5: Comparison of transfer distances for international examples

Location	Distance between old and new airport sites by road	Passenger numbers at time of transfer (millions)
Hong Kong	22 miles	28.6
Munich	17 miles	12.0
Denver	28 miles	31
Athens	16 miles	11.8
Oslo	35 miles	14.2
Heathrow – Isle of Grain	70 miles (M25)	81-82*
London City Airport – Isle of Grain	33 miles	6-7*

*Source: Airports Commission Interim Report

The largest example, Hong Kong, was a transfer of fewer than 40% of the number of ATMs that are seen today at Heathrow, London City and Southend airports, and involved transferring from a single airport with one runway, rather than three airports with four runways.

This would suggest that the single riskiest option in transition would be to have a full overnight transfer of operations, given the sheer scale of operations and the difficulty in replicating the stress testing of new systems and infrastructure on that scale in advance of such a transfer.

9.4.2 Staged Transfer

Whilst Heathrow T2's transition, staged over several months, may be seen as an example of a low risk way of facilitating a transfer, it is a very different proposition and scale compared to building a new airport approximately 70 miles away. Interline connections between T2 and existing terminals are relatively easy, as the other terminals used by Star Alliance airlines are walking distance from T2. The facilitation of interlining between Heathrow and the Estuary airport would be impracticable (in terms of keeping passengers and baggage effectively security cleared and "airside") and would involve likely transfer times in the order of 3.5 hours, including immigration clearance for interlining between third countries. Realistically, few passengers (especially premium passengers) would be willing to do this given the inconvenience and alternative hub options, so any transition would need to be short and minimise the number of passengers presented with this option. Undertaking a transition during a time of year with the lowest numbers of flights and passengers, would be a desirable option, although such periods are very short in duration for Heathrow (i.e. between Christmas and New Year).

A staged transition would be designed to avoid the risk of systems failing at the Estuary airport with a high number of flights and passengers in the early stages of opening. However, many airlines at Heathrow may perceive any transition that undermines the hub status of its operations to be a cost upon their business, so questions of compensation of some form (e.g. discounted charges) may arise.

Sequencing relocation by airlines raises a number of complex issues:

- British Airways is an 'anchor tenant' critical to making the Estuary airport work as a fully effective hub, but its operations alone are larger than the total operations of any airport relocated previously. Given the history of Heathrow Terminal 5, BA may be supportive of a two or three stage transition of services from Heathrow to the Estuary airport. BA could be asked to select the combinations of services transferred that are optimal for it. It may be that only some services on

some routes are relocated, but others are not, although BA would be keen for this to be a very short term measure to avoid customer confusion.

- Lengthy transition scenarios with flights split between airports would ideally be avoided and so any transition should be as short as is practicable, but long enough to optimise management of risk. While the transition at Heathrow T2 demonstrates one way of doing it, it may be seen as excessively conservative (two weeks of initial operation at 10% of flights that will be transitioned), and the remaining flights are immediately adjacent in the same airport albeit not the same terminal.
- The transition period may involve considerable duplication of costs in running two airports, although airlines would still be expecting to pay only for the airports they use. The progressive decline in operations at Heathrow would see airport revenues decline to a point whereby the intensity of operations is too low to sustainably operate the airport financially. Conversely, notwithstanding the high cost of capital involved in building the Estuary airport, it is also unlikely to run at an operating surplus until a threshold of operating intensity is reached. The size of these additional costs (which if the transition takes as long as six months, could run into hundreds of millions of pounds) and who bears them is likely to be controversial, as airlines may be unwilling to accept the costs for a relocation that was imposed upon them.
- Maintaining split operations at two airports would be expected to create some confusion among airline customers and staff, imposing some adjustment costs in the short term. This may be particularly onerous if a major airline (e.g. BA) has similar pools of staff having to serve both airports for several months (this is unlike the existing Heathrow and Gatwick operations which have dedicated staff for each airport, and dedicated fleets). While staff could be bussed en masse from one site to the other for an interim period, this would not be sustainable given the long travel times between the sites.

Airlines that are primarily point-to-point operators and foreign airlines that use Heathrow to feed their major hubs may be encouraged to move early to the Estuary airport. Plans would need to be discussed with airlines to establish the commercial interest in staging such a transition and the relative interests in moving early against moving late. Whatever measures are taken would need to be competitively neutral, so that no airline is seen as gaining an unfair advantage. Establishment of a proposed sequencing timetable with maximum flights per sequence for transition, with airlines incentivised to be initial operators could be a way of letting airlines themselves choose to be early or late movers. There may be a need to provide a temporary express coach service to connect the Estuary airport to Heathrow to facilitate interliners, although this may not be satisfactory as anything more than an interim solution (as can be seen by the very low proportion of transfers between Heathrow and Gatwick flights).

9.5 OTHER ISSUES

Two further issues arose during the analysis of the above issues, as discussed below.

Comparison with Brandenburg Airport, Berlin: Commercial agreements with airports, airlines and other entities would ideally contain provision for the risk that the Estuary airport does not open on time, requiring Heathrow to remain open for a longer period. This may cause additional costs and so the commercial negotiation strategies would need to minimise the consequences and liabilities. The most recent experience, Berlin's airport relocation (which is on a considerably smaller scale), highlights the need to ensure that the project management of the Estuary airport be robust with appropriate risk transfer to the private sector. Berlin's new Brandenburg Airport was originally planned to be opened in 2011, replacing Tegel and Schönefeld Airports, but has been subject to considerable delays for various reason including bankruptcy of one of the contractors and construction flaws including failings with the fire safety systems and wiring.

Brandenburg Airport, built adjacent to the site of the existing Schönefeld Airport, is to be a two runway airport with the capacity of 27 million passengers per annum. Currently, after two previous failed

attempts to provide certainty over opening dates, forecasts for an opening date for Brandenburg Airport are for 2016 at the earliest. Although the issues with the Berlin project provide an opportunity to learn and avoid replication elsewhere, the scale of the Estuary airport concept, with a capacity of more than 100 million passengers, inherently carries greater risks.

Significant delays in the Estuary airport's commissioning could impose heavy burdens upon staff if they have planned to move homes or have already done so in anticipation of changed commuting patterns. This could raise difficulties if staff face high commuting costs (and time penalties) to continue working at Heathrow whilst having relocated families towards the Estuary airport, and could lead to commercial and political pressure to compensate businesses and staff accordingly. Such delays may also place pressure on the reliability of Heathrow, London City and Southend airports with outdated equipment, and may have a negative impact on airline investments and plans for operating at the Estuary airport.

Airspace redesign: Having the Estuary airport open, even at a small proportion of full commercial operations, may present challenges if any flight operations are to remain at Southend, London City and Heathrow airports. If it is envisaged that both the Estuary airport and Heathrow remained open in parallel for an initial period as flights are transferred, this would have implications for the redesign of London airspace. Although new technology (e.g. through the SESAR programme) may make this easier, a considerable lead time may be needed for NATS and CAA to develop this programme and there may be noise implications for some parts of London. This issue would also need consultation with Eurocontrol partners as it could have implications for airspace usage for the Netherlands in particular.

9.6 CONCLUSION

While there are several examples worldwide of major city airports being transitioned from one airport to a new one, a transition from Heathrow (and potentially London City and Southend Airports) to an Estuary airport at the Isle of Grain would be larger and over a further distance than any others completed to date. The relocation would involve more than double the air traffic movements and 2.3 times the passengers relocated in the largest example to date – Hong Kong. It would also be a geographic relocation double the distance by road (70 miles) of the next longest relocation, Oslo. Given this scale of transition, the risks of relocating in one step, as has happened with other airports, are likely to be such that a staged transition would be more manageable and have a greater chance of success. However, the difference in location and distance from passenger catchments and existing employees, as well as the continued operation of two major airports (Gatwick and Stansted) in the vicinity of the closing and opening airports, means that such a transition is likely to be more challenging and may involve significant costs.

As the opening of an Estuary airport on the Isle of Grain requires the closure of Heathrow and potentially London City and Southend Airports, commercial agreements will be needed with Heathrow Airport Limited, London City Airport and London Southend Airport Company Limited around compensation for closure and possibly acquisition of the airports in advance. These negotiations will be complex, as airport companies will be well aware that negotiations with governments seeking to implement major projects have different dynamics to those of private investors that are strictly commercial. In order to avoid misjudgements in negotiations, there will need to be considerable professional fees expended on legal and commercial strategic advice to protect the interests of taxpayers. Heathrow, City and Southend Airports will all have to remain open for some years whilst the Estuary airport is developed, but during that period some capital equipment and systems are likely to become obsolete and not be economically viable to replace given the imminent closure of those airports. In order to not compromise the reliability and quality of service of the airports, provision will need to be made to maintain high standards of performance. This will increase operating and maintenance costs at the airport, which if passed on in airport charges is likely to be controversial with airlines as it would undermine their competitiveness compared to routes serving other airports.

The primary concerns of airlines will be airport charges (both at the Estuary airport and existing ones in the interim) and the details around timing and sequencing of the transition, as well as involvement in Estuary airport design and the availability of slots to operate commercially viable services.

There is no straightforward mechanism to transfer slots held by airlines at one airport to another airport. Given the purpose of the Estuary airport is to build capacity that relieves the congestion seen at Heathrow and the shortage of slots, it may be that airlines will have to seek access at the Estuary airport on a conventional "first come first served" basis.

It is likely that given longer relative surface access travel times to the Isle of Grain compared to Heathrow and London City Airport, and higher airport charges, some airlines would decide that the Estuary airport would be less attractive than maintaining operations at (or relocating to) existing airports. The Attitudes survey of key stakeholders indicates that some airlines are particularly concerned that the Estuary airport would have even higher charges than Heathrow (already the highest in the world) and a passenger catchment area that is inferior to Heathrow. This may mean that if Heathrow were closed, not all services would be relocated to the Estuary airport, but rather some may relocate to other airports (i.e. Gatwick and Stansted) or some routes may no longer be viable because of airport charges and competition with airlines from other London airports, undermining the hub concept.

The scale of the relocation (and past experience in opening Terminal 5) is likely to mean an overnight relocation will be seen as too risky, some sort of sequenced transition will be needed to transfer flights from existing airports to the new one over a period which may range from days to months. Careful negotiations will be needed with airlines at Heathrow to agree a sequenced transition that is commercially acceptable to them and operationally sensible. Given that it will be neither technically viable nor attractive for passengers to interline between the new airport and Heathrow, due to the distances involved, the hub concept would be considerably weakened during the transition period. In addition, with both airports open, there will be greater costs in having staff at both locations providing duplicate services. Many airlines are likely to be resistant towards paying for those costs at a time when they are expected to relocate staff and to not have the ability to interline with all flights. Airlines may expect compensation during such a period, because of lost revenue.

The relocation of the workforce serving Heathrow to the Isle of Grain would be a major exercise, particular because it would not be feasible for most existing workers to simply change their commutes to the Estuary airport given the likely travel time penalty involved. This would not be addressed by the new surface access infrastructure, as most existing workers do not live at the locations such infrastructure would serve. That would mean such workers would either face a long car based commute or to have to move homes, or they would face losing their jobs. As such, the Estuary airport would place significant pressure in terms of housing and related infrastructure in areas convenient for commuting to the Estuary airport. This would require a considerable taxpayer commitment for public infrastructure at least, if not also assistance to catalyse the development of housing in advance of the opening of the Estuary airport.

Transitioning Heathrow, as a major hub airport (potentially along with two smaller airports) across such a distance to a relatively remote and undeveloped location would be the largest project of its kind. The challenges are considerable, and if further consideration is to be given to the option, more detailed work should be undertaken to calculate the risk/cost profile of those challenges under different scenarios.

10. ATTITUDES TO MOVING TO A NEW HUB AIRPORT

10.1 INTRODUCTION

This chapter reports the findings of a survey conducted to explore in greater depth the attitudes that various stakeholder groups hold towards the concept of an inner Thames Estuary airport. The aim is to understand for each group – airlines, airport users, and affected airports – the various impacts, opportunities and risks that the Estuary scheme would create and their attitudes towards them.

A variety of data collection approaches were considered, including workshops, face to face interviews, online surveys, and telephone surveys. Keeping in mind the aims of the study, to explore the issues in greater depth, telephone interviews were selected as the principal approach, supplemented by some email communication and written responses to the Airports Commission's Call for Evidence which was open for responses in May 2014.

The telephone interview approach, whilst limiting the number of respondents that could be involved, enabled the unique perspectives of interviewees to be discussed, explored, challenged and measured to a far greater degree than a workshop setting or written or online survey would allow. It also enabled us to obtain senior level engagement from all involved stakeholders, able to represent the views of their organisations and discuss their strategies from an informed perspective.

During late May and early June, some 25 telephone interviews were conducted with international airlines (including full service carriers and low cost carriers), London airports, airport businesses, the cargo business community, Chambers of Commerce, Local Enterprise Partnerships, and businesses themselves. We looked to airlines to represent the views of the passengers they serve, supplemented by interviews with tourism agencies, while businesses were able to discuss their attitudes both as passengers and as enterprises serving or catalysed by proximity to a hub airport.

The structure of this chapter addresses the following stakeholder groupings in turn:

- Airlines (Section 10.3)
- Businesses (Section 10.4)
- Passengers (Section 10.5)
- Airports (Section 10.6)

Unless otherwise stated or marked in square brackets, all comments and statements in this report were made by interviewees. The following sections (10.3 to 10.6) therefore present summaries of the discussions with interviewees with our analysis and interpretation of the interview data generally confined to the Conclusions section (Section 10.7).

10.2 BASELINE ASSUMPTIONS FOR THE SURVEY

Each of the inner Thames Estuary scheme promoters has put forward their plans for the precise location of the airport and the surface access infrastructure that would be provided. In the absence of precise details on these and other key aspects of the schemes, we looked to establish only a minimal set of baseline assumptions for the Estuary schemes. We stated a general location for the airport in an inner Thames Estuary location, and rather than stating the surface upgrades that would take place, we sought to understand how factors such as surface access would impact on stakeholders' decision-making as an airport user or operator.

The key assumptions stated to interviewees were that the Estuary airport would be capable of operating 24 hours per day, that it was the Commission's view that it would be necessary for Heathrow to close for

commercial reasons and likely that London City and Southend airports would need to close because of airspace constraints.

Interviewees were informed that this report would quote and discuss comments received, but that comments would not be attributed to named organisations without permission. This does not affect the Airports Commission's potential obligations under the Freedom of Information Act and therefore respondents were asked to highlight where they consider information to commercially sensitive.

10.3 AIRLINES

A range of UK airlines took part in the survey, including large hub network carriers, European and transatlantic carriers and low cost airlines. The mixture of airlines included some that do not operate at Heathrow.

10.3.1 Key Issues

The key issues raised by airlines and explored in detail during interviews concerned:

- Airport charges;
- Location and surface access;
- Market impacts;
- Staff access and relocation;
- Deliverability;
- Transition
- Financing;
- Night flights; and
- Opportunities.

10.3.2 Airport Charges

Airlines interviewed universally highlighted airport charges as one of the most important issues in relation to the Estuary airport. Heathrow is already considered to have very high charges, among the highest in the world, and any attempt to impose higher charges at the Estuary airport would be met with fierce resistance.

On this point, airlines typically spoke with consideration of the threat posed by competing hubs at Amsterdam Schiphol, Paris Charles de Gaulle and, to a lesser extent, airports in the Middle East. Airlines recognise that these competing hubs are already gaining ground over Heathrow, but the view as to whether this is a recoverable position is mixed: some feel that London has sufficient demand itself that the Estuary airport could establish itself to compete with the alternatives; others feel that the competitive position may be being eroded irretrievably.

One airline felt strongly opposed to charges increasing as part of a forced closure of Heathrow and relocation to the Estuary airport, thereby offering airlines no choice.

Two major network carriers and one regional carrier raised significant concern about the effect that increased charges would have on short haul traffic: the Estuary airport will need to have charges that attract short haul routes since these are critical to feed long haul routes. They observed that without a high performing short haul network, long haul routes would cease to become economically viable and the hub airport concept could fail.

Some airlines took a pragmatic view towards charges, recognising that they pay a wide range of charges at the variety of airports from which they operate. For these airlines, the ability to establish a route was

stated in terms of economics and profitability: if there is a value proposition to operate and there is customer demand at the right price, then the airline may be willing to pay higher charges. Others were concerned that any increase would cause marginal routes to fall into unprofitability and therefore be cut.

A nationwide survey by ComRes, carried out on behalf of Medway Council in April 2014, explored the views of 2,034 members of the British public towards topics relevant to the Isle of Grain scheme. Approximately half of respondents believed that no additional cost to flights would be acceptable as a result of increased airport capacity; marginally more respondents were willing to accept an increase at an Estuary airport than they would be for an expanded Heathrow or Gatwick.

10.3.3 Location and Surface Access

The location of the Estuary airport is considered by airlines to be one of the most significant barriers to its success, which is directly linked to the attractiveness of the airport to passengers and ultimately its viability as a hub.

Airlines consider ease of access for passengers and staff to be a prerequisite for a successful hub airport. Their concerns are that the main customer base is located to the west of London, as is the majority of the workforce.

The location of the Estuary airport presents both a price and convenience challenge for airport users and workers. One airline characterised its passengers in relation to surface access as 'time sensitive' or 'price sensitive'. It asserted that the Estuary airport suits neither group, since price sensitive passengers will find travelling to the Estuary airport prohibitively expensive and time sensitive passengers will find it time-consuming and potentially complex, e.g. requiring changes of transport mode or service.

According to the ComRes survey, 43% of respondents believed that it would not be acceptable to pay additional surface transport costs to access the Estuary airport. However, slightly more respondents were more willing to pay extra to access the Estuary airport than to access an expanded Heathrow or Gatwick airport. The survey also found that 77% of respondents considered that the journey time from Central London to the Estuary airport should be one hour or less.

Passengers travelling on short haul routes and/or for short periods of time (e.g. day trips) would be most affected since the additional surface access journey time and cost would become prohibitive. Several airlines suggested that the remaining London airports might benefit from increased demand for short haul routes. Gatwick was singled out as becoming the best located short haul airport once Heathrow closes. The impact of this is that airlines might struggle to make their Estuary-based short haul routes profitable. Airlines stated their aspiration for their short haul routes to support themselves without requiring subsidy from the long haul business. Long haul routes are dependent upon the feeder traffic brought in by short haul routes; therefore, any underperformance of the short haul business will begin to erode the viability of the hub operation.

An airline serving London City Airport observed that the airport is located some 22 minutes from the City by DLR within a hotspot for the financial services sector; moving services to the Estuary would introduce time inefficiency for businesses.

10.3.4 Market Impacts

Airlines outlined some behaviours and likely market impacts that serve to question the view that the hub operation at the Estuary would broadly correspond to that at Heathrow. Building upon the idea that short haul trips may not be as practicable for passengers travelling from the Estuary airport as they are at Heathrow, airlines suggested that passengers may opt for the convenience of Gatwick, Luton or Stansted. Passengers located further west towards Birmingham or Bristol currently have an acceptable journey time to Heathrow but may find the additional distance and travel time to the Estuary airport unacceptable. Airlines believe these passengers may choose to fly from Birmingham or Bristol airports instead. One non-UK based hub carrier suggested that it might take the opportunity to strengthen these

regional airport routes to feed its European hub operation. A UK based low cost carrier also saw this as an opportunity to serve west of London demand from its existing bases. This would have the effect of weakening the economic viability of the Estuary airport and undermining its proposition, while allowing some leakage of traffic towards European hubs via regional UK airports.

Airlines serving Southend Airport could not envisage services transferring to the Estuary given the likely significant disparity in airport charges and the nature of the low cost leisure markets served by Southend Airport. An airline serving London City Airport believed that the convenience and time-savings that its current operation offers to its customers would be eroded by a relocation to a more remote airport; as a result it ability to remain competitive in the London market could be damaged unless it found an alternative, more convenient London airport.

The loss of up to three airports and the creation of one is considered by more than one airline to result in a loss of contestability. Even if some differentiation of services were offered at the Estuary airport (e.g. a low cost terminal), there would be a reduction in choice for airlines and passengers which could be damaging to fares and levels of service.

10.3.5 Staff Access and Relocation

Several airlines expressed concern about access to an Estuary airport for their staff. Fundamentally, airlines doubt that surface access will be adequate for their staff to get to the airport, particularly given the nature of the shifts and start times (e.g. 3am shift starts). They considered it unlikely that public transport systems would operate with adequate frequency and acceptable journey times during off-peak periods and night times, and expressed concern about the likely fares.

When asked about staff relocation, airlines operating at Heathrow reported that the majority of their staff live locally to the airport and that many would be unwilling or unable to move towards the Estuary airport. One airline considered that the age profile of its staff is such that some staff would be more likely to retire rather than move. Those that employ part time staff considered relocation particularly problematic.

One airline expressed concern that its suppliers may not be able to relocate.

10.3.6 Deliverability

Airlines raised doubts as to the deliverability of the infrastructure entailed by the Estuary airport, given its scale and complexity. They consider it essential that infrastructure, including surface access, should be in place for opening day.

10.3.7 Transition

Given the lack of credibility airlines place in the Estuary airport scheme, none had considered transition plans with any level of maturity. One airline could not envisage how such a transition could work, given its scale, and considered it to be a large business risk. A carrier with a comparatively small operation at Heathrow was concerned by the huge costs of physically moving equipment and teams to a new site, as well as the prospect of relocating its London offices, which are currently on long leases and specifically located for access to Heathrow.

No airlines interviewed committed to transitioning their business from Heathrow. Some reaffirmed that Heathrow would have to close in order for airlines to move across. Some stated that they would not move unless their alliance partners also moved. Several airlines reflected that they would need to consider the value proposition and consider the economics of their routes and networks given the size and nature of the catchment at the Estuary airport and the scale of the charges before committing to a move.

10.3.8 Financing

Airlines have concerns over the scale of the investment required for an Estuary airport and how it will be funded. In particular, airlines operating at Heathrow are opposed to the idea of a component of the charges paid at Heathrow, for example during the period 2020-2030, being used to pay in advance for the Estuary airport. The Regulatory Asset Base (RAB) approach to price regulation allows the cost of future capital investment to be reflected in charging caps, and so it could be expected that expansion at either Heathrow or Gatwick would be pre-financed to a degree through airport charges. However, the CAA does have the flexibility to apply alternative economic regulatory mechanisms. Nevertheless, the much greater scale of investment, coupled with the uncertainty around the degree to which any airline feels committed to the idea of operating at the Estuary airport, means that airlines would raise strong objections to this arrangement.

Airlines not operating at Heathrow raised concerns about the scale of Government money that would be required for surface access or other investments into the Estuary scheme. In particular they would strongly object to Air Passenger Duty increases or other means of raising revenue from passengers flying from airports other than the Estuary airport. They also believed that the scale of investment at the Estuary airport would prevent investments being made at other airports, for example to improve surface access to Stansted.

10.3.9 Night Flights

Night flights were broadly considered to offer little or no advantage to airlines, though any existing night flight slots were considered valuable to retain. The view held by airlines is that passengers do not want to depart or arrive in the middle of the night. Whereas airports in the Middle East are geared towards, and geographically located for, exploiting demand for night time hub operations, 24 hour operations in London or at other European hubs would not suit the vast majority of passengers. Heathrow Airport's submitted evidence presents an analysis of night flights at seven major hub airports (Amsterdam, Paris, Dubai, Frankfurt, Istanbul, Madrid, and Heathrow) of which only Dubai and Istanbul have any significant 24 hour activity. Time constraints at the other end of the route, and in some cases air traffic control restrictions over national airspace, restrict the times that flights can practically operate. However, early morning arrivals were considered to be particularly advantageous.

Those airlines that carry belly-hold freight were undecided as to the benefits that 24 hour operations would bring. They recognised the benefits for their cargo customers but would need to reconcile that against passenger demand.

10.3.10 Opportunities

Airlines saw considerably more risks than opportunities and several stated their view that an Estuary airport provides no opportunities beyond those afforded by a third runway at Heathrow.

In the absence of a strong catchment area and customers demanding the Estuary airport, and with the scale of government investment likely to be required, the scheme was not considered a strong option worthy of much further consideration.

One airline not currently serving Heathrow saw the potential opportunity to capture demand at Gatwick, Luton and Stansted from passengers not wishing to travel the additional distance to the Estuary airport. Another could see a potential opportunity to exploit any capacity that might be freed up at Gatwick if traffic were to move from there to the Estuary airport. A non-UK airline with a European hub saw a potential opportunity in strengthening routes from Birmingham; [it is believed that these would serve the airline's mainland Europe hub rather than offering point-to-point capacity].

On balance the risk of moving from a well located airport to a remote one with low passenger appeal, was seen by one airline to outweigh any potential benefits of capturing demand from a new catchment area.

10.4 BUSINESSES

The focus of our data collection from airport users was on businesses, local enterprise partnerships (LEPs) and chambers of commerce. The latter two groups were able to speak on behalf of their members and discuss a broad range of issues applicable to different types of businesses. We also consulted businesses operating on the airport and umbrella organisations representing the cargo industry. The viewpoints from all groups have been synthesised in the following sections.

The key issues raised by businesses and explored in detail during interviews concerned:

- Uncertainty;
- Cost;
- Relocation;
- Surface access and location;
- Land and property values; and
- Opportunities.

10.4.1 Uncertainty

A theme common to all interviews with businesses and business representatives was a sense of uncertainty that has been created already as a result of the lack of a decision on the location of the UK's hub airport, and the impact that this has on businesses' strategies and investments.

Several business representatives reported being aware of companies that are already delaying decisions concerning investments and office locations in anticipation of the government's decision. However, companies reported to us that the period of uncertainty does not end when the Airports Commission presents its findings, nor when the government of the day announces its decision. Rather, a new period of hiatus is created, characterised by delayed investment decisions, economic decline in areas affected by Heathrow's future closure, and a lack of confidence in the local market that will lead to reduced investment and an early impact upon jobs.

Businesses in the Kent area felt that a decision in favour of the Estuary scheme would give them a foundation upon which to build long term plans and to adapt their business strategies to incorporate the benefits and opportunities that proximity to the UK's hub airport would bring.

10.4.2 Cost

Whilst airlines anticipate the costs of the Estuary airport translating into high user charges, businesses are concerned that the scale of government investment required to deliver the scheme will translate into a tax burden for businesses. Several businesses expressed concern at the potential for cross subsidy that might be imposed through business rates or other taxes that might not be apportioned fairly to those that benefit from the new infrastructure.

10.4.3 Relocation

It is clear from the interviews that businesses' strategies in relation to the Estuary airport are not sufficiently mature to build a confident picture of those businesses that would relocate and when. This is supported by surveys conducted on behalf of Local Enterprise Partnerships in the Thames Valley and Buckinghamshire regions (Regeneris Consulting, 2013) and a survey by Optimal Economics in 2011. However, a survey led by SEGRO in 2013 consulted more than 70 businesses specifically based in and around Heathrow. The survey found that 50% of firms (which together employ around 9,000 people) would relocate to another hub airport if Heathrow was no longer the UK's hub, and a further 26% were unsure. The likely behaviours of various businesses can be illustrated by the following scenarios which are not intended to be exhaustive:

Businesses that will not relocate

Some businesses are firmly rooted in a particular location for historical reasons, the locations of their staff, and because the principal client and supplier base is relatively immobile. One such business we interviewed could foresee its international client base diminishing with the loss of convenient access to Heathrow. Similarly it could envisage momentum gathering for the cluster of high tech businesses it serves to relocate elsewhere, thereby losing a further core client sector.

Businesses that will 'wait and see'

Where proximity to a hub airport is just one factor among a number of significant factors such as proximity to customers, suppliers and a particular workforce, some businesses anticipate a 'wait and see' approach. Business representative organisations predict a large proportion of businesses falling within this category as the agglomeration and organic growth of businesses within easy reach of Heathrow presents a risk and challenge to relocation.

Businesses that will relocate

Some businesses are highly dependent on either the business that Heathrow airport provides or the connectivity that it offers. These businesses can be expected to relocate at around the same time as the airport transition or even in advance. Suppliers to the airport would require office or warehousing near the Estuary airport, but multinationals and large corporations might move to Central or East London in anticipation of good surface transport connections to the Estuary. One Small and Medium Enterprise (SME) we spoke to suggested that its High Tech business clients would be likely to remain in the UK rather than relocating to mainland Europe, given other benefits of being in the UK (skills, language etc.). However, those businesses may move as a cluster elsewhere in the UK after the Estuary airport becomes established.

Freight forwarding businesses typically locate themselves near to the hub airport so that they can consolidate cargo shipments as late as possible before aircraft departure. These companies must therefore relocate to survive. Some consolidation of smaller companies was envisaged, but the medium and larger freight forwarders would move. The cargo industry has grown organically around Heathrow for the past fifty years and the existing workforce is considered entrenched in the west London area. Cargo companies consider the availability of a workforce around the Estuary airport to be a major risk to business.

Businesses that will relocate overseas

A large number of multinational companies have located their offices in the Thames Valley, M4 and Heathrow area as well as along the major road networks serving West London. While many of these can be expected to remain in their present location (particularly if they own their own property) or move elsewhere within the UK, others are headquartered overseas and have less influence over their own office strategy. Business enterprise representatives believe that moving the UK's hub airport away from these multinational companies' offices would form a key decision factor among many others (such as property lease expiry, rental values and connectivity) that might prompt relocation overseas. In the period of uncertainty and local investment hiatus following announcement of the airport decision it was felt that businesses might examine the option of relocation and, rather than moving within the UK, may take the step of moving abroad to a region with greater economic certainty, connectivity and lower costs. Further delay in making a decision would give overseas competitor airports and cities the opportunity to strengthen their arguments to attract UK based businesses, with the risk that any businesses that did relocate would be hard to attract back to the UK.

Other scenarios

One business provided a unique perspective on its position as a holder of a substantial concession to supply Heathrow. The closure of the airport would terminate that contract with no guarantee of being successfully awarded the concession at the new Estuary airport. If unsuccessful, a large proportion of its

global business would cease trading, with a consequential impact on the rest of the business as economies of scale would be eroded. If successful in winning the contract at the Estuary airport, the company believes that far less than 5% of its staff would be willing to transfer to the Estuary airport, given shift-working arrangements and where staff currently live, and it would not in any case be economically viable to pay to relocate them. With warehousing on the M25 and suppliers on the inner section of the M4, its operation would become less efficient. Furthermore its start-up costs at the Estuary airport would include a long period during which inexperienced staff would generate much lower revenues (for the airport and for itself) than its present business at Heathrow.

Kent businesses could foresee some relocations on a different scale to those at Heathrow. Some businesses would reposition locally to take advantage of highway routes or to be closer to the Estuary airport, while others might move further away to avoid road congestion.

10.4.4 Surface Access and Location

Surface access is the 'number one' issue, according to a major business representative organisation. The actual location of the airport is considered secondary to the requirement for quick access, and ideally it should not be necessary to travel via Central London.

Several interviewees commented that business travellers benefit from, and to an extent rely upon, being able to travel from home to the airport for the first flight and to arrive at the airport on the last flight and still be able to get home. Their concern is that the additional surface transport distances and the exposure to journey time risk on the M25 means that this would not be viable for passengers living in the Midlands and the South West. Businesses observed that the M25 and major roads in Kent are already highways pinch points that would need substantial infrastructure development.

For businesses located in the Midlands and the South West, the location of the Estuary airport was seen as especially disadvantageous since the regional airports in those areas are not currently connected to London by air. [It could be argued that the additional capacity available at the new hub airport would enable those domestic routes to regional airports to be set up; however, the level of demand may be insufficient to justify the frequencies of services that would be necessary to support efficient hubbing and acceptable end-to-end journey times. Alternatively, it may be that regional airports would develop routes to other European hub airports that have a point-to-point value as well as serving the needs of passengers that plan to transfer onwards.]

10.4.5 Land and Property Values

Our interviewees included businesses that own properties and land around Heathrow and are therefore particularly exposed to changes in property values in the area. One of these businesses was able to provide the perspective of a broad range of commercial tenants, all of which have chosen to locate near the airport and are willing to pay a premium for proximity. The impact of a decision to close Heathrow would mean, for this property owner, an immediate devaluation of its portfolio of assets as tenants begin to renegotiate flexible and short term contracts and the market for business investment in the area is weakened. The full impact on the portfolio value and consequently the value of the company may not take effect until a period of time after the closure of Heathrow but was anticipated to be devastating. It was felt that property values might not recover for a period of 20-30 years, assuming regeneration of the Heathrow area was successful. The Mayor of London's own submission suggests a timescale of 25-30 years. Importantly, by having capital tied up in devalued property, the business we spoke to felt that its ability to invest in acquiring land and building commercial properties on behalf of its clients around the inner Thames Estuary location would be severely limited.

Business representatives raised the question of whether the government would compensate businesses for the loss in value of their property assets resulting from the decision to relocate a viable airport upon which they depend.

10.4.6 Opportunities

With the exception of those located in Kent, businesses saw few, if any, opportunities in the inner Thames Estuary scheme. The scale of the Estuary hub airport was seen by one business representative as attractive, and the [comparatively short term] benefits to the construction sector were also noted. Land around the Estuary airport site may also provide an investment opportunity where there is potential for growth and where customers require facilities.

Kent businesses see the development of an Estuary airport as providing significant opportunities. Some businesses already have strong links with Heathrow and these relationships would migrate to the Estuary airport. Other businesses would relish the opportunities created by a scheme of this magnitude, particularly since historically few large scale investment opportunities have been concentrated in the Kent region.

Several businesses and business representatives commented that the regeneration of East London was not a good enough reason to relocate the UK's hub airport. Similarly they had doubts about the potential for regeneration of the Heathrow site and observed that the transition to the Estuary airport would be a social re-engineering project on a scale never seen before [in the UK].

10.5 PASSENGERS

As the principal end users of airports, passengers are important stakeholders in the assessment of attitudes towards the inner Thames Estuary airport scheme.

Surveys can provide helpful data on passengers' priorities and their attitudes towards price, facilities, surface access, and other attributes that they consider when making travel choices. Passengers make different choices depending on where they are travelling to, for what purpose and for how long, as well where they are domiciled, whether they are frequent flyers and various other factors. Surveys can require large sample sizes to capture data representative of the target population.

ComRes surveyed 2,034 adults in early 2014 on behalf of Medway Council. Of these, only 50% had flown in the past 12 months and 48% were not aware of a Thames Estuary Airport proposal. The ComRes survey formed an important data source while also illustrating the challenge of canvassing opinions from sufficient numbers of people who are well informed about the schemes being considered by the Commission.

Our approach drew upon in depth interviews with airlines representing the views of the passengers they serve, supplemented by interviews with tourism agencies speaking on behalf of visitors to the UK, while businesses were able to discuss their attitudes both as passengers and as enterprises serving or catalysed by proximity to a hub airport.

The key issues from the passenger perspective are:

- Surface access;
- Flight costs; and
- Travel preferences.

10.5.1 Surface Access

Surface access to the Estuary airport is considered by all consulted groups to be a very important part of the end-to-end passenger journey. According to travel agencies, whilst proximity to the airport is not important, both the journey time itself and the reliability of the journey time are very important. For instance, travelling for any distance on the M25 is considered to be unreliable and therefore unattractive for a journey to the airport. Business representatives stated that passengers would prefer not to have to travel via central London. Airlines also discussed the importance of convenient surface access options and their concerns that a journey involving several changes would be unattractive to passengers.

Airlines believe that an Estuary airport location would limit the catchment for passengers willing and able to make short-haul day trips from the airport and return home the same evening. Airlines also distinguished between time sensitive and price sensitive passengers. They believe that the surface access arrangements likely to be in place to serve an Estuary airport would suit neither group.

Tourism agencies cited the need for tourists visiting the UK to have convenient onward travel from the airport to central London and to other destinations. Their tolerance for onward surface access is reported to be 2-3 hours; therefore an Estuary airport would limit the destinations that could be reached within that time. Inbound tourists are considered to be less price sensitive, though surface access costs should be broadly competitive

10.5.2 Cost

As described in Section 10.3.2, airlines are concerned that if airport charges at the Estuary airport were higher than at Heathrow then passengers might be dissuaded from flying from the airport, particularly on short haul trips, for which airport charges form a large proportion of the ticket price. This cost, coupled with the additional surface access cost for those passengers travelling to the Estuary airport from Heathrow's main catchment, may persuade passengers to fly from other airports such as Gatwick, Luton or Stansted.

According to the ComRes survey, 49% of surveyed adults considered that no additional cost would be acceptable if using the Estuary airport, compared with 52% for an expanded Heathrow or Gatwick. Of those who were willing to pay more, only half were willing to pay more than £10 extra for their flights.

10.5.3 Travel Preferences

Businesses and travel agencies described the objective of a seamless end-to-end passenger journey and raised concerns that this may be hard to achieve for an Estuary airport location, given the likely surface access arrangements.

Both airlines and travel agencies felt that 24 hour operations offered limited benefits to passengers who typically prefer not to arrive or depart too early or too late.

Tourism agencies raised the risk that any negative impacts on airport operational efficiency and reliability, particularly during transition phase or if delivery were delayed, could harm the airport's reputation. While inbound tourist traffic is quite resilient, a negative impact may be observed. The example of Berlin was cited, where the delays in opening the new Brandenburg airport have resulted in the existing airports, Tegel and Schönefeld having to handle increased passengers in congested and ageing infrastructure, with an anecdotal impact on reputation.

According to the ComRes survey, support for an Estuary airport reduced when it was suggested that the new airport would be at the expense of existing airports at Heathrow, London City and Southend.

10.6 AIRPORTS

Views on the impacts, opportunities and risks of the Estuary airport scheme were sought from all major airports in the London System.

The key issues raised by airports and explored in detail during interviews concerned:

- Passenger traffic forecasts;
- Asset management;
- Employment and relocation;
- Local economy;
- Financing; and

- Opportunities.

10.6.1 Passenger Traffic Forecasts

Airports believe that the demand for air travel will continue to grow, regardless of the Airports Commission's decision as to where the UK's hub airport should be located. The ability to capture that growth depends both on airports' availability of spare capacity to accommodate growth, especially at peak times, and also on the extent to which airlines react to the blight under which those airports marked for closure will operate.

Other airports believed that their ability to build long term relationships with airlines and encourage short haul or long haul route development would be severely harmed: airlines would be unwilling to invest in relationships with airports destined to close.

One airport highlighted the risk that in the intervening period competitor European hubs might incentivise traffic to move there.

For those airports that would remain open once the Estuary airport becomes established, the concentration of airlines and routes at the Estuary airport was anticipated to have a damaging effect on passenger traffic, with airlines either retrenching at those airports or failing to grow.

10.6.2 Asset Management

If the Commission were to recommend the Estuary airport option, directly affected airports predict that all capital expenditure plans at their airports would be halted and subjected to intense scrutiny. Airports would be looking to maximise the value proposition for their investors and maximise revenues for shareholders.

Other than where an economic case remained, all expansionary capital investment would cease. Similarly, capital expenditure related to maintenance and renewals would be reviewed with a view to 'sweating the asset' and avoiding unnecessary cost.

Various assets would be maintained beyond their normal working life rather than being renewed. The impact of this would be a greater risk of equipment failure with a consequential impact on operational reliability and resilience. Examples cited included escalators and air bridges.

10.6.3 Employment and Resourcing

Airports believe that the latter years before the opening of the Estuary airport will pose a significant challenge to resourcing. With employees facing job insecurity and limited job prospects in the area once the airport closes, one of the affected airports anticipates difficulty attracting and retaining competent staff in operational and management positions. Skilled and knowledgeable staff would, where opportunities for them exist, be attracted away from the airport. The impact from this could be an increase in cost, as the airport has to meet the expense of recruiting and training short term replacement staff as turnover increases. Some degradation in service standards could also be experienced and represents a risk as well as a cost to the business.

All affected airports reported having loyal and long-serving employees for whom the Estuary scheme presents a bleak outlook unless they are willing to relocate. Senior management staff are considered to be quite mobile, but airports believe that the larger part of their workforces would be resistant to relocating towards the Estuary airport. The cost of relocation for the Estuary airport and for employees is considered to be a major barrier, whilst the journey time to commute to the airport is estimated to be significantly higher than the majority of employees' existing commutes. Similar views were held by all airports. The Heathrow Employment Survey, carried out by Ipsos MORI in 2013 on behalf of Heathrow Airport, indicates that 54% of on-airport workers live within the five local boroughs and 75% of workers commute for less than 60 minutes (59% commute for less than 45 minutes).

10.6.4 Local Economy

The impacts on the local economy surfaced only to a small degree during telephone interviews with airports since more comprehensive evidence had been submitted in written form in response to the Commission's Request for Evidence.

Specific examples that were cited included some planned investments into business parks near the airports, and the redevelopment of Old Oak Common and White City (cited in Heathrow's submission), that are to a large degree predicated on good air transport connections. [In this sense, the airports reinforced their role as local economic catalysts.] The planned closure of the airports, even some years hence, would therefore undermine these investments and have a negative impact on the local economy that would be wider than the business parks themselves.

10.6.5 Financing

Airports found cause for concern in the scale of government money that is anticipated to be required to deliver the Estuary airport. Their concerns included the issue of state aid and public subsidy from a view of competition and fairness. However, one airport also had concerns that the Estuary airport would leave government with no appetite to invest in better surface access to other airports. The impact of this was considered even more damaging if the Estuary airport were not ultimately delivered.

10.6.6 Opportunities

The estuary airport scheme itself was not seen to provide any opportunities for directly affected airports. One airport could envisage capturing some unserved low cost traffic following the closure of airspace-conflicted airports. No airports volunteered any information on their intention to operate at the Estuary airport if the scheme were to be selected, though two airports noted that their experience in operating small airports would not readily translate to the new hub.

On behalf of their staff, airports could see potential job opportunities but cited the likely barriers around relocation costs and journey times.

10.7 CONCLUSIONS

The purpose of the Attitudes Survey was to explore the perceptions of airlines, businesses and airports towards the issues, risks and opportunities of the inner Thames Estuary scheme. Telephone interviews enabled the various views held by stakeholders to be explored, challenged and measured. Stakeholders actively engaged in the process and discussed their own businesses' perspectives as well as the wider issues, business trends, market impacts, customer requirements, challenges and opportunities.

With the exception of Kent businesses, all stakeholders considered the Estuary airport scheme to carry significantly more risk than opportunity. The common risks across all stakeholder groups were cost, surface access, and impacts on the market and economy.

Regarding cost, stakeholders were concerned about the scale of investment required to deliver the Estuary airport and how that would manifest itself in airport charges that might deter passengers, damage the economics of certain routes, particularly short haul, and ultimately undermine the success of the UK's hub airport. They were concerned about cross-subsidy from other airports and businesses towards the Estuary scheme, and that the scale of investment required by the scheme would prevent other investments being made, such as to improve surface access to other airports.

Surface access and the location of the Estuary airport were highlighted as significant concerns, in part because of the smaller and untested catchment area of the proposed location, but importantly because of the impact on passengers and businesses located to the west of London. The additional journey time required for these passengers was believed to make the airport unattractive, particularly for short haul travel and day return trips. If short haul routes were unable to attract sufficient passengers, then this may undermine the viability of the long haul routes they feed and therefore the hub airport in totality.

The location of the Estuary airport would force certain businesses and their staff to relocate. The distances involved, the commuting times by road or by public transport, and the likely infrequency of public transport services to suit shift-workers, are believed to be a considerable barrier to the relocation of staff from Heathrow to the Estuary airport. The additional time and inconvenience of commuting are also thought likely to deter staff from relocating from the other airports that would be closed.

Stakeholders identified a variety of market impacts that they believed would arise. Passengers may change their travel behaviours in favour of flying from more local airports in preference to travelling further to the more expensive Estuary airport, potentially transferring at competing European hubs instead. Faced with greater travel distances to the hub, some businesses would consider relocating abroad, particularly multinational companies for whom such decisions may be taken outside the UK. The continued uncertainty, even once the Commission's recommendation is announced, would continue to discourage investment and unsettle businesses' commitment to the regions west of London. The potential closure of Southend and London City airports could threaten inward and overseas investments into the local economies that are predicated directly or indirectly on good air transport connections. Over a long period of time, some clusters of businesses, for example in the high tech sector, may begin to move and regroup elsewhere, perhaps nearer the Estuary airport. Their suppliers and service providers, if unwilling to move as well, would experience a gradual decline in volume, as would those companies that are currently conveniently located near Heathrow to serve international clients.

The interviews carried as part of this study captured stakeholders' attitudes towards the inner Thames Estuary airport based on their current perceptions and understanding of the scheme. The businesses of Kent could see substantial opportunity in the Estuary airport scheme, tempered by recognition that housing and surface access would require careful planning. However, the aggregate view of the majority of stakeholders was that to relocate the UK's functioning hub airport in an unattractive location without a strong catchment area of its own would carry significant risk, borne by airlines and businesses, requiring a reshaping of the economic geography and applying a social engineering experiment on a scale never undertaken before in this country.

11. OVERALL SUMMARY AND CONCLUSIONS

This report presents the results of analyses of the issues raised in the Airports Commission's Terms of Reference for the inner Thames Estuary scheme. The report seeks to provide information on the magnitude of the impacts, risks and costs associated with each of the issues and to identify those that would be likely to have a material impact on the feasibility and deliverability of the scheme.

Where applicable, promoters' schemes have been examined and subjected to analysis to assess whether they would adequately address the various issues, and case studies have been explored to determine whether other more effective approaches exist and are successfully implemented at other airports internationally.

Section 2 examines the various **flood risk** mitigations put forward by scheme promoters, and considers international case studies of airports that have suffered major flood events in recent years and those that have successfully mitigated flood risks in a variety of different environments. The Estuary airport will require a comprehensive flood defence strategy to manage the risks of various sources of flooding and from climate change. In addition, strategies would be required to address the impact of the airport on neighbouring areas including under extreme conditions. While the level of detail provided to date for the four proposed schemes is variable, there is no reason to suppose that a successful package of measures for flood defence from all source of risk could not be developed, with mitigation elsewhere in the Thames and Medway estuaries if necessary.

Section 3 identifies that while **fog** could pose a risk to airport operations in the Thames Estuary, the occurrences of fog are not significantly more frequent or longer in duration than those at Heathrow or Gatwick airports. The Estuary airport may experience periods of fog in the night time and early hours which may cause some disruption to services operating at those times. However, technological advances in aircraft and ground navigational equipment are likely to mean that in the future more aircraft could be expected to be able to approach, land, taxi and take off in very low or zero visibility conditions.

Section 4 analyses the pattern of **wind** directions and speeds to determine whether winds or cross-winds might have an impact upon airport operations in the Thames Estuary. All aircraft have a demonstrated cross-wind speed above which a take-off or landing would not be allowed. Given the east-west orientation of the proposed runways and the direction of the prevailing wind, the instances in which the cross-wind component of the wind will exceed the demonstrated aircraft rating would appear to be very few, are comparable with Heathrow and Gatwick, and do not form a material concern.

Section 5 examines the potential for **bird strikes** to disrupt services and impact on the safety and resilience of operations. A study in 2003 concluded that the Hoo Peninsula is 'possibly the most problematic location in the UK to site an airport'. However, taking into account proposers' mitigations and those used at other airports, it is considered that the problems are not insurmountable. Whilst bird management on the airfield is a matter of resources and manpower, controlling the birdstrike risk from sites off the airfield will require the management or removal of habitat or the imposition of additional off-airfield bird control, which will significantly increase the ecological impact of the development and may be difficult without enacting new legislation or compulsory purchase.

Section 6 describes the risks that the development of an Estuary airport would have on the **SS Richard Montgomery**, a 1944 munitions vessel wrecked some 5km from the airport perimeter, and more significantly the risks that the vessel could have upon the airport. A policy of routine monitoring and an enforced exclusion zone has been adopted to date by the Maritime and Coastguard Agency. Full containment or removal are deemed high risk and high cost options, potentially requiring evacuation of the local area for a period of many weeks or months. However, since the costs and operational disruption of interventions to eliminate the risk posed by the SS Richard Montgomery would be prohibitive once the airport is being built or is operational, it would seem necessary for full treatment and/or removal and disposal of the munitions to be undertaken prior to construction of the Estuary airport.

Section 7 refers to NATS' report on the **airspace implications** of an inner Estuary airport. The report recognises that advanced concepts of aircraft navigation will mitigate some of the complexity of the current airspace system. Nevertheless, London City, Southend and the Estuary airports would share airspace and therefore any operations are likely to be mutually exclusive. This is likely to mean that an unrestricted operation at the Estuary would significantly restrict operations at London City and Southend airports potentially to a point at which they may not be commercially viable. Airspace simulations could provide greater understanding of this restriction. The proximity of the Estuary airport to the eastern part of the UK's airspace boundary means that changes to the airspace of neighbouring countries will be required to support effective operations; these airspace changes would be harder to achieve than if the changes were confined to UK airspace. A phased opening of the new airport and a phased closure of Heathrow could require some complex airspace management.

Section 8 concerns the **energy facilities** on the Isle of Grain, which currently comprise two active power stations, the landing point and High Voltage Direct Current converter station for an electricity interconnector with the Netherlands, and a substantial Liquefied Natural Gas (LNG) terminal, storage and regasification facility. The power generation and the LNG facilities infringe the Obstacle Limitation Surfaces that define a safe area around the airport free from tall buildings and obstructions, with the result that their existence may not be compatible with an airport. The LNG site poses potential safety risks to the airport and vice versa. Provisional HSE advice suggests that the HSE may 'advise against' development of an airport within the planning consultation zones of the LNG facility. Any fire or other safety incident at the LNG facility would be likely to have a major operational impact on airport operations. Grain LNG is a facility with strategic importance to the UK, for which there is no known alternative site. Even if a site could be found, the cost of developing a replacement facility could be expected to exceed the £1.3bn invested into Grain once its current development phase is complete.

Section 9 considers the various issues concerning **transition** of operations from Heathrow to an Estuary airport. There are no comparable examples in terms of the scale of the move and the distance involved. Given the scale, a staged transition appears to offer a greater chance of success. However, this brings with it the difficulty and inefficiency of resourcing two airports in parallel, as well as creating complexity in the airspace transition. It will not be practically viable or attractive to passengers to hub across the separate airport sites and so the hub concept will be considerably weakened during this period.

There are many complexities to the commercial agreements that would be needed to enforce the closure of Heathrow airport, and London City and Southend airports if required, without compromise to the reliability and quality of service in the intervening period. There is no regulatory basis for the transfer of airline slots from one airport to another and given the financial commitment of some airlines in acquiring slots at Heathrow, and specific conditions in some Air Services Agreements between the UK/EU and other countries, this may prove to be controversial and sensitive for airlines.

Airlines and other stakeholders have expressed great concerns about the surface access travel times to the Isle of Grain for passengers and staff. The proposed surface access infrastructure will not cater for most workers who live in the areas around Heathrow who would face prohibitively long journey times to the Estuary airport. Tens of thousands of new homes would have to be built in parallel with the new airport at sites convenient for commuting. This may require considerable Government funding for public infrastructure as well as potentially assistance to catalyse housing development.

Overall, the challenges to transition are considerable and amount to a significant cost and risk to the taxpayer in terms of commercial negotiations, infrastructure development and potential failure.

Section 10 addresses the findings from a survey of **attitudes** towards the Estuary airport scheme held by airlines, airport users and affected airports. With the exception of Kent businesses, all stakeholders considered the Estuary airport scheme to carry significantly more risk than opportunity. The common risks across all stakeholder groups were cost, surface access, and impacts on the market and economy.

Stakeholders were concerned about the level of cost required to develop the Estuary airport and the necessary surface infrastructure; how this would be financed by the taxpayer; the scale of investment potentially compromising investment in other needed infrastructure programmes; and whether the likely level of airport charges would be economically damaging to airline routes, in particular short haul routes feeding the hub.

Surface access and the remote location of the Estuary airport caused significant concerns in terms of the smaller, untested catchment area and the impact on passengers and businesses. For passengers, the additional journey time may be unattractive for short haul flights, upon which long haul routes are dependent. For staff, the commuting distance and time, especially for shift workers, was considered unattractive and unsustainable.

In terms of market impacts, passengers may opt to fly from nearer airports such as Gatwick, Stansted and Luton, or on flights from regional airports to an overseas hub, in preference to the additional journey time to the Estuary airport. Some businesses that have grown up in proximity to Heathrow would relocate abroad; some may move to the new airport or elsewhere; and others may accept a downturn in business. Respondents foresaw a period of uncertainty, low investment and job insecurity following the announcement of a decision in favour of the Estuary scheme.

Kent businesses could see greater opportunities as a result of the Estuary airport being nearby, recognising the risks and challenges of house-building and surface access development. Overwhelmingly, the majority of stakeholders viewed the Estuary scheme as carrying significant risk, uncertainty and cost for passengers and businesses.

Examined individually, the topics addressed by each chapter of this report have, in the main, highlighted significant but perhaps not insurmountable challenges and risks to the successful development of an airport in the inner Thames Estuary. Considered together, however, they appear to present a substantial risk that would incur large costs, in the order of billions of pounds, to appropriately manage. Part of that risk may not be mitigated or costed to a reasonable degree, including the risk to safety, the on time delivery of the airport, the consequential impacts on local and regional economies, the attractiveness of the airport to airlines and their customers, and ultimately the success of a hub airport located in the inner Thames Estuary.

There are many aspects to the Estuary airport scheme that have no useful precedent nationally or internationally. For example, there are no known examples of successful treatment of explosives such as are held within the SS Richard Montgomery. There are no examples of LNG Terminals located adjacent to large airports and no real world cases of an LNG facility suffering a major storage tank fire or explosion. Equally, there are no known examples of an airport of comparable scale relocating the distances involved, with the requirement to relocate and house (or make redundant, replace and house) a workforce of considerable size. The complexity of the interdependencies between airlines, airports, businesses and passengers means that any delay to programme delivery could have far-reaching consequences. Yet there appear to be many issues that will involve complex commercial negotiations, planning policy and execution, stakeholder commitment, social change, and substantial amounts of construction, all of which carry great risk of compromise to delivery by 2030.

A. APPENDIX A – NATS SUPPORT TO THE AIRPORTS COMMISSION: INPUT TO THAMES ESTUARY STUDIES

This appendix contains the report prepared by NATS directly on behalf of the Airports Commission.

TASKING

This briefing note sets out NATS input on the various airspace aspects of the operation of a new hub airport in the Thames Estuary, as requested by the Airports Commission Secretariat. This input builds upon material previously provided to the Airports Commission to consider potential Long Term measures to increase capacity and resilience in the south-east of England. Where appropriate, existing material is reused to set out previously made assertions in greater detail.

ASSUMPTIONS

In its Interim Report, the Commission concluded that the establishment of a new hub airport would necessitate the closure of Heathrow on commercial grounds and not on the grounds of airspace operations; this briefing note has been developed on this basis. Such a situation removes a significant number of airspace and route network interactions and constraints that could otherwise exist if Heathrow would have had to co-exist with the other London airports and a new hub airport in the Thames Estuary. If this premise proves to be incorrect, then this will invalidate the conclusions of this report and further analysis and detailed modelling will be required.

KEY AIRSPACE ISSUES

The Underlying Concept of Operation

The Concept of Operations that will exist over the timeframe that the airport will become operational (c.2030) will be more advanced and systemised than used to deliver today's operation. The advanced concepts currently being validated by the Single European Sky ATM Research (SESAR) Programme are expected to be fully embedded into European operations by the time a new hub airport becomes operational. Concepts such as Trajectory Based Operations and Performance Based Navigation (PBN) will underpin pan-European operations, both of which are explained in greater detail below. The assertions and conclusions set out in this paper are predicated on the capabilities and expected use of these two advanced concepts.

Trajectory Based Operations

This is one of the fundamental cornerstones of the future pan-European operation, with the concept currently being developed and validated by SESAR.

The key change from today's concept is that a safe, efficient and continuous 'trajectory' will be negotiated between the aircraft and all ATC service providers, and once agreed, ground and airborne systems will monitor the aircraft's compliance and notify deviations for resolution. The operation will thus be more predictable, systemised and strategic than the current operation, which is far more tactical and characterised by controller intervention.

The 'trajectory' will be the flight path that sets out the most fuel efficient route for that aircraft within the airspace framework. It will define, in 4 dimensions (horizontally, vertically and in time), the cruise-to cruise aspect of the flight (including arrival and departure aspects of the operation). The trajectory that is delivered will be as close as possible to that which is required to minimise the cost of the flight. It will be established by considering many factors, including the desired trajectory provided by the operator of the flight; interactions with the desired trajectories of all other flights; and operational conditions that may exist as the trajectory is provided (such as weather conditions; unexpected closure of airspace; and other factors that cannot be strategically managed).

The trajectory will be expected to span, and be de-conflicted by, multiple control agencies so that as close to the optimal route is delivered. Ground-based systems will provide continual conformance monitoring and potential conflict detection and options for resolution. The key to delivering this future service is being able to understand, manage and help deliver the trajectory that the aircraft operator wants.

Trajectory-based operations will see a move away from the tactical way in which the service is delivered today to a more systemised way of providing a service. NATS en-route services will be based on trajectory-based operations in the timeframe being considered in this briefing note, as will those of other European service providers, including those that provide services in neighbouring airspace, such as France and Maastricht.

Traffic arriving at and departing from a new airport in the Thames Estuary will thus have a cleared trajectory across large swathes of European airspace and the tactical nature of intervention and control that characterises today's operation will not exist in the timeframe being considered.

The benefits that trajectory-based operations will provide in mitigating the effect of different traffic profiles within neighbouring agencies need to be understood when considering the impact that a new hub airport located close to airspace boundaries could present (see later).

Performance Based Navigation

Advanced avionic navigation capabilities enable aircraft to adhere to flight paths to a far greater accuracy than previously possible. Such improved capabilities enable predefined airport departure routes – known as Standard Instrument Departures (SIDs) – to be developed with greater certainty that the aircraft will be able to adhere to them. Operations based on Performance Based Navigation (PBN) capabilities form a cornerstone of the CAA's Future Airspace Strategy (FAS) as they provide the opportunity to concentrate and route departing traffic away from major populations and fly more predictable departure paths.

Such a capability will enable SIDs supporting a new airport in the Thames Estuary to be developed that route aircraft around / away from conurbations in East & Central London, offering narrower noise swathes and ground noise footprints in accordance with government policy. The importance of PBN capability is acknowledged across the industry, with plans in place to mandate such a capability via Implementing Rule across Europe by December 2020, with the potential for local or regional implementations earlier, and will thus be the de facto standard in the timeframe that a new hub airport will be operational.

RUNWAY CHARACTERISTICS

The location and separation of the runways at an airport have an impact on the level of movements that can be accommodated. Whilst the number of movements that can be achieved by an airport with multiple runways capable of supporting independent parallel operations (as specified by ICAO[5]) increases with the number of runways used, it is not governed by a simple pro-rata relationship, due to the need to provide sufficient capacity & airspace to safe operations can be provided at all times. Previous input to the Commission set out that a maximum of 800k ATMs pa could be supported by an airport that operated four independent parallel runways of the length expected at any new hub airport; such a quantity is

5 ICAO Document 9643, Manual on Simultaneous Operations on Parallel or Near Parallel Instrument Runways.

confirmed in this briefing note[6]. Such a level is important when considering the potential impact on proximate airports.

Airports need a large volume of airspace around them to support effective operations. Scheme promoters have proposed different actual locations within the Thames Estuary, all either within or in the vicinity of the Hoo Peninsula. The impact on surrounding airspace and route structures of such a new airport will be significant. A location within a circa 5 mile radius of the centre of the Hoo peninsula will have a significant impact on the surrounding airspace structures and the conclusions set out in this report remain valid irrespective of the actual location within this region. In addition, it should not be inferred that locations just outside this area may not result in the same or similar challenges.

IMPACT ON OVERALL ATM NETWORK

Any airport needs effective ATM structures to provide it with expeditious arrival and departure routes. These need to be developed in a manner that considers many aspects of the operation, including stable and efficient landing procedures, departure routes that adhere to noise policy (i.e. acceptable noise disruption with a focus on concentration as opposed to dispersal) and the proximity of other traffic concentrations (i.e. other airports).

The current airspace and route network structure supporting the five London airports in the south-east is some of the busiest and most complex in the world. It is currently being revised to provide more fuel-efficient arrival and departure routes under a major airspace development programme. The extensive nature of the redevelopment means that it will not deliver a fully revised airspace structure until 2019/20.

6 It should be noted that scheme promoters have set out plans for even greater numbers of ATMs at an estuary airport. If such capacity were deliverable, possibly through constructing additional runways, the airspace impact on airports at London City and Southend would be even greater than set out in this report.

A new hub airport in the Inner Thames Estuary will need to be similarly supported by efficient arrival and departure routes, and within a region already supporting several major airports, although not Heathrow (which will not exist on commercial grounds if a new hub airport is established). Unrestricted operations of a new airport in the Inner Thames Estuary will have an impact on the operations of such airports due to the conflicting arrival and departure routes. The impact of such conflictions depends on several factors, including most significantly the number of runways and their orientations. This briefing note assumes that a new hub airport will, from the outset operate 4 runways supporting two independent arrival streams and two independent departure streams. Two scenarios regarding runway orientations are considered -East/West and North-East/South-West:

- East/West Orientation: Under this scenario, operations at London City and Southend airports would be significantly affected due to conflicting airspace requirements between these two airports and the new hub airport. To a first approximation and without detailed modelling, the airspace requirements necessary to provide unrestricted operations at the new hub airport would have a substantial impact on the operations at both City and Southend; the other three London airports (Gatwick, Stansted and Luton) are sufficiently distant to operate unimpeded from a capacity viewpoint. However, such a situation would have an impact on the efficiency of the Stansted operation from an environment viewpoint, with additional track-miles being flown by traffic operating from this airport. It is not possible at this stage to state categorically whether or not the level of capacity would be restricted to a level that would prevent City and Southend airports remaining commercial viabilities. They would however be severely limited in their operating capability due to the amount of airspace that would be required by the hub airport (i.e. sufficient to operate four independent parallel runways delivering up to 800k ATMs pa) and its need to be supported by arrival and departure routes that would be in close proximity to City and Southend airports. Simulations would be able to provide a greater understanding of regional airspace capacity that could exist in this part of the network when the new hub airport is operating in an unconstrained manner. Simulations may conclude that it is possible that a balance could be struck between London City and the Thames Estuary airports to share the local airspace to enable both to co-exist, although this may only be possible if operational constraints are placed on both airports: neither could co-exist and operate in an unfettered manner. The outcome would be sub-optimal from the viewpoints of the airport operators, potentially requiring scheduling restrictions to be developed to allow each airport efficient arrival and departure routes. Due to the proximity of Southend airport to the new hub airport and its runway orientation, similar such arrangements to develop an effective solution to sharing airspace between Southend and the new hub airport would be even more challenging.
- North-East/South-West Orientation: Whilst this scenario would result in lesser conflictions with London City as respective arrival and departure routes, such an orientation would have an impact on Gatwick Airport. This would severely restrict operational at Gatwick as the north-easterly arrivals and south-westerly departures would require airspace that is currently developed to support the Gatwick operation. Simulations would be able to provide a greater understanding of regional airspace capacity that could exist in this part of the network when the new hub airport is operating in an unconstrained manner. Should this scenario need to be developed further, a detailed review of possible airspace structures would be required to examine how Gatwick and the new hub airport could effectively co-exist. Similar limitations would apply to operations and Southend airport.

EXPLOITING TECHNOLOGY TO MITIGATE THE IMPACT ON NEIGHBOURING STATES

Effective transfer of control between neighbouring Air Navigation Service Providers (ANSPs) is essential for expeditious cross-border traffic flows. The current operation is underpinned by a set of 'Standing Agreements' whereby the majority of traffic transits the national airspace boundaries at pre-agreed locations (termed 'reporting points') at expected flight levels. A new hub airport in the Thames Estuary would be c.45NM to the east than Heathrow, thereby being closer to the boundaries with Belgium, Maastricht, France and the Netherlands. This will result in different traffic profiles managed not only by NATS in the south-east of England but by these neighbouring agencies.

The revised traffic profiles (i.e. arriving and departing traffic being at lower levels as it enters neighbouring airspace) may present operational challenges to such neighbouring agencies, whose operation has been developed to support the existing traffic flows.

For example, the current airspace structure results in the Maastricht UAC handling most of the traffic arriving at/departing from Heathrow that is arriving from/destined for the east. A new hub airport would see such traffic being lower at the easterly national airspace boundary to such an extent that Belgium, which operates the airspace below Maastricht, potentially being responsible for the control of such traffic under such circumstances. Such a situation would require significant airspace redesigns not only in the south-east of England but also within neighbouring airspace to ensure that effective cross-border transfers are maintained.

CONCLUDING REMARKS

Operating a new hub airport in the Thames Estuary presents a different set of challenges than the current operation and those that would exist if the additional runway is location at Heathrow or Gatwick.

However, many of the constraints that limit today's operation will be far less limiting in the timeframe that a new hub airport in the Thames Estuary will be operational, with the advanced concepts being developed by SESAR being common place and used throughout Europe by 2030.

Thus the proximity of a new hub airport in the Thames Estuary to the eastern part of the airspace boundary with resultant impact on neighbouring agencies should not be considered as insurmountable, with trajectory-based operations significantly reducing the tactical nature of the task. Furthermore, the impact on the airspace will be mitigated by the closure of Heathrow, which will provide additional airspace that could be used to support operations at the remaining London airports.

Simulations would be required to verify the extent to which London City and Southend could co-exist with a new hub airport, and whilst an East/West runway orientation would have an significant impact on both London City and Southend airports, the extent to which airspace could be shared could be examined to explore whether a form of limited operations could be delivered. Any such operations would be mutually restrictive.

A new hub airport in the Thames Estuary would require significant airspace changes to provide efficient arrival and departure routes to integrate it into the surrounding airspace. The amount of influence that NATS has over agencies providing services in neighbouring European airspace is less than it has over UK airports & agencies, and thus airspace changes in neighbouring airspace (e.g. Belgium, Maastricht) that would be required to support effective operations would be harder to progress that any changes that would be contained solely within UK airspace.

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