APPENDIX A3

TECHNICAL ASSESSMENT REPORT

For the IFA2 Interconnector at Solent Airport

35588103/RP/080917/3 Addendum 2

NOVEMBER 2017

Incorporating

CONTACTS

IAIN COUTTS
Senior Aviation Consultant

e iain.coutts@arcadis.com

Arcadis.
34 York Way
London, N1 9AB
United Kingdom

DR AHMED MAKI
Buildings Physicist

e mak.maki@arcadis.co.uk

Arcadis.
34 York Way
London, N1 9AB
United Kingdom

MARTIN STANDAART
Senior EMF/RFI Specialist

e martin.standaart@arcadis.com

Arcadis Nederland B.V.
Piet Mondriaanlaan 26
3812 GV, Amersfoort
Netherlands

MARTIN VAN ESSEN
EMC Specialist

e martin.vanessen@arcadis.com

Arcadis Nederland B.V.
Piet Mondriaanlaan 26
3812 GV, Amersfoort
Netherlands

JANE WILSON
Principal Safety Consultant

e jane.wilson@arcadis.co.uk

Arcadis.
34 York Way
London, N1 9AB
United Kingdom

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1	1	08/09/2017	Draft Report issued for comment.		I Coutts J Wilson S Scannali
	2	06/10/2017	Comments provided on Revision 1 addressed		S Scannali
	3	10/11/2017	Comments from FBC on Revision 2 addressed	Various comments throughout	S Scannali

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EXECUTIVE SUMMARY

National Grid Interconnector Holdings (NG) is proposing to develop and implement a new electricity interconnector facility, the Interconnexion France-Angleterre 2 (IFA2). The facility is being developed jointly with Réseau de Transport d'Electricité (RTE), the French transmission system owner and operator. It will link the United Kingdom's electricity transmission network with France's, and is expected to help enhance the security, affordability, and sustainability of energy supply to both countries.

The facility consists of two converter stations, one sited in each country. The UK converter station is to be sited to the north-east of Solent Airport at Daedalus ("Solent Airport"). National Grid proposes to route high-voltage direct current and high-voltage alternating current cables in a shared cable corridor to the west and north of the Solent Airport main runway.

As part of the planning application and land acquisition processes, NG, in agreement with Fareham Borough Council (FBC) and Regional and City Airports Management (RCAM), the airport operator, commissioned a number of initial assessments as part of best practice development and design to determine whether the siting of the converter station and routing of cables at Solent Airport could affect the airport's existing operations. These assessments were also intended to help address stakeholder concerns about the proposals to site the converter station at Solent Airport. Additionally, they were also provided as supporting information to the public consultation and planning application processes.

Over 2016 and 2017 a further, more detailed technical assessment was undertaken to progressively develop the initial work. As part of this, Arcadis was commissioned to undertake an independent peer review as well as a further technical assessment of the converter station to assess whether the IFA2 Facility can co-exist safely with the existing airport and its operations. This work, presented in [1], [2], [36] and [37] includes a hazard identification and risk assessment study, and as a result of this a *Hazard Log* [37] has been developed in accordance with the standard *CAP 760* [15]. The project is now part way through the detailed design process.

This document supports the interim Safety Justification [38] for the IFA2 Facility at Solent Airport and is part of the work intended to support the application to the Fareham Borough Council (FBC) Executive Committee for the full planning acceptance and consent to progress to the next stage in the project.

Specifically, this report which forms part of the assurance evidence referenced within the *Hazard Log* [37], includes additional review and technical assessment to address some specific hazards in the *Hazard Log* [37]:

- a revised assessment of airfield safeguarding taking account of the IFA2 design and updating the assessment in [2];
- additional wind flow analysis carried out to supplement that in [1], [2] and [16]. The additional analysis covers the interaction effects between the IFA2 Converter Station and the Faraday Business Park;
- further independent peer review of some additional documents related to Radio Frequency Interference (RFI) and Electromagnetic Frequency (EMF) documents and consideration of EMF/RFI effects to confirm some assumptions made in the assessments in [1] and [36] and to consider some specific hazards within the hazard log that were not explicitly covered by the body of evidence available;
- consideration of the possible effects upon Maritime & Coastguard Agency (MCA) equipment arising from the IFA2 Facility;
- an assessment of Instrument Landing Systems (ILS), both generically and in the context of the IFA2 Facility at Solent Airport. Currently there are no plans to introduce ILS to the airport;
- an assessment of Unmanned Aerial Vehicles (UAVs), considering the risks that non-commercial UAVs could pose to Solent Airport and whether the IFA2 Facility could exacerbate these risks.

A summary of the conclusions associated with each of the above topics is given below.

Aerodrome Safeguarding Analysis

The aerodrome safeguarding analysis aims to ensure that the existing proposed development will have no impact on the safe operation of the airport. The proposed design of the buildings within the development are not infringing any of the obstacle limitation surfaces (OLS) and are compliant with the associated legislation and standards. The design of the IFA 2 building roof is pitched, which is less attractive to birds than a flat roof. A bird hazard management plan will be needed. Lighting within the development should follow the Airport Operators Association (AOA) advice [11] to ensure that the operation of the airport is not adversely impacted. The use of cranes during construction may present a temporary risk, but the type of crane used should be considered and agreed with the airport at the earliest opportunity, in order to assure that any risk is mitigated and is acceptable, particularly as the site is in such close proximity to the runway.

Wind Assessment

The wind effects analysis has considered the impact of the updated design of the IFA2 Converter Station combined with the future proposed Faraday Business Park buildings on the main runway and covers a realistic range of wind directions and wind speeds. One main effect observed is that the future proposed Faraday Business Park buildings act as a shield to the IFA2 Facility and have the overriding impact on the runway. This also explains the worst-case wind direction now being at the angle of 90^0 EoN, compared to 70^0 EoN from the earlier analysis when only the IFA2 Building is considered. This is because at this angle the future buildings produce three tails of faster winds, which covers the biggest area on the main runway compared to the other angles. The highest relative increase wind speed onto the main runway caused is a maximum of 29% at a height of 5m above the ground.

The wind impacts indicated above can be mitigated by extending the “frontline” buildings nearest the runways and closing the gaps.

Additionally, it was confirmed at the hazard identification and risk assessment [2, 37] studies report that localised changes in wind patterns are easily managed and that pilots quickly become familiar with any changes in wind patterns and adapt their flying accordingly through good airmanship.

Technical Assessment of EMF/RFI Effects

The work included in Arcadis’ *Technical Assessments* [1, 36] completed the main review of the analysis available concerning EMF and RFI effects. Due to additional information being made available very recently, a further review regarding EMF and RFI has been conducted. Additionally, some areas where there were perceived to be gaps in the existing hazard mitigation evidence have also been considered.

Based on the evidence reviewed so far, whilst further testing evidence is required, there are no issues concerning EMF/RFI emissions due to the IFA2 facility and the expectation remains that risks concerning RFI and EMF will be acceptable as defined in *CAP 760* [15]. Work is in progress to complete the testing and measurement activities that are planned to verify that the requirements and the planning conditions are met. All verification required to demonstrate that safety requirements are met is recorded as a dependency in the Safety Justification [38]. Some points requiring clarification are raised by the assessment, these should be addressed as the design documentation develops.

Avionics Impacts of Emissions from IFA2

The impact upon avionics equipment from emissions originating from IFA2 has been analysed. The analysis includes assessment of the impacts on Flight Management Systems (FMS) and other specific aircraft navigation systems. The analysis also assessed the impact of wideband noise on aircraft sensors.

It has been determined that any emissions from the IFA2 Facility will rapidly diminish with distance and will have no discernible impact on aircraft that are operating within the normal bounds of the airfield using the systems assessed within this assessment.

Instrument Landing Systems

The assessment has identified no specific risks related to IFA 2 in introducing a future ILS system or similar system at Solent Airport. Whilst there are no current plans to introduce ILS, the assessment has considered possible options for future systems and issues that will need to be progressed by the airport operator should the decision be taken to introduce an instrument landing capability or similar in the future.

It should be noted that the international standards for an Instrument Approach Procedure (IAP) require the existence of an instrument runway and an approach control service. Within the UK, an IAP implemented in accordance with the CAA's *CAP 1122* [39] framework will be limited to a minimum descent height of 500 feet above the runway threshold. This regulatory limitation determines that all of the options for the provision of an instrument approach at Solent Airport will provide the same operational performance capability in respect of cloud base and visibility. The operational benefits for all of the instrument approach types that may be considered by Solent Airport in the future are identical. This leads to a strong business case for GNSS based approaches as they do not require investment in the installation and ongoing maintenance costs of ground based navigation aid infrastructure.

Unmanned Aerial Vehicles

Unmanned Aerial Vehicles (UAVs) had previously been considered at a fairly high level. At this stage of the project, a more detailed assessment has now been carried out, whereby the potential impact (risks and effects) that UAVs could have on the IFA2 Facility and vice versa has been assessed in more detail, and is now included as part of the Hazard Identification and Risk Assessment [2 & 37].

This latest assessment has not identified any additional risks and mitigation measures that were not previously known, and there are currently no recommendations to add further controls, mitigations and actions not otherwise identified.

It is concluded that the proposed IFA2 Facility would not exacerbate the possible risks posed by UAVs themselves upon Solent Airport.

There is a potential for non-commercial, third party UAVs from external sources to enter the airport and IFA2 Facility boundaries, potentially causing damage or injury / death (depending on the type and size of UAV) to personnel. This is a generic external risk affecting all airports. Appropriate measures to prevent this need to be considered by the Airport Operator. There is no reason to believe why suitable measures should not be achieved within the programme for introducing UAVs to Solent Airport.

REFERENCES

Ref No	Reference Identifier	Title
1	35588100/NT/300916/1	Technical Assessment (Main Report) of the possible impact of the IFA2 Interconnector at Solent Airport Daedalus.
2	35588100/NT/300916/2	Technical Assessment (Hazard Log) of the possible impact of the IFA2 Interconnector at Solent Airport Daedalus.
3	-	Draft Daedalus Masterplan – 12 October 2016
4	CAP 738	Civil Aviation Publication - CAP 738 Safeguarding of Aerodromes, CAA
5	-	The Town and Country Planning (Safeguarded Aerodromes, Technical Sites and Military Explosives Storage areas) Direction 2002
6	-	Air Navigation Order made under Section 60 of the Civil Aviation Act 1982
7	-	Lee-on-Solent Airport AIP
8	CAP 168	Civil Aviation Publication - CAP 168 Licensing of Aerodromes, CAA
9	CS-ADR-DSN – Aerodrome Design	CS-ADR-DSN, Certification Specifications and Guidance Material for Aerodrome Design, EASA
10	CAP 772	Civil Aviation Publication - CAP 772 Wildlife Hazard Management at Aerodromes, CAA
11	-	Safeguarding of Aerodromes: Advice Note 2 – Lighting near Aerodromes
12	BS 5489-1:1203	British Standard Institution's BS 5489 Code of Practice for the design of road lighting
13	BS EN 13201-2:2015	British Standard Institution's BS EN 13201 Road lighting
14	BS 7121-3:2017	British Standard Institution's BS 7121 Code of practice for safe use of cranes
15	CAP 760	Civil Aviation Publication - CAP 760 Guidance on the Conduct of Hazard Identification, Risk Assessment and the Production of Safety Cases, CAA
16	35588100/NT/300916 Addendum 1	Technical Assessment - Wind Flow Analysis
17	35588102/RP/010617	Wind Flow Analysis for the IFA2 Facility
18	G3221.181I	IFA2 UK Onshore Environmental Statement, NG
19	G-003-0219	IFA2 Open Cut Trench Cross Section Under Taxiway, NG
20	500-001	IFA2 AGL Ducting, Issue B, NG
21	LSAEM/2015/019/TR/005	RF Survey Test Report for IFA2 Development at Solent Airport, NG
22	OVE-IFA2-REP-001	IFA2 Converter TV and Radio Reception Study, NG
23	935-11-600	Operation Manual for the 935-11 DF System, Cobham
24	G3221.181I	Drawing: IFA2 Overview Map Daedalus New Boundary, NG
25	1JNL568775	Radio and Telecomms Interference and EMF assessment, ABB
26	CIGRE TB391	TB 391 – Guide for measurement of radio frequency interference from HV and MV substations, Cigré
27	25-7-17 MoM	Minutes of meeting on 25 July 2017 at Lee-on-Solent Airport to discuss IFA2 – MCA Interface and Equipment
28	PPL15142-SE-RA-001-v00	Preliminary impressed voltage assessment for cables at Daedalus
29	NEN 3654:2012	NEN 3654:2012, Mutual Influence of Pipelines And High-Voltage Circuits

Ref No	Reference Identifier	Title
30	IEC 61000	IEC 61000 Electromagnetic compatibility (EMC), International Electrotechnical Commission
31	CAP 722	Civil Aviation Publication - CAP 722 Unmanned Aircraft System Operations in UK Airspace – Guidance, CAA
32	EASA NPA 2017-05	EASA NPA 2017-05 (A) and (B) - Introduction of a regulatory framework for the operation of drones
33	CAP 382	Civil Aviation Publication - CAP 382 Mandatory Occurrence Reporting Scheme, CAA
34	EU 376/2014	Regulation (EU) No 376/2014 on the reporting, analysis and follow-up of occurrences in civil aviation
35	IR 2015/1018	Implementing Regulation (EU) 2015/1018 laying down a list classifying occurrences in civil aviation to be mandatorily reported
36	35588102/RP/270617	Technical Assessment (Main Report) of the possible impact of the IFA2 Interconnector at Solent Airport Daedalus
37	35588102/RP/080517	HAZARD LOG REPORT Technical Assessment of the Effects of IFA2 interconnector at Solent Airport
38	35588103/RP/080917	Safety Justification for the IFA2 Interconnector at Solent Airport Daedalus.
39	CAP 1122	Application for Instrument Approach Procedures to Aerodromes without an Instrument Runway and/or Approach Control
40	ICNIRP	International Commission on Non-Ionizing Radiation Protection
41	Solent Aerodrome Chart	AD 2-EGHF-2-1, Lee-on-Solent Aerodrome Chart
42	TSO 145 / ETSO 145	TSO-C145, Airborne Navigation Sensors Using the GPS Augmented by the WAAS, FAA; ETSO-C145, Airborne Navigation Sensors Using the GPS Augmented by the WAAS, EASA
43	TSO 146 / ETSO 146	TSO-C146, Stand-Alone Airborne Navigation Equipment Using the GPS Augmented by the (WAAS), FAA; ETSO-C146, Stand-Alone Airborne Navigation Equipment Using the GPS Augmented by the (WAAS), EASA
44	TSO 129 / ETSO 129	TSO-C129, Airborne Supplemental Navigation Equipment Using GPS, FAA; ETSO-C129, Airborne Supplemental Navigation Equipment Using GPS, EASA
41	1JNL553364 Rev A	HF Performance Report

TERMS AND DEFINITIONS

Term/Abbreviation	Definition
AAIB	Air Accidents Investigation Branch
ADF	Automatic Direction Finding
ADS-B	Automatic Dependent Surveillance-Broadcast
AGL	Airfield Ground Lighting
AHRS	Attitude and Heading Reference Systems
AIP	Aerodrome Information Publication/Package
Airport, The	Solent Airport at Daedalus
ANPS	Air Navigation Service Provider
AOA	Airport Operators Association
ARP	Aerodrome Reference Point
ATC	Air Traffic Control (Tower)
ATM	Air Traffic Movements/Management
ATS	Air Traffic Service
BHMP	Bird hazard management plan
BS	British Standards
BSI	British Standard Institution
CAA	(UK) Civil Aviation Authority
CAP	Civil Aviation Publication
CFD	Computational Fluid Dynamics
CFIT	Controlled Flight into Terrain
CNS	Communication Navigation Surveillance
DC	Direct Current
DF	Direction Finder
DME	Distance Measuring Equipment
EASA	European Aviation Safety Agency
EASA NPA	European Aviation Safety Agency – Notices of Proposed Amendment
EFIS	Electronic Flight Instrument System
EGHF	The ICAO Code for Solent Airport

Term/Abbreviation	Definition
EGNOS	European Geostationary Overlay Service
EGPWS	Enhanced Ground Proximity Warning System
EMC	Electromagnetic Compatibility
EMF	Electromagnetic Frequency
EMI	Electromagnetic Interference
EoN	East of North
FBC	Fareham Borough Council
FHA	Functional Hazard Assessment
FLIR	Forward Looking Infrared (Cameras)
FM	Frequency Modulation
FMCW	Frequency Modulated Continuous Wave
FMS	Flight Management System
GA	General Aviation
GAT	General Air Traffic
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
HV	High Voltage
IAP	Instrument Approach Procedure
ICAO	International Civil Aviation Organization
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEC	International Electrotechnical Commission
IFA2	Interconnexion France-Angleterre 2
IHS	Inner Horizontal Surface of an aerodrome’s OLS
ILS	Instrument Landing System
IRS	Inertial Reference System
LNAV	Lateral Navigation
LPA	Local Planning Authority
LPV	Localiser Performance Vertical

Term/Abbreviation	Definition
LV	Low Voltage
MCA	Maritime and Coastguard Agency
MOR	Mandatory Occurrence Reporting
NATS	National Air Traffic Services
NDBs	Non-Directional Beacons
NEN	Nederlands Normalisatie Instituut
NG	National Grid Interconnector Holdings Limited
NOTAM	Notice to Airmen
OAT	Operational Air Traffic
OCH	Obstacle Clearance Height
OFZ	Obstacle Free Zone
OLS	Obstacle Limitation Surfaces
PNT	Position Navigation or Time
RAIM	Receiver Autonomous Integrity Monitoring
RCAM	Regional and City Airports Management
RF	Radio Frequency
RFI	Radio Frequency Interference
RNAV	Area Navigation
RTE	Réseau de Transport d'Electricité
SBAS	Satellite Based Augmentation System
Solent Airport	Solent Airport at Daedalus
TAWS	Terrain Awareness and Warning System
TSO	Technical Standards Orders
TV	Television
UAV	Unmanned Aerial Vehicle
UCFIT	Un-Controlled Flight into Terrain
UHF	Ultra High Frequency
UK	United Kingdom
VFR	Visual Flight Rules

Term/Abbreviation	Definition
VHF	Very High Frequency
VOR	VHF Omni Range
WAAS	Wide Area Augmentation System
WHMP	Wildlife Hazard Management Plan

1 INTRODUCTION

National Grid Interconnector Holdings (NG) is proposing to develop and implement a new electricity interconnector facility, the Interconnexion France-Angleterre 2 (IFA2). The facility is being developed jointly with Réseau de Transport d'Electricité (RTE), the French transmission system owner and operator. It will link the United Kingdom's electricity transmission network with France's, and is expected to help enhance the security, affordability, and sustainability of energy supply to both countries.

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This addendum supports the interim Safety Justification for the IFA2 Facility at Solent Airport [38] and is part of the work intended to support the application to the Fareham Borough Council (FBC) Executive Committee for the full planning acceptance and consent to progress to the next stage in the project. Specifically, this report which forms part of the assurance evidence referenced within the *Hazard Log* [37], includes additional review and technical assessment to address some specific hazards in the *Hazard Log* [37], including:

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2 AERODROME SAFEGUARDING

This section of the report analyses the IFA2 Interconnector Facility, focusing on the associated buildings of the converter station, against aerodrome safeguarding criteria. This section introduces the concept of aerodrome safeguarding, its context in relation to the IFA2 Interconnector Facility and any recommendations or mitigation measures required arising from the assessment.

This is an update to the initial Aerodrome Safeguarding Assessment completed in 2016 [1]. The design of the facility has progressed since the initial assessment and therefore this revised assessment takes the latest design into account.

2.1 Purpose of Aerodrome Safeguarding

The primary purpose of aerodrome safeguarding is to protect aircraft from obstacles and obstructions whilst operating in the vicinity of airports. With regards to airports the purpose is to take measures to ensure the safety of aircraft, and thereby the passengers and crews aboard them, while taking-off or landing, or while flying in the vicinity of an aerodrome. Thus, measures are taken to prevent aircraft colliding with each other, or with fixed and mobile objects, while manoeuvring on the ground, while taking-off or landing, or while flying in the vicinity of the aerodrome. Measures are also taken to prevent interference with, or distortion of the guidance given, or indications from visual aids, radio aids to air navigation and meteorological instruments. It also includes the measures taken to reduce the risk of aircraft experiencing a bird strike, particularly during take-off and landing.

This is achieved by a process of analysing proposed developments to:

- protect the blocks of air through which aircraft fly, by preventing penetration of surfaces created to identify their lower limits;
- protect the integrity of radar and other electronic aids to air navigation, by preventing reflections and diffractions of the radio signals involved;
- protect visual aids, such as approach and runway lighting, by preventing them from being obscured, or other lights being confused for them;
- reduce the hazard to aircraft from bird strikes, by preventing the increase of bird numbers in the vicinity of the aerodrome.

Safeguarding is included in UK legislation as an integral part of the planning procedure. It is set out in Directions contained in circulars issued under the Town and Country Planning Acts. Local Planning Authorities (LPAs) are advised, usually by issue of maps, of the safeguarded area around an aerodrome. Normally these extend to some 15 km from the aerodrome. The LPAs are required to approach the Safeguarding Consultee named on the map (usually the aerodrome concerned) about any Planning Application within this area, should it meet certain criteria relating to the height and location of the proposed development to the aerodrome. In addition, any proposed developments with bird attractant properties within 13 km of the aerodrome will also be referred for consultation. The reason for the 13 km area is explained in Section 2.7 of this report.

An explanation of the legislation in relation to Solent Airport is provided in Section 2.5.

2.2 CAP 738 – Safeguarding of Aerodromes

Civil Aviation Publication – CAP 738 [4] is a guidance document produced by the CAA for airports and those responsible for the safe operation of an aerodrome or a technical site. It describes the processes and procedures that should be followed when assessing the impacts on aerodrome and aircraft operations against new development proposals. There are a range of factors that must be considered when planning developments in the vicinity of an airport or aerodrome and *CAP 738* [4] is the main point of reference in the UK for these issues. *CAP 738* [4] includes a Safeguarding Process Flowchart (*Figure 1, Chapter 1, CAP 738*) as a guide for ensuring the correct procedures are followed when assessing developments.

CAP 738 [4] contains the relevant information within which the IFA2 Interconnector Facility at Solent Airport is assessed against aerodrome safeguarding criteria. The main aspects of the assessment cover the following broad areas:

- Obstacle Limitation Surfaces (OLS);

- Bird Strike Hazard;
- Lighting;
- Cranes.

To provide overall context to *CAP 738* [4] there are several other measures to analyse, as follows:

- Technical Site Safeguarding;
- Wind Turbines;
- Roads & Railways.

Technical Site Safeguarding analyses the impact of development on aeronautical systems. This assessment is described in the following sections. Wind turbines can interfere with air navigation systems by appearing as aircraft on radar screens. No wind turbines are proposed in this application and this is not relevant as part of the study. Vehicles on roads and railways are considered as potential obstructions to aircraft and are classed as mobile obstacles. However, due to the nature of the proposed development the IFA2 Interconnector will have no impact on adjacent roads or railways, therefore no further analysis is necessary.

2.3 The Town and Country Planning (Safeguarded Aerodromes, Technical Sites and Military Explosives Storage Areas) Direction 2002

The Town and Country Planning (Safeguarded Aerodromes, Technical Sites and Military Explosives Storage areas) Direction 2002 [5] is the UK Government guidance on the management and implementation of the aerodrome safeguarding process through the planning system. It sets out the main processes that must be followed to ensure that appropriate consultation is undertaken for developments in the vicinity of aerodromes and other technical sites related to aviation, such as radar installations.

Civil aerodromes in the UK are licensed under an Air Navigation Order made under *Section 60* of the *Civil Aviation Act 1982* [6]. The CAA is responsible under the Air Navigation Order for being satisfied that a licensed aerodrome is safe for use by aircraft. Part of this provision includes being satisfied that the physical characteristics of the aerodrome and its surroundings are safe to use by aircraft. Once satisfied, the CAA will issue an Aerodrome Licence with a named individual stated as the Aerodrome Licence Holder.

Some of the main aspects of *The Town and Country Planning (Safeguarded Aerodromes, Technical Sites and Military Explosives Storage Areas) Direction 2002* [5] which will need to be considered for the IFA2 interconnector at Daedalus include the Safeguarding Map, Officially Safeguarded Aerodromes, Other Aerodromes, and the Aerodrome Information Package. These are described in more detail in Subsections 2.3.1 to 2.3.3 below.

2.3.1 Safeguarding Map

The need for and purpose of the safeguarding map is described in *The Town and Country Planning* legislation [5]. A safeguarding map for individual aerodromes is lodged with relevant local planning authorities to indicate the type of development they must consult on. The safeguarding map is centred on the aerodrome and contains colour-coded areas showing the extent of the safeguarded area to indicate the appropriate developments to refer for consultation. The colour coding within the map largely refers to the height of proposed buildings and structures that will trigger the requirement for a consultation.

2.3.2 Officially Safeguarded Aerodromes

There are a number of officially safeguarded aerodromes in the UK, largely due to their importance to the aviation industry and overall transport system.

All major airports in the UK are officially safeguarded and this is to ensure that they can continue to operate safely and efficiently without being inhibited by buildings, structures, physical objects and any other feature that may obscure runway lights or impair the performance of navigational aids.

Generally, all development within the safeguarded area, which is broadly the extent of the Obstacle Limitation Surfaces (OLS), must be referred for consultation with the relevant airport. Officially safeguarded aerodromes are included in the list of statutory consultees within the planning system.

Local planning authorities will refer to the safeguarding map when deciding whether or not to consult on a particular development.

2.3.3 Other Aerodromes

In addition to the officially safeguarded aerodromes, there are many other aerodromes in operation around the UK. These are typically small to medium sized airports and airfields. They do not experience the same level of protection under planning legislation as officially safeguarded aerodromes.

However, best practice advice for these aerodromes is to establish a process to protect the safe and efficient operation of the aerodrome against new developments. Measures should be taken to agree on consultation procedures between the aerodrome and local planning authorities.

These aerodromes do not have official safeguarding maps but the CAA recommends that an unofficial safeguarding map be lodged with the relevant local planning authorities and that local authorities act reasonably towards non-officially safeguarded aerodromes when assessing new development.

2.4 Aerodrome Information Package

The Aerodrome Information Package (AIP) contains relevant aeronautical information and general airport information on a particular airport or aerodrome. The AIP for Solent Airport [7] is published as Lee-on-Solent under the International Civil Aviation Organization (ICAO) Code EGHF. With regards to safeguarding, the information in the AIP is used as background data for completing the safeguarding assessment. The AIP contains important data on the position and height above mean sea level of the Aerodrome Reference Point (ARP). The ARP is the main point of reference for the geographical location of the airport. The ARP is usually situated on the mid-point of the main operational runway.

The AIP also states the important lengths and dimensions of all operational runways.

Using this data from the AIP enables us to obtain the relevant information required to input into the safeguarding assessment, particularly when assessing the building heights against the obstacle limitation surfaces, which is discussed in Section 2.6.

2.5 Solent Airport

Solent Airport is not currently an officially safeguarded aerodrome and the legislation explained in previous sections is not strictly applicable to the airport. Therefore, developments are not automatically required to be referred for a formal consultation.

Solent Airport is categorised under the definition provided in Section 2.3.3 Other Aerodromes. As such, no official safeguarding map is required, nor is there an obligation to consult on local planning applications. Any safeguarding process is advisory. However, it is clear that due to the management and ownership status of the aerodrome that there is an effective process in place for safeguarding to ensure development in the surrounding area and within the aerodrome boundary itself is analysed against safeguarding criteria.

It is evident that an aerodrome safeguarding process is in place which will ensure that the new development will not adversely impact the operation of the airport. Therefore, the assessment completed in this study follows the principles described above.

2.6 Obstacle Limitation Surfaces

Obstacle Limitation Surfaces (OLS) form a complex series of three-dimensional surfaces, which vary depending on the characteristics of the runway and are fully defined in *ICAO Annex 14, Chapter 4* of *CAP 168* [8] and *Chapters H & J of EASA document CS-ADR-DSN Certification Specifications and Guidance Material for Aerodromes Design* [9].

They extend upwards and outwards from the edges of the Runway Strip and/or Runway Clearway and comprise the following:

- Take-Off Climb Surfaces;
- Approach Surfaces;
- Transitional Surfaces (sometimes called “side slope”);

- Inner Horizontal Surface;
- Conical Surface;
- Outer Horizontal Surface.

The surfaces are shown in Figure 1 below.

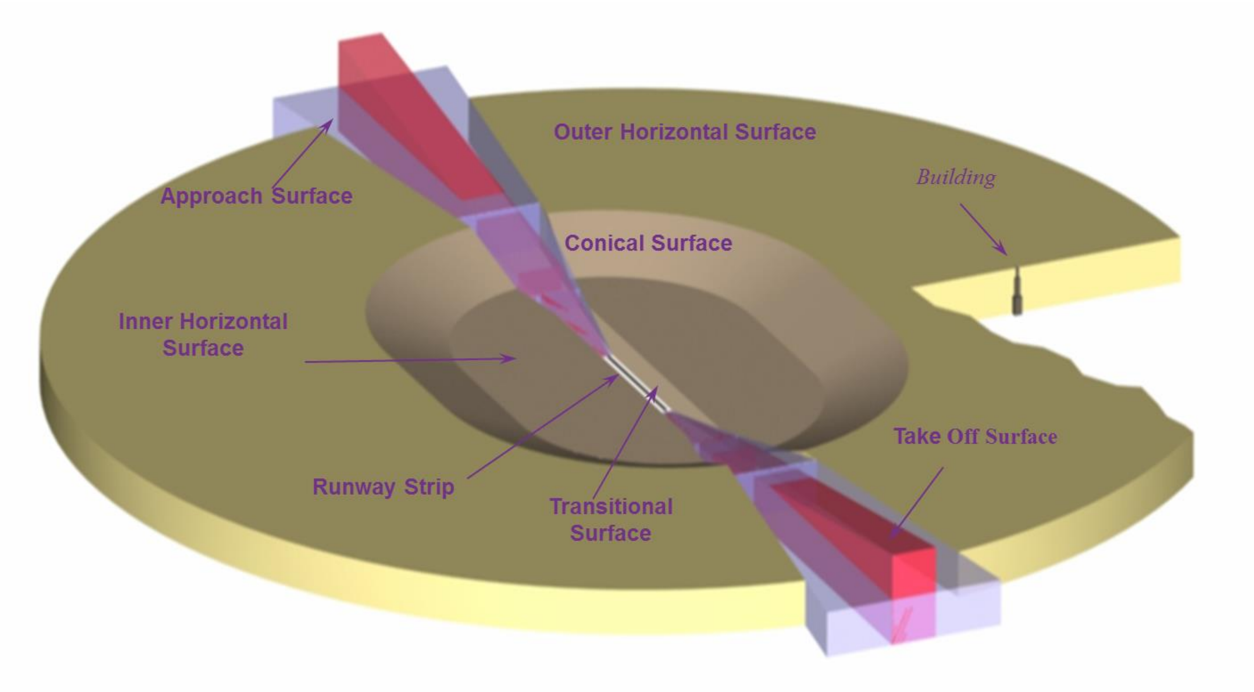


Figure 1 Obstacle Limitation Surfaces

The requirement is that no new objects penetrate these surfaces, unless shielded by an existing immovable object. These surfaces apply to aircraft parked on aprons, but not to those taxiing.

Additionally, there is a set of inner obstacle limitation surfaces, which together make up the Obstacle Free Zone (OFZ). The objective of the OFZ is to protect aircraft making a precision instrument approach and during any subsequent missed approach from both fixed and mobile obstacles. The OFZ comprises the following:

- Inner Approach Surface (a portion of the Approach Surface);
- A portion of the Runway Strip;
- Inner Transitional Surface;
- Baulked Landing Surface.

No object, whether fixed or mobile, is allowed to penetrate the OFZ, unless it is frangible and its presence is essential to air navigation. However, if the main Obstacle Limitation Surfaces, listed above, are not penetrated by a fixed object, then there will also be no impact on the OFZ. Therefore, these surfaces mainly apply to mobile objects, such as aircraft using the taxiway system and aircraft at the runway holds awaiting entry to the runway.

Solent Airport does not currently have any Instrument Landing Systems (ILS) installed and as the primary objective of the OFZ is to protect aircraft making a precision approach, this does not strictly apply to the airport at this time. However, the understanding is that whilst there are no foreseeable plans to introduce ILS at Solent Airport, the possibility cannot be discounted. Nevertheless, the OFZ is less onerous than the other surfaces and if these are protected and free from obstacles then the OFZ will be protected by default.

Finally, the Plane of Approach Lights is a surface, or more commonly, a series of surfaces, based on the heights of the individual lights in the approach light system. It is established to ensure that objects do not obscure or distort the lighting pattern observed from aircraft on the approach. The plane extends from the threshold to 1.5 times the length of the system at a width of 120m equally disposed about the extended centreline of the runway. The gradient of the section beyond the outermost end of the system is an extension of the surface joining the threshold lights and the outermost light.

Solent Airport does not currently have approach or runway lighting installed so this does not apply to the airport. However, these may be installed in future upgrades and this must be considered within the context of developing the wider site.

2.6.1 Assessment

The closest point of the proposed National Grid development at Solent Airport is located just under 1km from the ARP and therefore is situated within the OLS. The AIP states that the ARP is 9.95m above mean sea level. Figure 2 (also included in Appendix A) illustrates the position of the buildings in relation to the airport and the OLS.

Figure 2 Position of buildings in relation to Solent Airport and OLS

Figures 3 and 4 (also included in Appendix A) illustrates the location of the buildings in relation to the OLS in further detail.

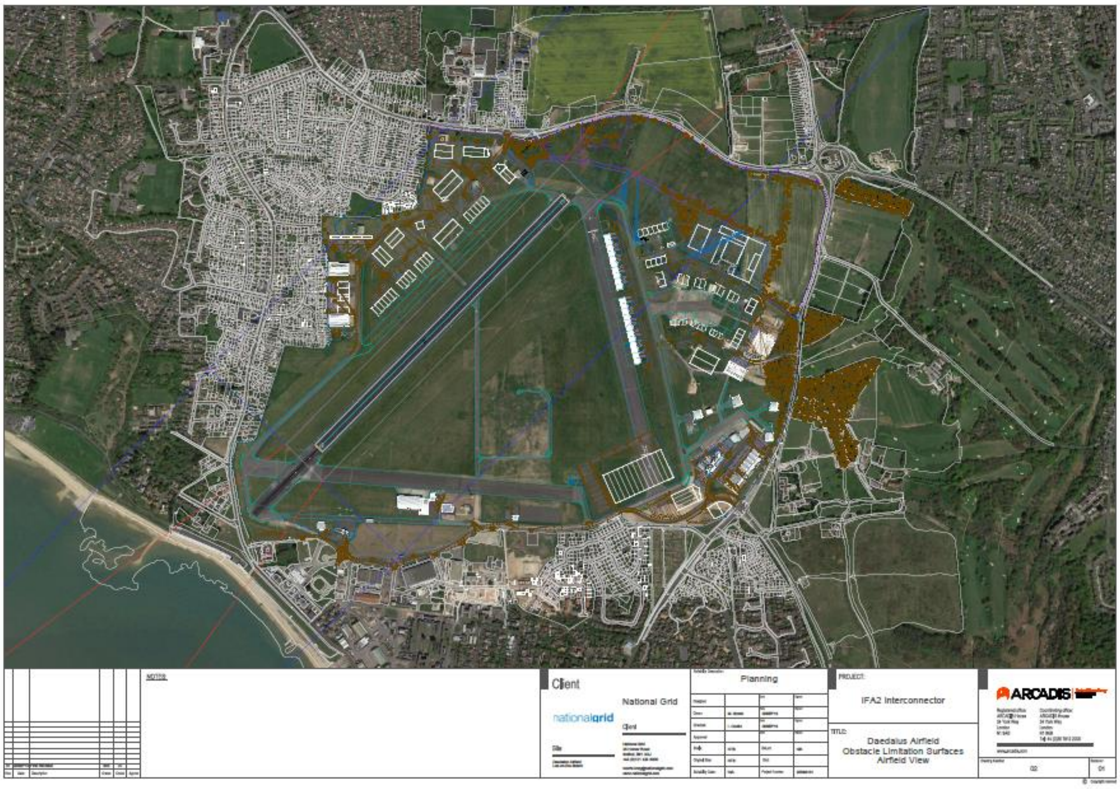


Figure 3 Position of buildings in relation to OLS with background image

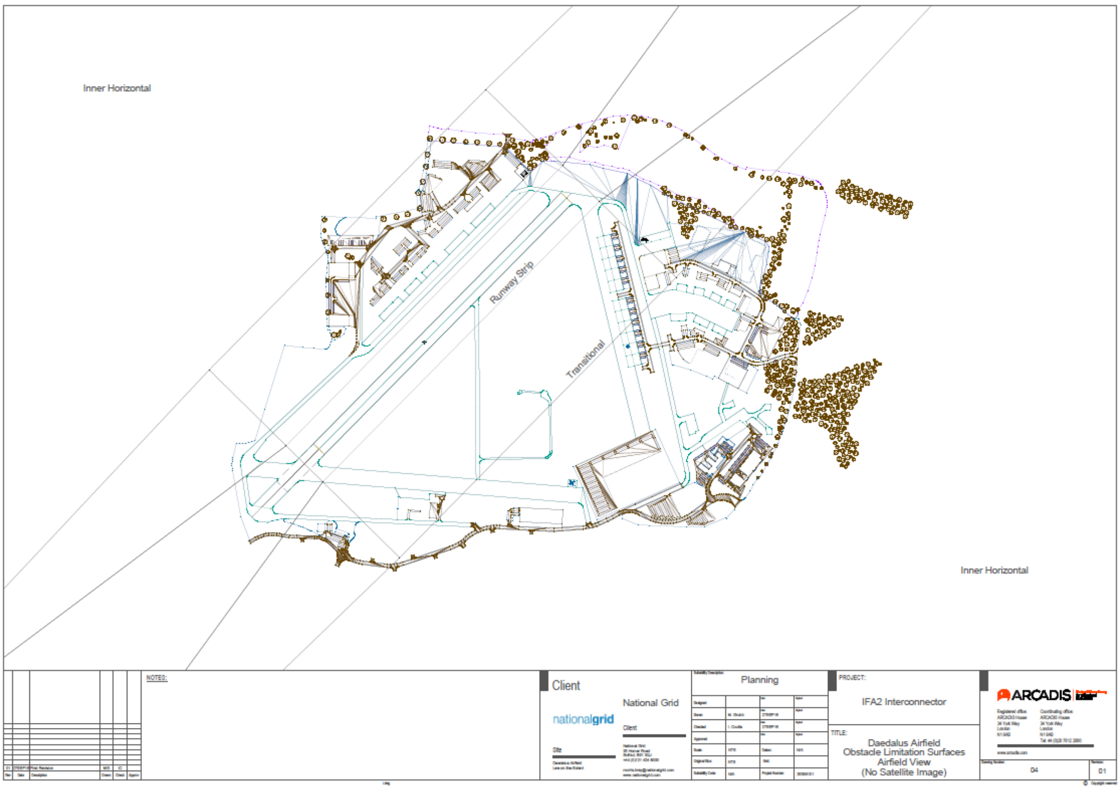


Figure 4 Position of buildings in relation to OLS without background image

Figure 5 shows the location of the Transitional and Inner Horizontal Surfaces in relation to the runway. The IFA2 Interconnector buildings are situated within both the Transitional Surface and the Inner Horizontal Surface. The buildings are not situated underneath any of the other surfaces.

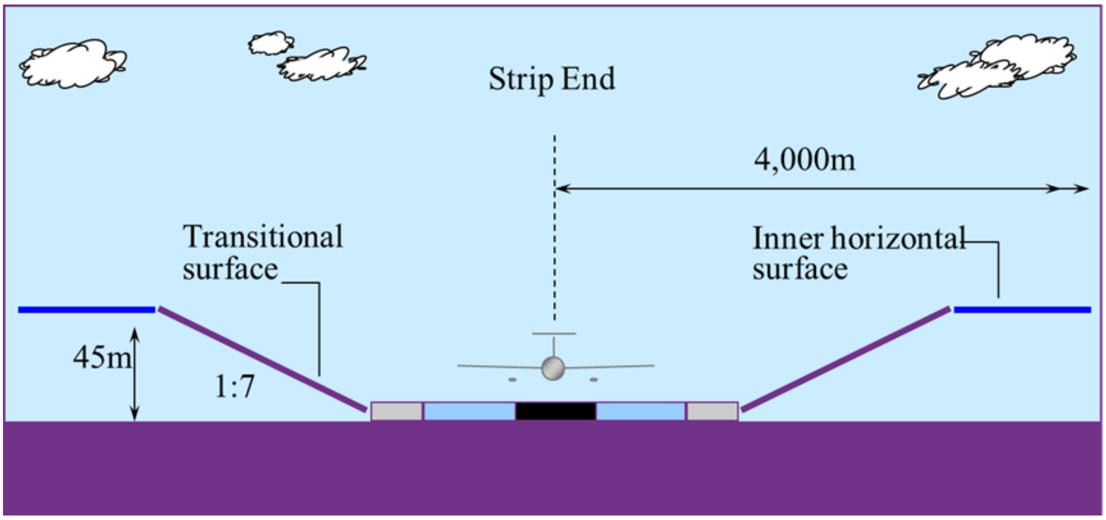


Figure 5 Transitional and inner horizontal surfaces

The Transitional Surface is a sloped surface rising 1:7 from the edge of the runway strip. It slopes up until it meets the Inner Horizontal Surface (IHS). The IHS is a horizontal surface located 45m above the surface of the ARP.

There are various different independent and connected buildings proposed within the site. However, the maximum height of any of the buildings within the development is 19.94m above ground level. This is the height of the vent stacks on the AC Filter Hall.

2.6.1.1 Transitional Surface

A portion of the development site is situated within the Transitional Surface and as described in the previous section, this is a sloping surface (slope of 1:7) beginning at the edge of the runway strip and ending where it meets the Inner Horizontal Surface 45m above ground level. The assessment has analysed the building closest to the most onerous section of the Transitional Surface and determined that it is situated under the maximum height that would create an infringement.

The height of the Transitional Surface at the most onerous section of the building is 36m.This clearance increases for the buildings situated further away from the runway. The maximum building height within the development site is 19.94m, therefore the development will not create an infringement of the Transitional Surface.

2.6.1.2 Inner Horizontal Surface

All new developments including buildings, vegetation and other obstacles must not exceed 45m above ground level. Anything higher than this would create an infringement of the OLS. The maximum height of the buildings are 19.94m, therefore the new buildings will not create an infringement of the OLS.

The location of the converter station in relation to the relevant OLS described above is illustrated in Figure 6 (also included in Appendix A). This demonstrates that the buildings will not infringe the surfaces and will therefore have no impact on the OLS.

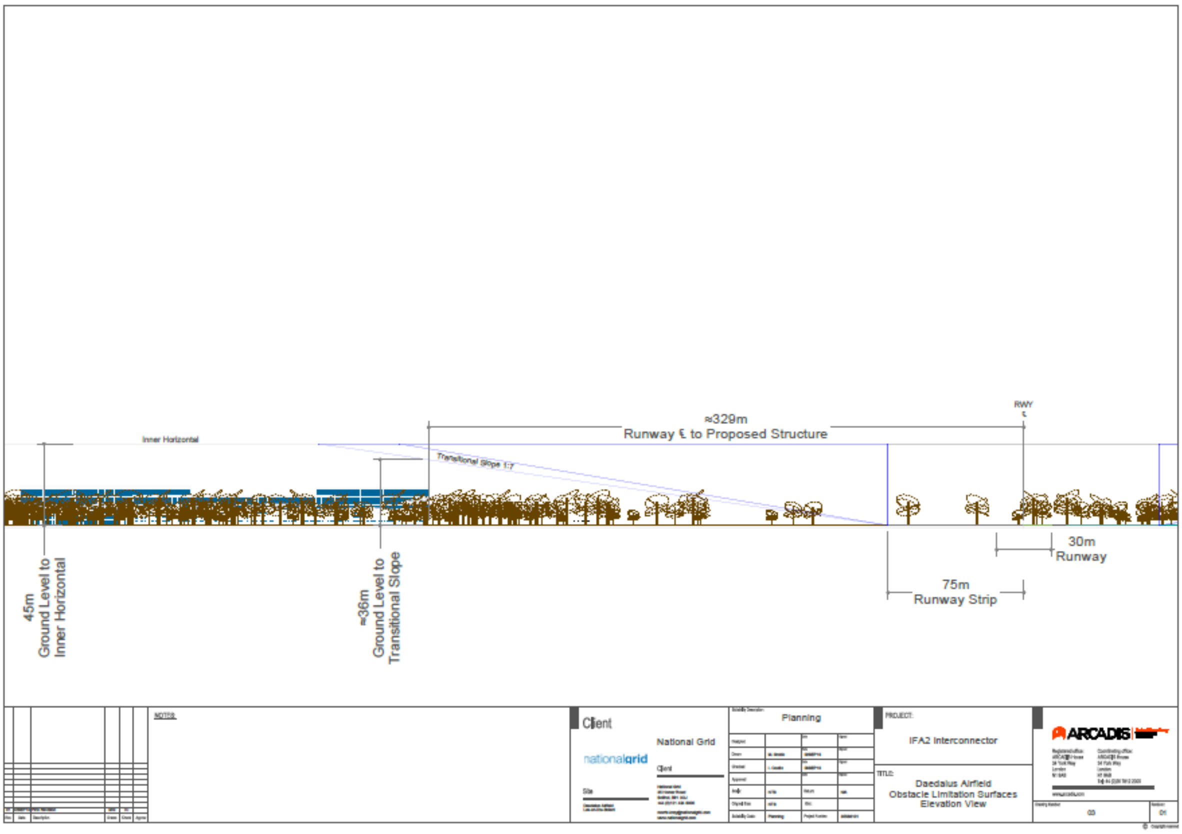


Figure 6 Location of the IFA2 Facility in relation to the relevant OLS

2.6.1.3 Landscaping

The plans indicate that landscaping and trees are proposed within the development. It is extremely unlikely that the trees will be taller than the buildings so no infringement is likely. Once established, the trees will continue to grow but they would need to be 45m in height before creating an infringement.

It is likely that other vegetation in the surrounding area that is more established will be an issue before the new trees on this site so they are not considered to be an issue from the perspective of the OLS. Regular pruning should be undertaken on surrounding vegetation if it is considered a risk to a potential infringement of the OLS. This is recorded as a contributory factor and action for ongoing management in the *Hazard Log* [2].

2.7 Bird Strike Hazard

Bird strikes – collisions between birds and aircraft – have been around since the dawn of aviation. The first bird strike fatality was recorded in 1912 when Cal Rogers, the first man to fly across America, lost his life after a gull became jammed in the controls of his aircraft. Since then more than 190 deaths have resulted from over 50 crashes of civil aircraft and over 300 military aeroplanes have been lost following bird strikes. The cost to the civil aviation industry worldwide is estimated to be over £750 million per year in damage and delays.

Aircraft are particularly vulnerable to collisions with large birds such as waterfowl and flocks of small and medium sized birds such as starlings and gulls. Most bird strikes take place when aircraft are below 2,000 ft., thus they are most susceptible when approaching to land at an aerodrome or shortly after take-off. Aircraft up to 13 km from an airport may be at this altitude; therefore, the aerodrome safeguarding process at airports will assess all developments within a radius of 13 km against the risk of bird strikes. It is essential that features attractive to birds are not introduced to the aerodrome or the surrounding environment unless they are proactively managed and monitored.

Provided certain bird attractant features are avoided, it is possible for landscaping proposals, including water features, to be acceptable to the aerodrome safeguarding process. Similarly, there are certain bird attractant properties in building design that should not form part of the design for buildings on or near an aerodrome. This applies to all developments at Solent Airport.

The main issue in building designs are flat or low-pitched roofs. These provide an ideal environment for loafing, roosting and nesting. The best way to mitigate this risk is to avoid flat or low-pitched roofs in the design of the building. However, this can be unavoidable in certain circumstances due to the nature of the development and the operational requirements of the building. Advice from the airport Operators Association (AOA) states that flat or shallow pitched roofs should not be greater than 10m x 10m. If this cannot be avoided in the design then all parts of the roof should be accessible by foot to ensure that any hazards arising from birds loafing, roosting and nesting can be dispersed and any eggs or nests can be removed.

As regards the IFA 2 facility the roof design is pitched, and all actions related to bird hazard management are captured in the safety justification and the hazard log.

2.7.1 Assessment

The first point of reference for airports regarding the management of wildlife on and surrounding the airport is *CAP 772 – Wildlife Hazard Management at Aerodromes* [10].

The proposed development includes various buildings of different sizes, some of which are connected to each other. Some of the buildings within the site are designed with a flat roof, others have pitched roofs. The largest buildings with flat roofs are the Control Building and the Service Building.

The design of the converter station has developed with consideration for bird hazard management. It includes a pitched roof with appropriate roof access for maintenance and clearing of birds' nests as required

A Bird Hazard Management Plan (BHMP) will be required to cover the management activities required in relation to the IFA 2 converter station buildings. There are several buildings proposed for this development and they are located in close proximity to each other. Therefore, one consolidated BHMP would be sufficient to manage all of the buildings. The BHMP will detail the inspection regime and activities undertaken to manage the risk of birds loafing, roosting and nesting on the roofs of the building. Given the nature of the development, it is assumed that there will be a permanent or regular on-site presence and that the buildings will be well maintained. A nominated person should be responsible for the plan.

Solent Airport already has an active Wildlife Hazard Management Plan (WHMP) in place. Therefore, an alternative to a standalone BHMP would be to integrate and update the WHMP reflecting the addition of the IFA2 Facility. The goals of the Solent Airport WHMP are:

- Reduce infringements of critical airspace by high and moderate risk wildlife species;
- Ensure that adequate systems are in place to define roles, responsibilities and procedures for managing wildlife risks at Solent Airport;
- Define the methods by which wildlife hazards are managed at Solent Airport;
- Develop performance goals and targets for adaptive management of wildlife issues and outline how these will be assessed and reviewed.

Solent Airport's WHMP states that the Airport Manager is responsible for the "*overall coordination, supervision and management of the WHMP"*. The airport Operations Wildlife Officer is responsible for implementing the WHMP. The WHMP is a comprehensive document detailing the overall aims and objectives of the process. It includes the operational methodology of mitigating the bird strike risk and outlines the roles and responsibilities for airport personnel.

To the put the bird strike risk at Solent Airport in perspective, for the last full year of available information, 2016, there were no reports of bird strikes at the airport. In 2015 there were also no reported bird strikes.

The IFA2 Facility is to be constructed within the boundary of the airport and will therefore be situated within the area covered by the WHMP.

The plans indicate that landscaping and trees are proposed within the development. However, the purpose of the landscaping is mainly to provide amenity. The proposals are not a significant part of the development. As particular varieties of trees and vegetation can attract birds, it is recommended that these are omitted from the landscaping plans to reduce the bird strike risk. However, if this is not feasible or desirable then the species should not be berry bearing, as berries are an attractant to birds. Regular inspection of the landscaping should be undertaken to ensure that no nesting is taking place.

2.8 Lighting

The approach and runway lights are protected by provisions in the *Air Navigation Order* [6] which states that other lights shall not be installed which are liable to endanger aircraft taking-off or landing, or which are liable to be mistaken for an aeronautical light. Situations that may endanger aircraft operations are:

- Where intensity causes glare in the direction of an approaching aircraft;
- Where the colour could cause it to be mistaken for an Aeronautical Ground Light (AGL);
- Where, when viewed from the air, they make a discernible pattern similar to AGL;
- Where the overall amount of illumination detracts from the conspicuousness of the AGL.

It is outside of the scope of work for this project but it should be noted that outdoor light displays, particularly those involving lasers, searchlights or fireworks, are also of concern if in the immediate vicinity of an aerodrome, or under one of the approaches, and should be notified to the CAA. Advice is available from, and notification of displays should be sent to, the Airspace Utilisation Section, Directorate of Airspace Policy / CAA.

2.8.1 Assessment

The main consideration regarding lighting for the IFA2 Interconnector is the location and positioning of lights on the buildings and immediate surroundings, such as car parks. Airport lighting is not currently installed at Solent Airport, however, night flying is permitted but only by resident aircraft. The only night flying permitted for visiting aircraft is for departures only. It is acknowledged that extension of night-time flying operations may be a possibility in the future. Consideration must be given to possible lighting of the airport in the future and it would be prudent to ensure that any lighting proposed on the development site must not obscure potential future airport lighting. Therefore, whilst lighting within the converter station compound would not obscure future runway lighting it could potentially distract pilots operating at the airport.

The final lighting detail and design for the site is currently being developed. However, the most effective method of ensuring that the lighting does not create operational issues for the airport is to use downward pointing lights with no or very limited light spillage. The AOA recommends [11] that flat glass full cut-off lanterns mounted horizontally be used. This will ensure that no light is emitted above the horizontal.

The AOA also reference the British Standard Institution's *BS 5489, Code of Practice for the design of road lighting* [12]. This recommends the use of lighting conforming to the maximum luminous intensity of lighting. Each class in Table 1 below is compliant with the flat glass full cut-off lighting principle. Ensuring the lighting design complies with this standard will protect potential future runway lighting and minimise pilot distraction from ground lighting.

It should also be noted that the same requirements apply to all buildings within proximity of the airfield and this is not unique to the buildings in the converter station compound.

Angle from the downward vertical	Maximum Luminous Intensity (cd / klm)		
	Class G4	Class G5	Class G6
70°	500	350	350
80°	100	100	100
90°	10	10	0
>95°	0	0	0

Table 1 Source: BS EN 13201 Road lighting, Part 2 Performance requirements, Table A.1 [13]

As the converter station buildings will not penetrate the Obstacle Limitation Surfaces there is no requirement to install aviation-warning lights on the structures.

2.9 Cranes

Normally cranes, and other items of construction equipment, are not subject to the planning application process, unless this aspect is made a condition of the planning permission for the development. In addition, cranes may be required for other purposes not involving new developments, such as maintenance and repair of existing structures. The BSI's *BS 7121, Code of practice for the safe use of cranes* [14] contains the following paragraph:

"*9.3.3 Crane control in the vicinity of aerodromes/airports*

The appointed person should consult the aerodrome/airport manager for permission to work if a crane is to be used within 6km of the aerodrome/airport and its height exceeds 10m or that of the surrounding structures or trees."

Note: The Air Navigation Order [6] makes it an offence to act recklessly or negligently in a manner likely to endanger aircraft.

Most airports in the UK have a crane authorisation process involving the issue of permits, covering both cranes on the airport and in the area covered by the British Standard. It is essential to consider this at an early stage of the development if it is anticipated that a crane will be required during construction. This is particularly important for the use of fixed cranes that cannot be removed or lowered quickly at the request of the airport.

2.9.1 Assessment

The issue of cranes is more of a construction issue than a planning issue at this stage but it should be considered as early as possible as it may impact on the construction method and programme. Cranes may be a particular issue in the vicinity of the main runway where temporary cranes may be necessary as part of the construction phase. Early consideration must be given to the type of crane anticipated.

Within the 6 km crane circle, it is usually best practice to operate cranes that are capable of being lowered on request within a reasonable period of time. Fixed cranes not capable of being lowered, particularly within or near the approach and take-off areas should generally be avoided. Fixed cranes within the 6 km circle but outside of the main approach and take-off areas can be acceptable provided close cooperation and coordination is in place between the airport and the crane operator.

Air traffic movements at Solent Airport are dominated by Visual Flight Rules (VFR) so in periods of low visibility airport movements are suspended, particularly as precision approaches are not currently possible. Therefore, any cranes situated in the vicinity of the airport should be visible to aircraft operating in the area.

The height of cranes may infringe the OLS and in this case, cranes over 45 m in AGL would result in an infringement of the IHS. However, as this is a temporary object this is generally accepted provided the appropriate information is promulgated via standard aviation communications, notably through the issuing of a Notice to Airmen (NOTAM) and the provision of obstacle lighting on the crane.

2.10 Conclusion

The IFA2 Converter Station has been assessed against aerodrome safeguarding criteria. The aim has been to ensure that the proposals do not currently impact on the safe and efficient operation of the airport and as far as is practical, ensure that future developments on the airport itself will not be impacted by the proposals.

The assessment analysed the new buildings against the OLS. The buildings are situated within the Transitional Surface and the Inner Horizontal Surface but at a maximum of 19.94 m in height, the buildings will not create an infringement.

The design of the IFA 2 converter station includes a pitched roof which reduces the potential to introduce bird hazards. The site will be well managed and there is a good relationship between the airport and surrounding operators, so the measures outlined in the report will be sufficient to ensure that the risk is at an acceptable level as defined by *CAP 760* [15]. This is recorded as an action in the *Hazard Log* [37] for the management of the converter station.

Lighting within the development should follow the AOA advice [11] to ensure that the operation of the airport is not adversely impacted.

The use of cranes during construction may present a temporary risk, but the type of crane used should be considered and agreed with the Airport at the earliest opportunity particularly as the site is in such close proximity to the runway, in order to assure that any risk is mitigated and is acceptable.

The development is considered acceptable from an aerodrome safeguarding perspective and will not adversely impact on the operations of the airport. Therefore, the plans for the IFA2 Converter Station will not conflict with aerodrome safeguarding criteria.

3 WIND ASSESSMENT

This section presents wind analysis to assess the potential impact of the IFA2 Converter Building, coupled with the future proposal of the Faraday Business Park buildings, on trailing winds on the main runway at Solent Airport.

Technical Assessment (Main Report) [1], *Technical Assessment – Wind Flow Analysis* [16] and the *Wind Flow Analysis for the IFA2 Facility* [36] reports have presented preliminary analysis of the wind flow around the Converter Building, based on outline proposals for the building structure. This work was undertaken in support of the planning application process for the IFA2 Facility, together with Hazard Identification and Risk Assessment [2, 37] and other Technical Assessments.

The preliminary analysis concluded that the highest relative increase in wind speed onto the main runway caused by the building is a maximum of 30%, at a height of 5m above the ground (for wind speeds of 10, 15, and 20m/s respectively). At low wind speeds like 5m/s, the building has little to no impact on the main runway in the wind direction coming from the direction of the building onto the main runway. Similarly, at wind speeds more than 5m/s in the same direction, there is no significant building wake impact above 30m above the ground.

It was confirmed within the Hazard Identification and Risk Assessment studies [2, 37] that localised changes in wind patterns are easily managed and that pilots quickly become familiar with any changes in wind patterns and adapt their flying accordingly through good airmanship.

A recommendation was raised in the *Technical Assessment* [36] that the analysis should be repeated when the final design of the converter station and future development plans for the area are known.

Since completion of the preliminary analysis, the design of the Converter Station has been revised, the height has been reduced and the building is more compact. Additionally, some further details are known regarding the landscaping in the immediate vicinity of the of the building. These changes have the potential to affect the previous results in terms of wind turbulence, which is likely to be reduced since the span of the geometrical extent has reduced.

More detailed wind analysis has now been completed where the model used to simulate the wind flow has been developed in more detail with the revised building profile and to take into account more of the immediate surroundings such as the upstream earth mounds planned (to relocate earth displaced by the construction).

As previously, the analysis assesses the potential impact of the IFA2 Converter Station on trailing winds on the main runway, considering both pessimistic and more realistic wind conditions.

Figure 7 below shows the extent of the domain (i.e. the area modelled) that is to be analysed using Computational Fluid Dynamics (CFD). CFD is a tool that uses numerical analysis and data structures to solve and analyse problems that involve fluid flows.

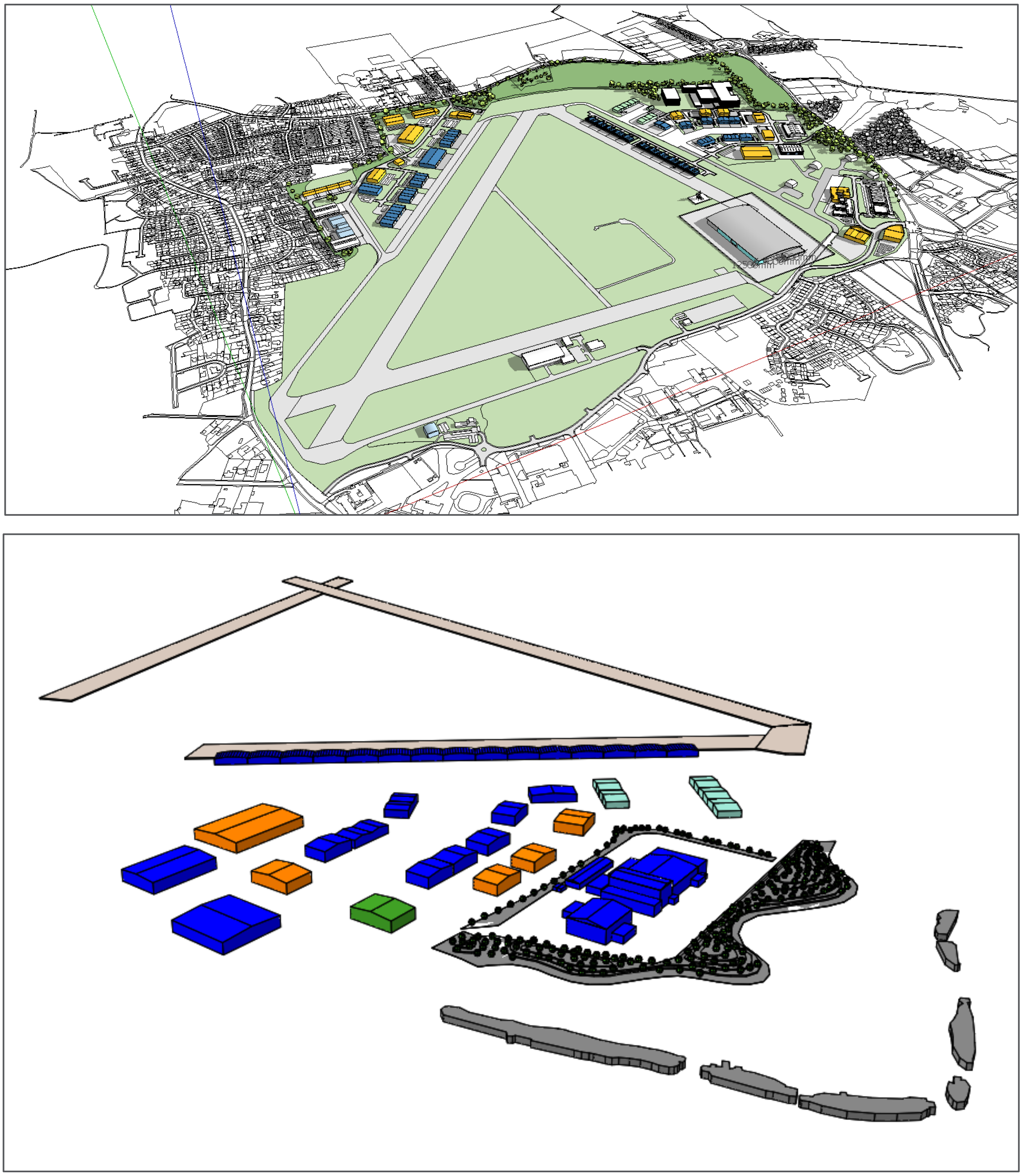


Figure 7 CFD Domain of Analysis

3.1 Analysis

3.1.1 Investigation of the Worst-Case Wind Direction

In order to determine the worst-case wind direction in terms of impact on the runway, a CFD analysis has been carried out. The method of CFD analysis has been chosen as the most appropriate tool to model the turbulence effects in the wind patterns.

The CFD analysis is based on a wind velocity of 20m/s since wind rose data indicates that this is likely to be the maximum wind speed. This input represents the meteorological wind speed which is measured at a height of 10m above ground. The details of this has been justified in the previous wind assessment reports [16].

Figure 8 below shows the analysis of a range of wind angles between 60^0 to 100^0 EoN (at 20m/s) to determine worst-case wind direction in terms of impact of the combination of buildings on the main runway (also see Appendix B for magnified images of the results).

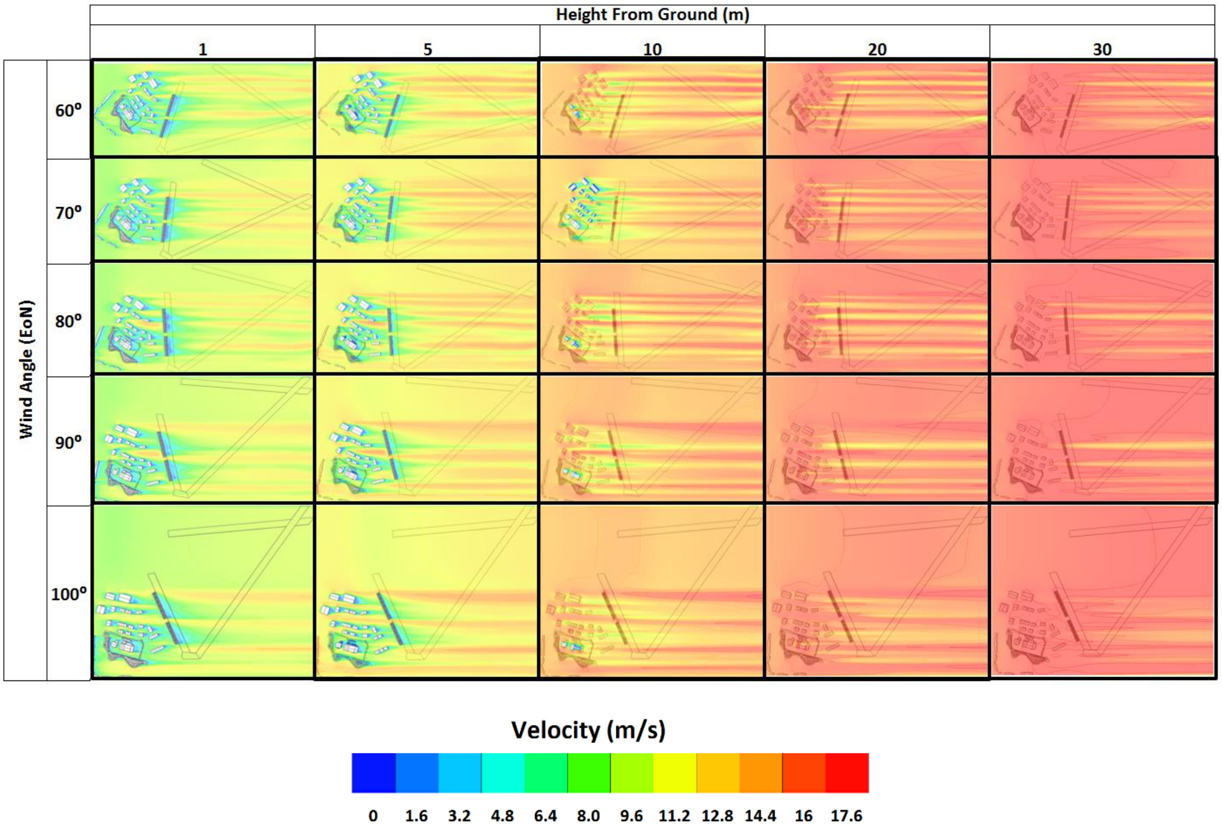


Figure 8 Results of wind flow for a range of directions and heights (flow direction from left to right).

In order to determine the worst-case direction in terms of impact on the runway, it is necessary to consider both wind speed and the zone of impact, a higher wind speed over a larger area being the worst case. From the results illustrated in Figure 8 above, it is concluded that the worst-case wind direction is at the angle of 90^0 EoN (East of North). Whilst the highest wind speed reached is similar for all angles, at 90^0 EoN the buildings produce the faster winds over a larger area on the main runway compared to the other angles. It is also worth noting that generally over a height of 20m above the ground, the building acts a windshield where the tails are slower than the prevailing wind direction.

Comparing the above results to the previous analysis in the *Technical Assessment* [36], repeated below in Figure 9, we find that the future proposed Faraday Business Park buildings both act as a shield to the IFA2 and have the overriding impact on the runway. This also explains the worst case changing from 70^0 to 90^0 EoN. The evaluation of the worst case is detailed in the next section.

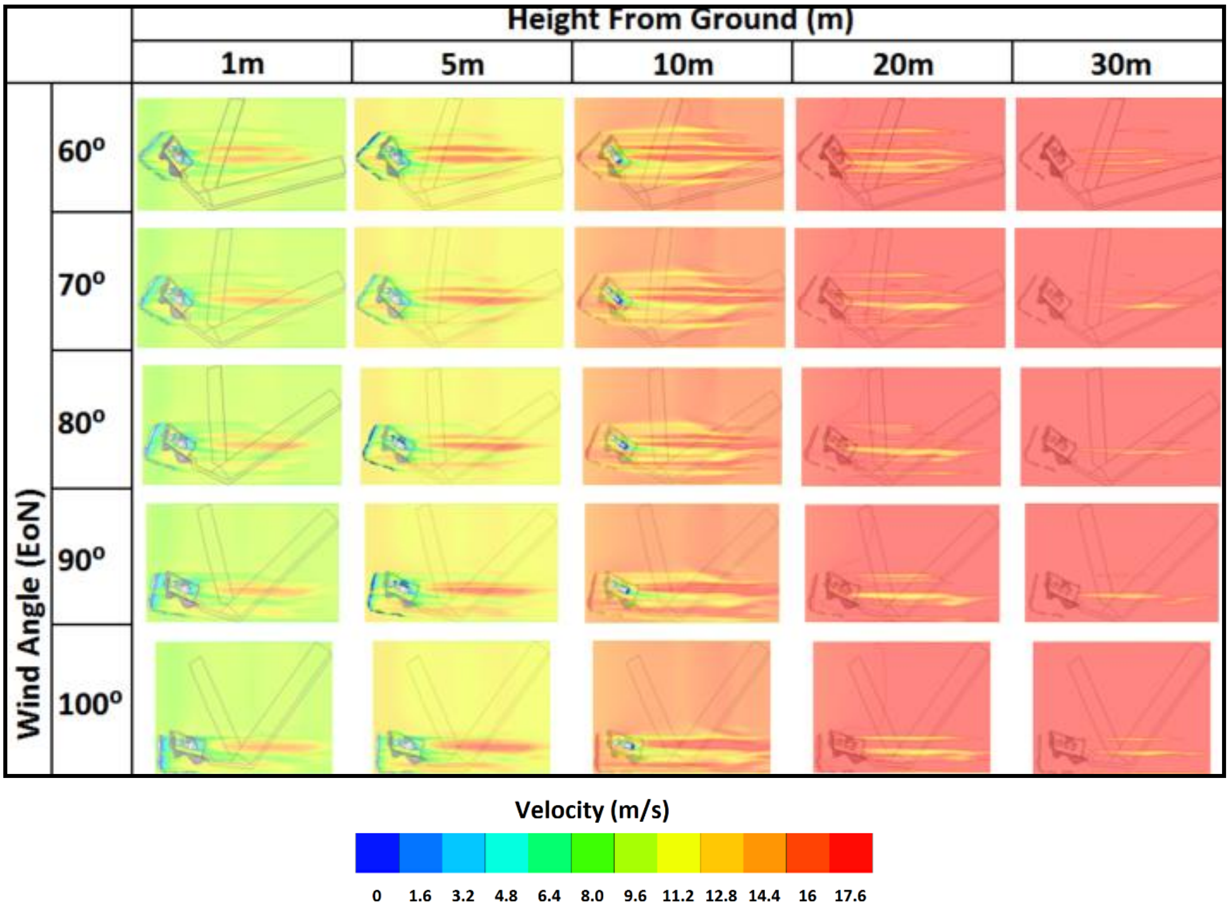


Figure 9 Results of wind flow for a range of directions and heights (flow direction from left to right) excluding the Faraday Business Park buildings [36].

3.2 Evaluation of Results

The 90^0 EoN is considered as the worst case angle for the new configuration that includes the Faraday Business Park buildings. Figure 10 below shows the results for 20m/s at 5m from the ground. The two red circles indicate that the main wind speed increase is due to the "frontline" buildings. The highest relative increase in wind speed onto the main runway in this case is a maximum of 29%. It is recommended that such buildings should be designed in a more continuous manner as illustrated in Figure 11.

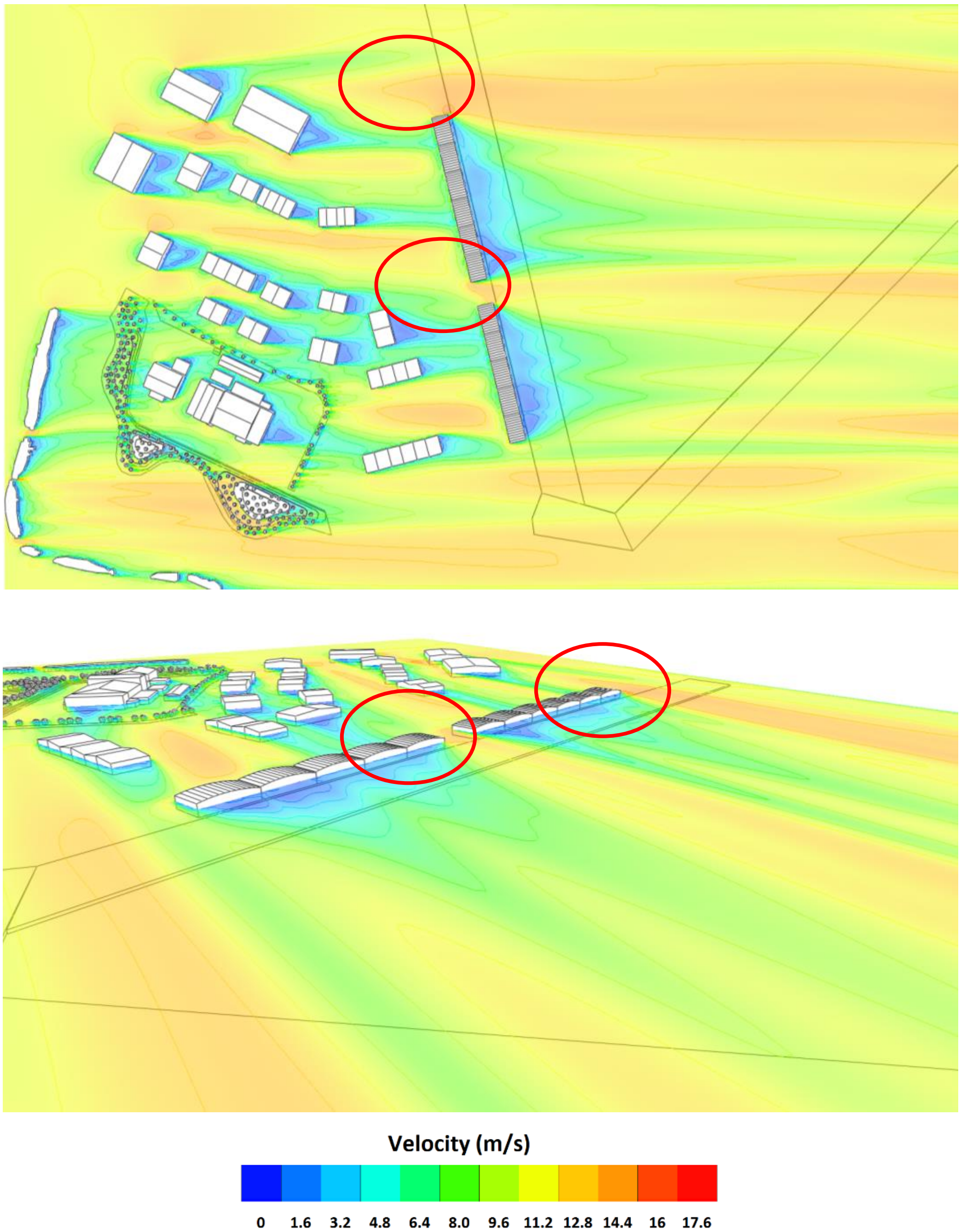


Figure 10 Angle=90^0, 20m/s at 5m from ground.

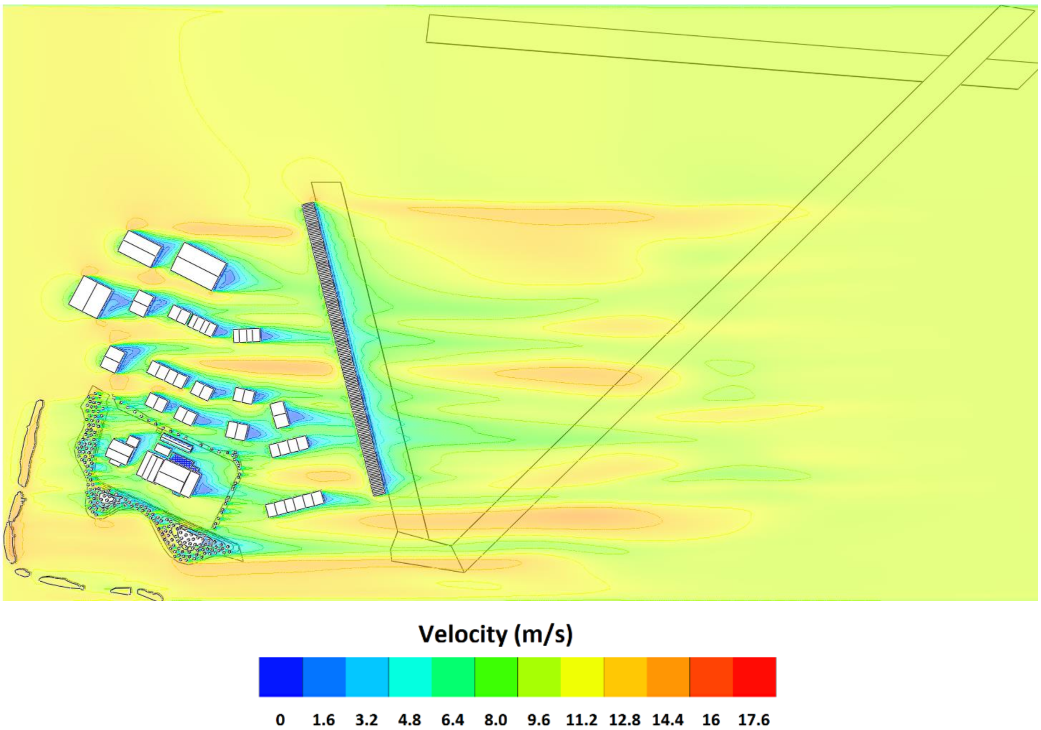


Figure 11 Angle=90^{0}, 20m/s at 5m from ground with buildings nearest the runways extended.

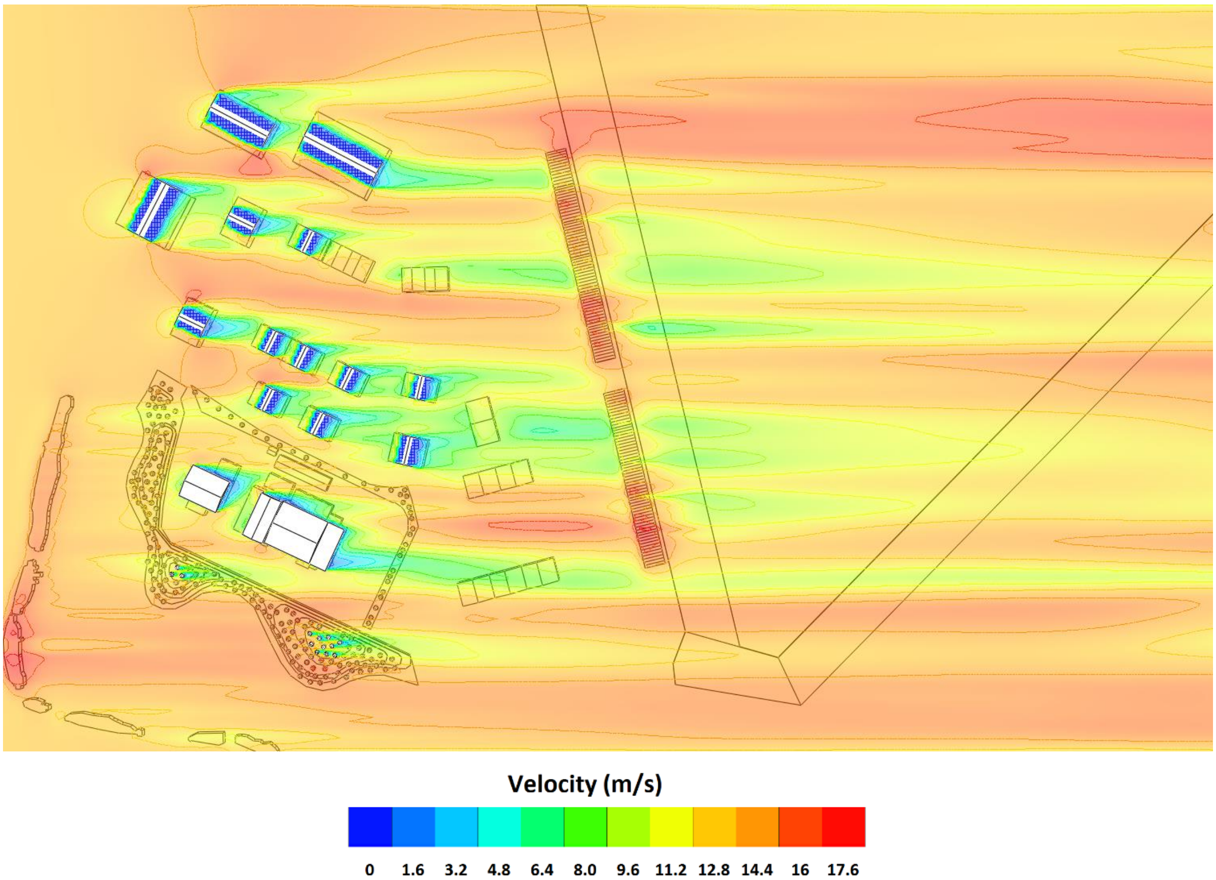


Figure 12 Angle=90^{0}, 20m/s at 10m from ground.

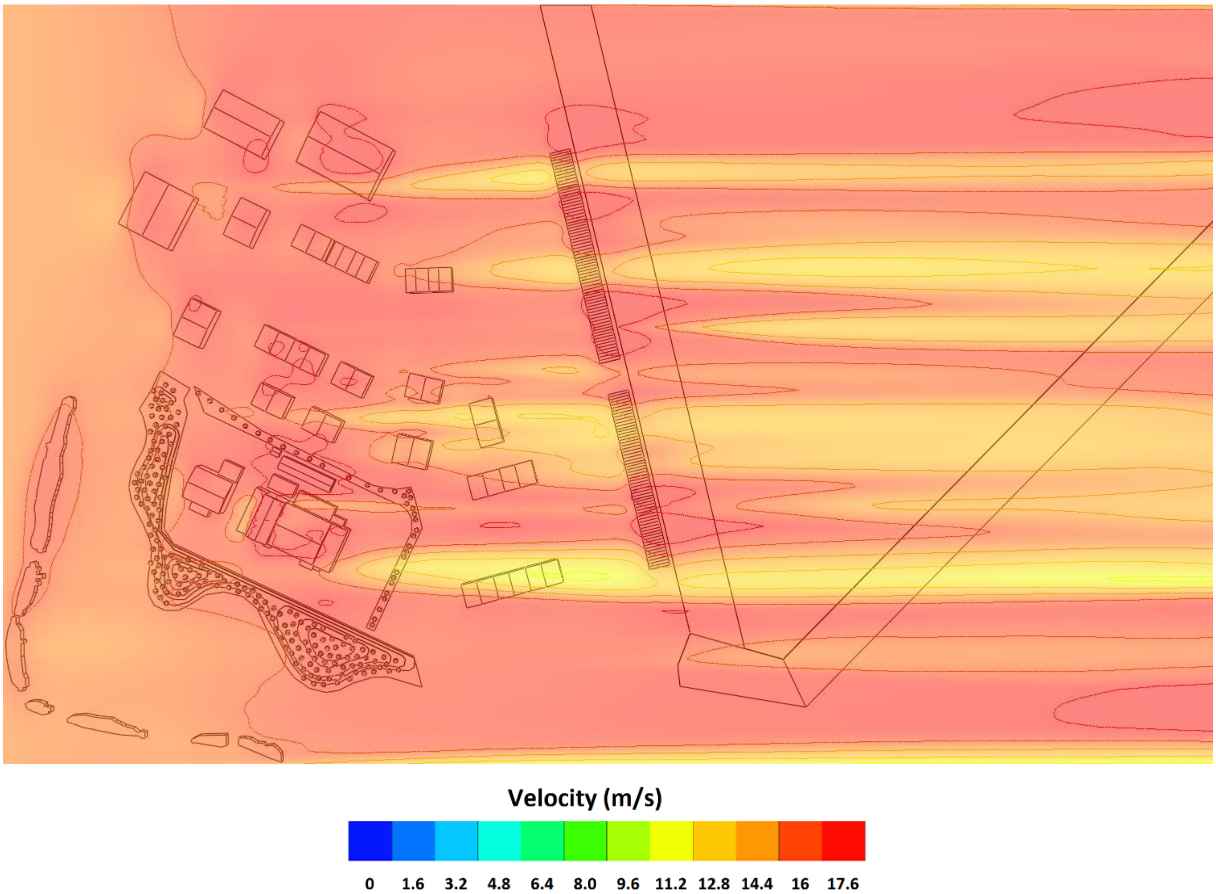


Figure 13 Angle=90^{0}, 20m/s at 20m from ground.

The main observations from Figures 12 and 13 is that above the height of 20m, the impact of the site on the runway generally diminishes.

It was confirmed within the Hazard Identification and Risk Assessment [2, 37] studies reported in the *Technical Assessment* [1] that localised changes in wind patterns are easily managed by good airmanship and reports issued to airport management through Notice to Airmen (NOTAMs) if necessary. It was also confirmed that pilots will quickly become familiar with any changes in wind patterns and adapt their flying accordingly.

3.3 Conclusion

The detailed wind effects analyses that have been carried out consider the impact of the updated design of the IFA2 Converter Station combined with the future proposed Faraday Business Park buildings on the main runway, and cover a realistic range of wind directions and wind speeds. One main effect observed is that the future proposed Faraday Business Park buildings act as a shield to the IFA2 Facility and have the overriding impact on the runway. This also explains the worst-case wind direction now being at the angle of 90^{0} EoN, compared to 70^{0} EoN from the earlier analysis when only the IFA2 Building is considered on its own. This is because at this angle, the future buildings produce three tails of faster winds, which covers the biggest area on the main runway compared to the other angles. The highest relative increase wind speed onto the main runway caused is a maximum of 29% at a height of 5m above the ground.

The wind impacts indicated above can be mitigated by extending the “frontline” buildings nearest the runways and closing the gaps between the buildings to form a complete wind shield to the runway from the 90^{0} EoN direction.

Additionally, it was confirmed within the Hazard Identification and Risk Assessment studies [2, 37] that localised changes in wind patterns are easily managed and that pilots quickly become familiar with any changes in wind patterns and adapt their flying accordingly through good airmanship.

4 ELECTROMAGNETIC FIELD (EMF) AND RADIO FREQUENCY INTERFERENCE (RFI)

4.1 Introduction

The Arcadis work undertaken during 2016 and 2017 to date, reported in *The Technical Assessments* [1, 36], included an independent peer review of the analysis carried out by other parties concerning the EMF and RFI effects of the IFA2 Facility. Since then further analysis has been carried out by other parties on behalf of NG which now also requires an independent peer review by Arcadis. Additionally, some areas where perceived “gaps” existed in the hazard mitigation evidence were identified in the *Technical Assessment* [36], based on the *Hazard Log* [37]. These “gaps” were thought unlikely to result in any significant safety impact, but further consideration is given to these here in order to confirm this.

Since the initial analysis, detailed in the *Technical Assessments* [1, 36], further analysis reports, listed below, have been issued to Arcadis, which we have reviewed and is reported in this section:

- RF Survey Test Report for IFA2, Development at Solent Airport [21];
- TV and Radio Reception Study [22];
- Radio and Telecoms interface and EMF assessment [25].

Arcadis has also been provided with and has reviewed the following draft document:

- Preliminary impressed voltage assessment for cables at Daedalus [28].

Other information concerning the IFA2 Facility design has become available which has been used for information as follows.

- Drawing: IFA2 Overview Map Daedalus New Boundary [24];
- Airfield Ground Lighting AGL ducting layout [20];
- More recent drawings on the cable cross section (*G3221.181I* [18] and *G-003-0219* [19]).

Specific areas identified in the *Technical Assessment* [36] that are given further consideration here are as follows:

- MCA equipment: Specifically, further information has been sought and checks made on certain MCA equipment to confirm that no adverse effects are expected from IFA2 due to EMF or RFI. The document *Operation Manual for the 935-11 DF System,* [23] has been provided for information;
- Some of the conclusions in the *Technical Assessment* [36] are confirmed, now further detailed design information is available concerning cable route and cross section [18, 19] and the Airfield Ground Lighting (AGL) [20];
- The model aircraft radio controlled equipment was identified for consideration in [36]. However, this was not identified at the FHA as being related to safety. Furthermore the model aircraft club stated that they intend to relocate from Solent Airport before the end of 2017 and saw no need to consider this equipment.

4.2 High Frequency Electromagnetic Interference (RFI)

4.2.1 TV and Radio Reception Study

The *TV and Radio Reception Study* [22] is a more recent issue of the detailed assessment of television shadowing effects, which was previously reviewed by Arcadis in the *Technical Assessment* [1]. As before, the analysis concludes that whilst there is a potential theoretical shadowing effect, the impact is not significant. The shadowing area predicted is smaller than in the previous version of this document, but the reason for this is not explained in the *TV and Radio Reception Study* [22]. It is understood that this is because the analysis is based on the revised profile of the IFA2 Building, which is more compact than assumed in the previous analyses.

It was suggested by Arcadis in the *Technical Assessment* [1] that where an electromagnetic signal is reflected and a receiver may receive two or more signals from the same source, the use of a multi-pad could improve coverage generally and reduce any risk of disruption to signals behind the convertor station even further. This had not been considered in the analysis. The use of a multi-pad is also not considered in this re-issued version of the document; hence this suggestion is re-iterated.

As advised in the *Technical Assessment* [36], the *TV and Radio Reception Study* [22] would benefit by being more transparent regarding underlying assumptions, calculation tools, criteria and methodologies used, etc. Additionally, it is suggested that a conclusion on digital audio broadcasting should be added.

In the *Technical Assessment* [36] Arcadis advised that consideration should be given to communication methods used by the emergency services (*Recommendation R8*) and that carrying out a survey in the potential shadowing areas, both before and after IFA2 would be beneficial to manage business risks (Recommendation R14). Both of these recommendations are re-iterated here. It is understood that there are plans in place to complete these recommendations.

4.2.2 RF Survey Test Report for IFA2 Development at Solent Airport

The *RF Survey Test Report* [21] reports on measurements taken of the ambient Radio Frequency (RF) environment at Solent Airport and compares them to the standard limit proposed by Cigré in *TB 391 – Guide for measurement of radio frequency interference from HV and MV substations* [26] which permits a higher level of emissions, measured 200 m from the installation. Based on this comparison, the report indicates that the use of the Cigré at-receiver limit will provide an appropriate level of protection against EMI to the reception of lower level signals.

Arcadis generally agrees with the conclusion as presented, however, as advised in the *Technical Assessment* [1], the *RF Survey Test Report* [21] would benefit from more transparency concerning underlying information that could potentially impact the results. In particular, information on sensitive parameters that can affect the results would be beneficial such as:

- Date and time each of the measurements were taken;
- The environment when the measurements were taken, e.g. fog or heavy rain, that can influence the measurements;
- Reasons why the selected locations were chosen and whether the three measurements were taken at the same time as the signal can change;
- The basis behind the radio signal frequency range selected in the context of IFA2;
- The basis behind the selected method of measurements and justification that this provides sufficient accuracy.

Since the issue of this report, further clarification has been provided on the conditions at the time the measurements were taken. It is recognised that the measurements were intended to provide an indication in a typical environment.

4.2.3 Radio and Telecoms Interface and EMF Assessment

The report *Radio and Telecomms interference and EMF assessment* [25], produced by the Main Contractor for the IFA2 Converter Station (ABB), discusses the sources of electromagnetic disturbance due to the converter station at Solent Airport and describes steps to mitigate this disturbance and limit exposure to EMFs. Overall, it is considered that the calculation methods described in the report are appropriate and correct in theory. Testing and measurements will be required as the project progresses to confirm that the requirements concerning exposure limits are met and this is recognised in ABB’s report [25] as a conclusion. The need for testing and measurement to verify that safety requirements are met is recorded as a dependency in the Safety Justification [38].

The report [25] assumes that all equipment will be placed in metallic enclosures or buildings. However, it should be noted that the cables will have to leave the IFA2 Building, where they could function as antennas and cause electromagnetic radiation. This needs to be considered as further mitigation may be required to prevent electromagnetic disturbance.

Table 2 in the report [25] details measures for extended mitigation specific to the converter station at Solent Airport as outlined in the *RF Survey Test Report* [21] and the design measures that are being implemented. The general design measures are believed to be suitable, but the use of materials may present an issue regarding the longevity of the design. The use of several metal types can lead to electrical corrosion and reduce the life time of the ‘box’ surrounding the converter equipment. The corrosion process may be accelerated due to the proximity of the development to the sea. It is also suggested in Table 2 of the report

[25] that a thinner steel can be utilised without losing shielding efficiency, although no clarification is given why this is the case.

4.2.4 MCA Equipment

It is possible that some MCA equipment could potentially be susceptible to EMF or RFI effects from the IFA2 Facility. A meeting was held on the 25th July 2017 with MCA to establish the equipment that is important to MCA's operations, the meeting minutes [27] highlight MCA interfaces and equipment. This concluded that the equipment that needed to be considered in the context of IFA2 are:

- a GPS based flight management / terrain awareness system;
- a homing device;
- a weather radar system;
- remote controlled lights on the runway.

Very little documentary information was available for this review; the only document provided being the *Operational Manual for the 935-11 DF System* [23] referred to by MCA as the "homer". This gives limited technical information. It is understood from this however that this is a GPS location system with a few radio communication and Search and Rescue facilities. MCA has advised that they set the equipment up on the apron outside the MCA facilities at Solent Airport. Following arrival at the rescue area they use the equipment to locate precisely the casualty.

Regarding the GPS based systems, it is considered highly unlikely that GPS will be subject to disturbance from the IFA2 Facility due to the frequencies used and the way that GPS make uses of several satellites for positioning.

The *DF Operation Manual* [23] details six receivers for the homer which are working in the 30 to 470 MHz band. There is no potential for disturbance due to IFA2 during flight. The only area where disturbance cannot be ruled out is within 200m of the converter station (based on the Cigré standard [26]), which could only occur in the event of very low flight above the IFA2 convertor station. With the recent work in [26], this limit may be changed to 60m. Due to the flight speed the helicopter would only be within a range of 200 meters from the convertor station for a very short duration.

Based on the *DF Operation Manual* [23] the homer also uses a beacon system. It is understood that this is mostly used during flight and for search and rescue and no disturbance would be expected from the convertor station.

There is no information available concerning the weather radar system and the remote control of the runway lighting. If these are far away from the cables (other site of the runway and taxiway and more than 200 meters from the convertor station) no disturbance would be expected. Further information would be necessary to confirm this as distances cannot be established from the information available.

4.2.5 Other Comments

Considering the revised building layout and locations and comparing this with the Cigré specifications [26], one new building is now situated within the 200 meters distance of the convertor station. The 200 meters is the distance in Cigré within which there is no guarantee that the RFI/EMC limits are below the European specifications. However the more recent work (References [21], [25 and [41]) is recognised, which once the work is completed, is likely to demonstrate negligible emissions 30m from the converter station and beyond.

Note that this comparison has taken the measurements locations in the *RF Survey Test Report* [21] and Figure 14 below shows the south-west corner of the IFA2 Converter Building (taken from Google Earth). The approximate location of the corner of the convertor building is based on the drawing *G3221.184I Overview map Daedalus New Boundary* [24].

Figure 14 Location of the south-west corner of the IFA2 Converter Building (Source: Google Earth).

4.3 DC and Low-Frequency Interference

4.3.1 Radio and Telecoms Interface and EMF Assessment

Arcadis has reviewed the calculations in the *Radio and Telecomms Interference and EMF Assessment* [25], with regards to DC and low frequency interference, and we are in general agreement that the values for power frequency electric and power frequency magnetic fields do not exceed the indicated norm at the station fence. Therefore, there is no violation of exposure to field levels expected at this location.

However, a few important questions are raised which require clarification:

1. What sources / source currents have the simulations used and whether the values used are in accordance with the expected operational currents? The field strengths are proportional to the sources and are therefore of paramount importance to the integrity of the results.
2. It is reported in Section 2.2 of the report [25] that "*the EMF requirements stated in "E2.1-a.i Converter System Basis of Design", together with the revision in "TB233 EMF requirements*"" applies for electric and magnetic field levels. It needs to be clarified what standards these levels / test values are compatible with e.g. European standard. It is noted that in the standard *ICNIRP* [40] the power frequency electric field indicates 5 kV / m (rather than 9 kV / m) and the power frequency magnetic field 100 µT (rather than 360 µT). Even so, these values are not exceeded by the currently reported simulation results.

4.4 Preliminary Impressed Voltage Assessment

A draft document, *Preliminary impressed voltage assessment for cables at Daedalus* [28], has been provided which states the cable contractor's intentions regarding assessing the risks of induced voltage by the cables on the following objects:

- The fence line around Daedalus airfield;
- The fence line around the converter station;
- Existing metal objects installed underground (i.e. metal pipes and drains);
- New drains (if metal);
- Existing/New LV cables installed in the airfield to provide lighting to the runway.

Arcadis has reviewed this document and no significant issues have been identified, however the following comments have been sent to NG for the development of the plans stated in the *Preliminary impressed voltage assessment* [28].

Chapter 4 of the *Preliminary impressed voltage assessment* [28] considers induced voltage and earth potential rise of the ground near the facility and the fact that cables grounded near the facility could transfer this voltage to elsewhere. This phenomenon of transfer potential can also occur the other way around: Cables (cable shields), coated metal pipelines or other long conductors grounded elsewhere bring zero voltage to an environment which in case of an earth fault has been risen to a high voltage, again creating potential large voltage differences.

Large gradients may occur across the soil immediately next to the facility, in case of an earth fault. Chapter 4 concludes that this will have to be assessed when full details are known. This is agreed, Arcadis advises that the assessment of Earth Potential Rise is kept under review.

Chapter 5 of *Preliminary impressed voltage assessment* [28] considers voltage induced due to magnetic coupling. Arcadis generally agrees with the statements made in the *Preliminary impressed voltage assessment* [28], in particular:

"The distance between the fence line and the power cables is considerable for the majority of route (i.e. over 50 metres) and therefore induced voltage on the fence will be negligible."

Arcadis believe that induced voltages on the fence are unlikely to exceed the norms, based on the source being a cable and the separation between cable and fence. The length of the parallel geometry however was an area of uncertainty. Checks based on the norm *NEN 3654, Mutual Influence Of Pipelines And High-Voltage Circuits* [29], referred to as a "unity check" indicates that induced voltages on the fence should not exceed the norms.

Chapter 5 states that "Metal objects that cross power cables will not cause a problem with regard to induced voltage. Only metal objects that run parallel for long distances (i.e. km), this is agreed. The fence at the perimeter of the airport is a metal object that runs parallel for over 1 km, however, it has been agreed that no harmful voltages are expected to occur on the perimeter fence.

4.5 Conclusion

Based on the information reviewed as stated above, although further testing evidence is required , there are no issues raised concerning EMF/RFI emissions due to IFA2 and the expectation remains that risks concerning RFI and EMF will be acceptable as defined in *CAP 760* [15]. Work is in progress on the testing and measurement activities that are planned to verify that requirements are met. All verification required to demonstrate that safety requirements are met is recorded as a dependency in the safety justification.

Recommendations raised in the *Technical Assessment* [36] continue to remain valid. In particular, the recommendations shown in Table 2 below are relevant to this review. Some points that require clarification are raised by the assessment, these should be addressed as the design documentation develops.

No	Recommendation	Current Status
R8	The analysis on RFI so far has focussed on safety related systems. Consideration should also be given to potential interference to other objects and systems, e.g. businesses, mobile phones, etc. which should comply with IEC 61000 standards [30].	RFI impact is concluded to be low / negligible. Some additional recommendations are raised for mitigation of business risk, rather than any safety risk (See R14). Communication methods used by fire brigade or police within an area less than approximability 150m of the convertor station should be checked. This is included as part of the hazard mitigation action in M16B.
R14	It is recommended that measurements are made of existing digital TV and radio shadowing effects in the nearby residential areas, the business parks on the airfield, and users of surrounding land. This will enable a comparison with measurements after the IFA2 Facility has been built to allow for mitigation of business risks, if required.	
R15	It is recommended that a drawing of the airport be created showing all the new and installed equipment and cables, together with the EMC/EMF and RFI influence area. This will provide a reference basis and assist future planning for airport development.	

Table 2 Review of recommendations [36]

5 AVIONICS IMPACTS OF EMISSIONS

5.1 Introduction

This section of the report considers the potential impact on aircraft avionic systems from any radio frequency emissions from the IFA2 Facility.

It has been determined that any emissions from the facility would be of the form of low-level wideband noise that will rapidly diminish with increased distance from the facility. Furthermore, it has been confirmed that the emissions are not at a level to cause equipment damage. It has also been determined that magnetic fields from the facility and associated cables will be localized and less than 10 micro Tesla.

Solent Airport currently supports a diverse range of aircraft operations including:

- General and business aviation fixed and rotary wing aircraft;
- Coastguard Search and Rescue helicopters comprising Leonardo AW169 and Sikorsky S92 aircraft;
- Military aircraft including Hercules, Apache and Chinook aircraft;
- Unmanned Aerial Systems.

The airport is currently a visual operation and does not have any airfield radio navigation aids, although it has been assumed that:

- There are currently aircraft operations into the airport that are supported by but that are not dependent on the use of satellite navigation;
- In the future GNSS Instrument Approach Procedures may be introduced at Solent Airport.

5.2 Approach Taken

Due to the diverse nature of the aircraft and operations into Solent Airport the assessment has taken a generic approach to assess the impacts of the power conversion facility on applications and supporting technologies for which civil aviation standards exist.

The assessment of impact on military aircraft is therefore limited to systems that are required for aircraft to operate as General Air Traffic (GAT), which encompasses all flights conducted in accordance with the rules and procedures of the International Civil Aviation Organisation (ICAO). By this definition some equipment carried on military aircraft required for State operational purposes, known as Operational Air Traffic (OAT) may be beyond the scope of this assessment.

Unmanned Aerial Vehicles (UAVs) currently cover a broad range of platforms and missions that are not yet subject to agreed standards. The assessment of UAV technologies is therefore undertaken at a high level and may require further assessment as the technologies mature.

It should be noted that there are many diverse UAV operations for photographic purposes e.g. overhead line and building inspection. These operations raise the potential for UAVs to be operated in very close proximity to, or even within the power conversion facility, and are therefore outside of the operational envelope of a conventional aircraft.

5.3 Impact on Avionics Systems

5.3.1 Flight Management System

The manner in which equipment is integrated on modern aircraft is unique to each aircraft type. Historically Communications, Navigation and Surveillance (CNS) equipment were installed on aircraft as equipment performing specific functions. In current avionics, there is a high degree of integration that combines diverse functions and data into what is generically termed a Flight Management System (FMS), although the precise terminology and system boundaries vary between system suppliers and aircraft integrators.

An FMS is an on-board multi-purpose navigation, aircraft performance and aircraft operations computer. It is designed to provide integrated and harmonised data between different elements associated with a flight from pre-engine start and take off, through to landing and engine shut-down.

An FMS comprises four main components:

- The flight management computer;
- The automatic flight control or automatic flight guidance system;
- The Aircraft Navigation System;
- An Electronic Flight Instrument System (EFIS) or equivalent electromechanical instrumentation.

The FMS may also include capabilities to integrate high resolution digital maps and to display weather radar images.

It has already been established that the emissions from the power conversion facility will be low level wideband 'electrical noise' that will not cause damage to electronic systems. As a result, the impacts on aircraft systems relate to the potential for loss or corruption of data fed to the FMS processing systems from various sensors on the aircraft that have external antennas.

5.3.2 Aircraft Navigation Function

The aircraft navigation function continuously determines the aircraft position using a combination of data from different sources to establish the most probable position. Sensors that contribute to the estimation of position may include Inertial Reference System (IRS) and Global Navigation Satellite System (GNSS) inputs in addition to receivers for ground based navigation aids such as Non Directional Beacons, VHF Omni Range Distance Measuring equipment and Instrument Landing Systems (NDB, VOR, DME and ILS). Other inputs may include information from the air data computer derived from the static and pitot ports that sense the external air pressure.

5.3.3 Aircraft Functions other than Navigation

In many aircraft the FMS, or sensors that provide inputs to the FMS, also supply Position Navigation or Time (PNT) data to other aircraft functions including but not limited to Terrain Awareness and Warning System (TAWS) and Automatic Dependent Surveillance-Broadcast (ADS-B)

Additionally, the FMS may provide time for the synchronization of the aircraft clock and precise time stamping of data messages and aircraft position for cabin moving map displays.

5.3.4 Terrain Awareness and Warning Systems (TAWS)

Terrain Awareness and Warning Systems (TAWS) are also referred to as Ground Proximity Warning System (GPWS) or Enhanced (EGPWS). TAWS is an automatic safety net that acts to reduce the incidence of Controlled Flight into Terrain which historically has been a major cause of aircraft accidents.

The TAWS function relates the aircraft position in three dimensions, determined from GNSS that may be derived from the FMS, or a dedicated GNSS receiver, to a digital terrain/obstacle/airport database. This enables independent confirmation of the aircraft height over the terrain map.

The TAWS also takes inputs from the radio altimeter and from other navigation sensors to provide a timely and distinctive warning to the flight crew of sink rate, ground proximity, rising terrain ahead of the aircraft, altitude loss after take-off or go-around, incorrect landing configuration and downward glide slope deviation.

It is worthy to note that TAWS is a safety net and is not certified for aircraft navigation. Attention is drawn to the loss of an S92 search and rescue aircraft in Ireland in May 2017 where the TAWS was ineffective, as an island was not included in the terrain database.

5.3.5 Automatic Dependent Surveillance-Broadcast (ADS-B)

ADS-B is a modern surveillance technique that relies on aircraft broadcasting their identity, GNSS position and other information derived from the aircraft FMS. This information is broadcast on the aircraft transponder and can be received on the ground for surveillance purposes (ADS-B Out) or on-board other aircraft in order to facilitate airborne situational awareness and aircraft spacing and self-separation (ADS-B In).

5.3.6 Attitude and Heading Reference Systems (AHRS)

The AHRS provides attitude, pitch and roll, heading, turn, standard turn bank angle, slip, angular rate, acceleration, and other information to enable a pilot, autopilot or other equipment in the aircraft to control and guide the aircraft in a safe manner.

The primary inputs to the AHRS are from on board inertial and magnetic sensors. The AHRS may also be aided by inputs from other sensors including an Air Data Computer or GNSS. The loss of the aiding inputs may cause AHRS mode changes and degraded performance.

It is noted that there has been a reported occurrence of in-flight disturbances in a Phenom 300 following loss of GNSS that resulted in cascaded failures of the AHRS, stall warning protection and yaw damper systems.

It is noted that in some aircraft, attitude and heading information from the AHRS may also be provided to assist weather radar antenna pointing. Additionally, it is possible that GNSS aiding may be employed within the SAR aircraft, embedded within searchlights and FLIR/Cameras for stabilization.

5.4 Impact of Wideband Noise on Aircraft Sensors

5.4.1 VHF/UHF Communication and Conventional Navigation Aids

Noting the similarities in the powers, frequencies and modulation schemes of the Radio Frequency (RF) technologies in navigation and aeronautical and maritime communications systems, these systems are considered as a ‘technological class’ of systems.

Conventional communication and navigation systems used in aviation applications are based on analogue technologies employing high power transmitters with amplitude, frequency or pulse modulation systems. The use of high power transmitters, together with relatively narrow band receivers, results in high signal to noise ratios.

The limited RF bandwidths of this class of system effectively limits the noise power from a wideband emission that could enter the receiver. In the event of high levels of interference, the performance of the communications channel will gracefully degrade with reduced audio signal to noise ratios.

5.4.2 Global Navigation Satellite System (GNSS)

It is clear from the analysis in this document that position derived from GNSS is a key input to many aircraft safety related systems, including navigation, TAWS, ADS-B and the AHRS. It should be noted that the AHRS also provides steering commands to the flight control systems.

The spread spectrum signals from GNSS satellites were designed to be covert and are below the level of the thermal noise. The GNSS receiver uses correlation techniques to recover the GNSS signal. Any wideband interference within the GNSS frequency band adds to the level of the existing thermal noise, although the receiver is able to recover the GNSS signals with noise levels significantly higher than the thermal noise level.

Aircraft use of GNSS and the GNSS receivers employed are subject to certification by regulatory authorities. In Europe, this role is undertaken by the European Aviation Safety Agency (EASA). The loss of GNSS is a consideration in the aircraft certification process that requires an alternate means or reversion mode to be available on the aircraft.

5.4.3 Radio Altimeter

Radio altimeters are used primarily in the areas around airports during aircraft approach and landing although they continue to operate throughout a flight providing an input to the TAWS safety net.

The radio altimeter determines aircraft height by transmitting a signal towards the ground and by measurement of time delay or phase between transmitted and received signals. Radio altimeters operate in the 4200-4400 MHz band and are either pulsed or Frequency Modulated Continuous Wave (FMCW) systems. The altitude measurement range of radio altimeters is typically between 100 to 2500 feet. Radio altimeters employ a large bandwidth that allows accurate measurements to be performed with low levels of transmitted power.

As with all radar systems that rely on passive reflection, the received signal has a low signal to noise ratio. Any wideband electrical noise emissions from the facility would increase the receiver noise floor potentially eroding radio altimeter sensitivity.

The major factor that mitigates the impact of wideband noise is that the radio altimeter has a high gain antenna with a narrow beam-width directed towards the ground. The directional antenna therefore reduces the area of influence of any interference sources on the ground to being directly under the aircraft.

5.5 Conclusion

The analysis considers the potential impact on aircraft avionic systems from any radio frequency emissions from the IFA2 Facility and concludes that there are no impacts of concern; any emissions from the IFA2 Facility will rapidly diminish with distance and will have no discernible impact on aircraft that are operating within the normal bounds of the airfield.

6 INSTRUMENT LANDING SYSTEMS

6.1 Introduction

Solent Airport currently supports visual operations and does not have any airfield radio navigation aids. This section of the report identifies potential future options that may be available for the airfield to improve the navigation environment and analyses their compatibility with the airport and with the IFA2 Facility.

The option for future upgrading of the aerodrome to have an instrument approach capability, which is expected to have the strongest business case for implementation, is also proposed.

6.2 Aids for Aerodrome Location

Before the advent of satellite navigation many aerodromes (e.g. Cotswold, Shobdon and Rochester) serving General Aviation (GA) aircraft, installed Medium Frequency Non-Directional Beacons (NDBs). The NDBs enabled aircraft equipped with Automatic Direction Finding (ADF) equipment to navigate to the aerodrome. Other airfields additionally installed a Distance Measuring Equipment (DME) allowing aircraft to determine distance to the aerodrome (e.g. Blackbushe and Fairoaks).

When NDB and DME are used together, by having a range and bearing to the aerodrome, an aircraft can determine its own position relative to the navigation aids, which also allows it to remain clear of other airspace structures. NDB and DME facilities installed in this manner provide pilots with an aid to navigation, although the facilities provide no operational credit to improve the aerodrome operating minima. It is noted however, that a number of training organisations have designed ‘discrete’ Instrument Approach Procedures (IAPs) to allow instrument flight training in visual conditions.

The provision of navigation facilities at an aerodrome requires the operator of the facilities to be certified by the UK CAA, as a Communication Navigation Surveillance (CNS) Air Navigation Service Provider (ANSP). A considerable level of effort is therefore required to bring the airfield into the CAA regulatory oversight processes for ANSPs. Therefore, the high capital expenditure for the installation of the NDB and DME facilities together with the ongoing running costs of the facilities, balanced against the low operational benefits, are unlikely to result in a positive business case.

It should be noted that within the GA community, the carriage of satellite navigation devices has effectively replaced the need for NDB/DME for aerodrome location purposes.

6.3 Instrument Approach Procedures (IAPs)

There are global and European safety initiatives by the International Civil Aviation Organisation (ICAO) and the European Aviation Safety Agency (EASA) to ensure that three-dimensional approaches with vertical guidance are available at all instrument runway ends. The expectation is that as three-dimensional approaches become available at all instrument runways, the two-dimensional approaches will fall into disuse and will be withdrawn. This is of particular relevance to NDB approaches that require high levels of skill to fly accurately. It should be noted however that at this time there are no impending regulations requiring existing two-dimensional approaches to be withdrawn, or that preclude the installation of new two-dimensional IAPs.

6.3.1 CAA Publication CAP 1122

International regulations currently require that IAPs can only be implemented into an instrument runway and at an aerodrome that has an Air Traffic Service (ATS), including approach control. A cross-CAA working group evaluated the issues associated with the approval of instrument approaches where one or more deficits in either aerodrome infrastructure or Air Traffic Service provision previously precluded promulgation of an IAP.

In 2014, the CAA published *CAP 1122* [39] titled “Application for instrument approach procedures to aerodromes without an instrument runway and/or approach control.” The publication details a framework for a ‘risk based’ approval process for certain aerodromes that do not meet all of the standards. The objective of *CAP 1122* [39] is to detail a way forward that will allow wider deployment of IAPs at UK aerodromes whilst providing continuing assurance regarding acceptable levels of safety and utilising current policy to the greatest extent possible.

The implementation of IAPs to aerodromes without an instrument runway and/or approach control is an exception to the normal standard. It may not therefore be possible to adequately mitigate the limitations to ensure a safe operation at all locations. One of the limitations of an approval under the *CAP 1122* [39] framework is that the Obstacle Clearance Height (OCH) of the approach will be limited to a minimum of 500 feet.

Although *CAP 1122* [39] was developed in response to a high demand for satellite based IAPs from smaller aerodromes, is also applicable to IAPs supported by conventional navigation aids and therefore applies to all of the implementation options identified in the following sections.

6.4 Two-Dimensional Instrument Approach Guidance

Two-dimensional IAPs only provide lateral guidance to an aircraft on approach, with the vertical path being determined by aircraft height. This is determined by the aircraft barometric altimeter, which allows the descent to be managed by the pilot in accordance with the instrument approach chart.

Two-dimensional approaches may be provided by a conventional navigation aid, generally referred to as a Non-Precision Approach (NPA), or by Global Navigation Satellite System (GNSS) where the approach is termed Lateral Navigation (LNAV).

A high proportion of Controlled Flight Into Terrain (CFIT) accidents have been shown to occur during Non-Precision Approaches (NPAs). Factors contributing to these accidents include loss of situational awareness and the lack of precise vertical guidance.

6.4.1 Conventional Non-Precision Approaches

A conventional NPA is supported by a ground based navigation aid, either an NDB or a localiser for lateral guidance, together with a DME for provision of range information. An NPA may also be based on a VHF Omni Range (VOR) facility although these are normally sited for terminal or en-route navigation.

As there are no suitably located VOR facilities capable of supporting an instrument approach in the vicinity of Solent Aerodrome, the VOR option will not be considered further.

6.4.1.1 NDB/DME Approach

An NDB only provides a signal with the origin being at a known location and does not provide any guidance information, other than a Morse code identification signal. The aircraft ADF equipment determines the bearing to the NDB but not the track. As a result, flying an NDB approach accurately, requires a high degree of pilot skill to account for wind drift to remain on the intended approach path. In cross wind conditions this can be a high workload activity that is undesirable in the final approach phase of flight.

It should also be noted that many new aircraft are not equipped with ADF and in many older aircraft the ADF has been removed to make space for panel mounted GNSS equipment.

6.4.1.2 Localiser/DME Approach

A localiser operates in the VHF band, between the FM broadcast band and the aeronautical VHF communications band. The localiser comprises equipment housed in a shelter and a large antenna array that forms the approach guidance. For obstacle limitation purposes the localiser antenna is normally located between 500 and 1000 feet from the stop end of the runway. From initial inspection of the *Solent Aerodrome Chart* [41] it is apparent that there is limited terrain at the stop end of Runway 21, which would preclude siting of a localiser antenna for a runway aligned approach. It is permissible for a localiser antenna to be sited offset from the runway centreline at a location where the localiser course intersects the runway centreline and is at an angle not exceeding 5°, to create an offset approach.

The localiser DME is an expensive capital item with initial implementation costs exceeding £0.5M together with on-going revenue costs including radio licences and annual flight inspection.

It should be noted that the localiser equipment only serves one runway end and that if an approach is required to both ends of the runway then a second localiser installation is required. With careful siting the DME facility may serve the approaches to both runway ends.

6.4.2 RNAV (GNSS) Two-Dimensional Approaches

An Area Navigation (RNAV) Lateral Navigation (LNAV) approach is a two-dimensional approach that can be flown by aircraft equipped with GNSS. The equipment must comply with the relevant aviation Technical Standards Orders (TSOs) or European TSOs that provide either integrity through Receiver Autonomous Integrity Monitoring (RAIM) or a Satellite Based Augmentation System (SBAS), such as the European Geostationary Overlay Service (EGNOS).

A major advantage of an LNAV approach based on GNSS at a small airfield is that the aircraft positioning for the approach is provided by a satellite navigation constellation and no navigation equipment is required on the ground at the airfield.

6.5 Three-Dimensional Instrument Approach Guidance

6.5.1 Instrument Landing System (ILS)

An Instrument Landing System comprises a localiser and Ultra High Frequency (UHF) Glide Path equipment, sited approximately 300 meters beyond the landing threshold, that defines the vertical approach path.

The cost of implementation of an ILS with its associated remote control and indication system at a new site are significant and likely to be in excess of £1M for each runway end.

6.5.2 GNSS Approach with Vertical Guidance

A GNSS Localiser Performance Vertical (LPV) approach is a three-dimensional approach that provides horizontal and vertical guidance, with accuracies comparable to an ILS.

An LPV approach requires the use of GNSS that is augmented by an SBAS, such as EGNOS in the European region. Aircraft equipment is required to be compliant with *TSO/ETSO 145* [42] or *146* [43] and is widely available within business and general aviation aircraft.

The LPV and LNAV approaches share a common lateral profile and within the UK, when an LPV approach is implemented, the approach chart is also required to include the two-dimensional LNAV approach. This ensures that aircraft with GNSS, compliant with *TSO/ETSO C129* [44] that does not include an SBAS capability, are also able to use the approach.

6.6 Recommended Option

The assessment has identified no specific risks related to IFA 2 in introducing a future ILS system at Solent Airport. Whilst there are no current plans to introduce ILS, the assessment has considered those issues that will need to be progressed by the airport operator should the decision be taken to introduce ILS in the future.

In determining the relative benefits of the instrument approach types identified in the preceding paragraphs, it should be recalled that the international standards for an Instrument Approach Procedure require the existence of an instrument runway and an approach control service.

Within the UK, an IAP implemented in accordance with the CAA's *CAP1122* [39] framework will be limited to a minimum descent height of 500 feet above the runway threshold. This regulatory limitation determines that all of the options for the provision of an instrument approach at Solent Airport will provide the same operational performance capability in respect of cloud base and visibility.

The operational benefits for all of the instrument approach types that may be considered by Solent Airport in the future are identical. This leads to a strong business case for GNSS based approaches as they do not require investment in the installation and ongoing maintenance costs of ground based navigation aid infrastructure.

7 UNMANNED AERIAL VEHICLE (UAV)

7.1 Introduction

Unmanned Aerial Vehicles (UAVs) had previously been considered at a fairly high level. At this stage of the project, a more detailed assessment has now been carried out, whereby the potential impact (risks and effects) that Unmanned Aerial Vehicles (UAVs) could have on the IFA2 Facility has been assessed, and is now included as part of the Hazard Identification and Risk Assessment [2 & 37].

This section of the report presents the initial findings covering effects, controls, and mitigations, and recommends actions to be considered in achieving the levels of safety required of the IFA2 Facility at Solent Airport. It goes some way to addressing the potential risk associated with UAVs and how they might be mitigated by the IFA2 programme and also other parties.

7.2 General UAV Issues Considered

This section addresses how UAV operations lead to accidents and applies to non-commercial and commercial operators (it does not address the risks to infrastructure or people from the payloads that may be carried on UAVs; e.g. Radar, Lidar, Lasers etc.). The difference is that the controls and mitigations avoiding and preventing accidents are quite different for non-commercial and commercial operations as regulated by the CAA and EASA (in *CAP 722* [31]) and in the future through the outcome of *EASA NPA 2017-05 (A) and (B)* [32]).

7.2.1 The Consequence of UAV Failure

There are four significant events that could result in UAV accidents that apply to both non-commercial and commercial operation of UAVs. They are:

- Controlled Flight into terrain (CFIT). (Intended impact on ground and infrastructure due to UAV risk mitigation processes (i.e. it is the safest choice to make);
- Un-Controlled Flight into terrain (UCFIT). (Impact on ground, infrastructure and personnel due to unexpected UAV operation);
- Mid Air Collision;
- Impacts on infrastructure and personnel on the ground (prior to and after flight, during take-off, taxiing and landing).

7.2.2 Causes of UAV Failures:

- Loss of Data Control Link;
- Equipment failure;
- Loss of operator control (or Operating System control);
- Human error;
- Meteorological effects;
- GPS masking.

7.2.3 Hazards Related to UAVs:

There are three concerns from the IFA2 risk analysis in the *Hazard Log Report* [2, 37] that may impact UAV operations at Solent Airport (covered by HAZ21):

- Impact on wind flow due to the IFA 2 converter station building;
- EMI and RFI effects on digital and magnetic navigation equipment generated by the IFA2 infrastructure;
- The dissipation of heat through the air.

7.3 The Risks from Non-Commercial UAVs

For the purposes of this UAV impact analysis, non-commercial UAVs are those that are operated outside the specific requirement of *CAP 722* [31] and are flown as leisure craft for hobby and non-commercial gain. Solent Airport have only experienced one event breaching the airport perimeter with non-commercial UAVs in the last fourteen months, when a UAV was found early in the morning on the runway. Ownership was not established and RCAM noted the event. Due to the event occurring outside Solent Airport operation hours, the safety of other airspace users was not compromised. In an analysis of the CAA Mandatory Occurrence Reports no evidence was found of any occurrence reported about UAVs at Solent Airport, which suggests that the risks from non-commercial incursions to Solent Airspace are low, but should not be discounted. Solent Airport does not currently have proactive defences against UAVs that might breach their airspace boundaries, but they consider that they have very good local relationships and currently are satisfied that their approach to managing safety impacts from non-commercial UAVs is proportionate. As they currently operate in Class G airspace, this is a reasonable position to take, leaving the obligation on pilots transitioning through that airspace to maintain visual awareness of other airspace users and pilots take full responsibility for their own safety, although they can ask for help form ATC.

National Grid needs to be aware that there is a risk that non-commercial UAVs could impact the facility if they breach the airport boundary and the IFA2 boundary. They could impact the facility and cause infrastructure damage or impact with personnel causing serious injury, or death (depending on the UAV, the type of impact and the area of impact).

7.4 Risks Associated with Commercial UAVs

Currently, Solent Airport does not host commercial UAV operations although Fareham Borough Council (FBC) has been approached by Tekever and it is understood that they may be a future tenant (for operation, manufacture, test and evaluation). Solent Airport has previously hosted UAV operations for FBC as a one-off-task which were supervised by RCAM, outside normal operation hours. RCAM have minor and very brief experience of overseeing the management of UAVs, but they are very aware of their obligations in doing so. Furthermore, the airport Manager prior to moving to Solent Airport was part of the ATM operations at Boscombe Down when UAV operations were safely integrated into the extremely complex and busy airfield operations. If in time UAV operations are considered at Solent Airport, the risks associated with their operation will have to be identified and managed appropriately by stakeholders.

UAV operations are slightly different depending on; location, planned tasks, equipment, co-operating systems and processes, but the arrangements for setting up safe systems of work is well documented and well understood throughout the regulating, operating and ATM organisations.

7.5 Controls and Mitigations and Actions Against HAZ21

Controls, mitigations and actions are identified in HAZ21 [2, 36] relating to UAVs in the context of potential effects from the IFA2 Facility. They are deemed reasonable and sufficient in the light of the current analysis and there are currently no recommendations to adding further controls, mitigations and actions not otherwise identified.

7.6 Reporting and Recording of UAV Incidents and Accidents

EASA and thus the CAA have in place a process which operators should use to report aviation occurrences, this is the Mandatory Occurrence Reporting (MOR) System as laid out in *CAP 382 Mandatory Occurrence Reporting Scheme* [33] and directed by *EU376/2014* [34] or *IR2015/1018* [35]. Regarding the MORs, note the following points:

- There are numerous times when a possible occurrence has been reported several times;
- The details of the occurrence are often scant or incomplete;
- There are few occurrence reports raised by commercial UAV operators;
- There are no occurrence reports raised by non-commercial UAV operators.

Notwithstanding the foregoing observations, it is recognised that the reports are investigated and reviewed by the CAA monthly and although there is regular reporting by airline or private operators of seeing UAVs in flight, there is generally only a slight reduction in safety margins.

It is considered that appropriately qualified personnel reviewed the findings of the Air Accidents Investigation Branch (AAIB) incidents and thus we have not conducted any further review on the record of UAV accidents.

7.7 CAA's Current View on UAV Safety

As the world view on UAV safety management matures it is important to bear in mind that regulation changes are likely. Constant review of safety arrangements should be undertaken. It is worth noting that the CAA's current view on the future of UAV safety is:

- The CAA would welcome a register of UAV users that is tied to systems allowing real-time tracking and tracing of UAVs. This would be a significant aid to the police and others involved in enforcing UAV regulations;
- The CAA would welcome steps to introduce no fly zones to improve safety and are actively involved in work to define these for UAVs in the future;
- Fitting geofencing to UAVs, automatically stopping them flying close to airports and other key infrastructure, is also a key element of helping to make sure UAVs fly safely. (Forthcoming UAV rules for Europe being proposed by the EASA also call for mandatory geofencing for UAVs) (Note that if this is not implemented effectively, the solution may introduce different risks that have to be managed).

The current law requires that anyone operating a UAV must do so responsibly and observe all relevant rules and regulations. The rules for flying UAVs are designed to keep all airspace users' safe. The CAA is very clear that it is totally unacceptable to fly UAVs close to airports and other aircraft and anyone breaching the rules can face severe penalties including imprisonment. The CAA's 'drone code' provides advice on how to fly UAVs safely and responsibly.

7.8 Conclusions

This latest assessment has not identified any additional risks and mitigation measures that were not previously known, and there are currently no recommendations to add further controls, mitigations and actions not otherwise identified.

It is concluded that the proposed IFA2 Facility would not exacerbate the possible risks posed by UAVs themselves upon Solent Airport.

There is a potential for non-commercial, third party UAVs from external sources to enter the airport and IFA2 Facility boundaries, potentially causing damage or injury / death (depending on the type and size of UAV) to personnel. This is a generic external risk affecting all airports. Appropriate measures to prevent this need to be considered by the Airport Operator. There is no reason to believe why suitable measures should not be achieved within the programme for introducing UAVs to Solent Airport.

7.9 Recommendations

These conclusions are deemed valid at the time of writing although, it would be prudent for all safety stakeholders to be conscious of the latest availability of UAV information as the project moves forward from:

- Regulation;
- Mandatory Occurrence Reporting;
- Air Accident Investigation Reports;
- Local police reporting of non-commercial UAV incidents.

8 CONCLUSION

The technical assessments presented above, provide support to the interim Safety Justification [38] for the IFA2 Facility at Solent Airport and are part of the work intended to support the application to the Fareham Borough Council (FBC) Executive Committee for the full planning acceptance and consent to progress to the next stage in the project. The assessments cover the following:

- a revised assessment of airfield safeguarding taking account of the revised IFA2 design;
- additional wind flow analysis covering the interaction effects between the IFA2 Converter Station and the Faraday Business Park;
- further independent peer review of some additional documents related to Radio Frequency Interference (RFI) and Electromagnetic Frequency (EMF) documents and consideration of EMF/RFI effects and to consider some specific hazards within the hazard log;
- consideration of the possible effects upon Maritime & Coastguard Agency (MCA) equipment arising from the IFA2 Facility;
- an assessment of options for future navigational systems including an instrument landing capability, both generically and in the context of the IFA2 Facility at Solent Airport. Currently there are no plans to introduce ILS to the airport;
- an assessment of Unmanned Aerial Vehicles (UAVs), considering the risks that non-commercial UAVs could pose to Solent Airport and whether the IFA2 Facility could exacerbate these risks.

The conclusions reached on each of the above topics is given below.

Aerodrome Safeguarding Analysis

The aerodrome safeguarding analysis aims to ensure that the existing proposed development will have no impact on the safe operation of the airport. The proposed design of the buildings within the development are not infringing any of the obstacle limitation surfaces (OLS) and are compliant with the associated legislation and standards. The design of the IFA 2 building roof is pitched, which is less attractive to birds than a flat roof. A bird hazard management plan will be needed. Lighting within the development should follow the Airport Operators Association (AOA) advice [11] to ensure that the operation of the airport is not adversely impacted. The use of cranes during construction may present a temporary risk, but the type of crane used should be considered and agreed with the airport at the earliest opportunity, in order to assure that any risk is mitigated and is acceptable, particularly as the site is in such close proximity to the runway.

Wind Assessment

The wind effects analysis has considered the impact of the updated design of the IFA2 Converter Station combined with the future proposed Faraday Business Park buildings on the main runway and covers a realistic range of wind directions and wind speeds. One main effect observed is that the future proposed Faraday Business Park buildings act as a shield to the IFA2 Facility and have the overriding impact on the runway. This also explains the worst-case wind direction now being at the angle of 90^0 EoN, compared to 70^0 EoN from the earlier analysis when only the IFA2 Building is considered. This is because at this angle the future buildings produce three tails of faster winds, which covers the biggest area on the main runway compared to the other angles. The highest relative increase wind speed onto the main runway caused is a maximum of 29% at a height of 5m above the ground.

The wind impacts indicated above can be mitigated by extending the “frontline” buildings nearest the runways and closing the gaps.

Additionally, it was confirmed at the hazard identification and risk assessment [2, 37] studies report that localised changes in wind patterns are easily managed and that pilots quickly become familiar with any changes in wind patterns and adapt their flying accordingly through good airmanship.

Technical Assessment of EMF/RFI Effects

The work included in Arcadis’ *Technical Assessments* [1, 36] completed the main review of the analysis available concerning EMF and RFI effects. Due to additional information being made available very recently, a further review regarding EMF and RFI has been conducted. Additionally, some areas where there were perceived to be gaps in the existing hazard mitigation evidence have also been considered.

Based on the evidence reviewed so far, whilst further testing evidence is required, there are no issues concerning EMF/RFI emissions due to the IFA2 facility and the expectation remains that risks concerning RFI and EMF will be acceptable as defined in *CAP 760* [15]. Work is in progress to complete the testing and measurement activities that are planned to verify that the requirements and the planning conditions are met. All verification required to demonstrate that safety requirements are met is recorded as a dependency in the Safety Justification [38]. Some points requiring clarification are raised by the assessment, these should be addressed as the design documentation develops.

Avionics Impacts of Emissions

The impact upon avionics equipment from emissions originating from IFA2 has been analysed. The analysis includes assessment of the impacts on Flight Management Systems (FMS) and other specific aircraft navigation systems. The analysis also assessed the impact of wideband noise on aircraft sensors.

It has been determined that any emissions from the IFA2 Facility will rapidly diminish with distance and will have no discernible impact on aircraft that are operating within the normal bounds of the airfield using the systems assessed within this assessment.

Instrument Landing Systems

The assessment has identified no specific risks related to IFA 2 in introducing a future ILS system or similar system at Solent Airport. Whilst there are no current plans to introduce ILS, the assessment has considered possible options for future systems and issues that will need to be progressed by the airport operator should the decision be taken to introduce an instrument landing capability or similar in the future.

It should be noted that the international standards for an Instrument Approach Procedure (IAP) require the existence of an instrument runway and an approach control service. Within the UK, an IAP implemented in accordance with the CAA's *CAP 1122* [39] framework will be limited to a minimum descent height of 500 feet above the runway threshold. This regulatory limitation determines that all of the options for the provision of an instrument approach at Solent Airport will provide the same operational performance capability in respect of cloud base and visibility. The operational benefits for all of the instrument approach types that may be considered by Solent Airport in the future are identical. This leads to a strong business case for GNSS based approaches as they do not require investment in the installation and ongoing maintenance costs of ground based navigation aid infrastructure.

Unmanned Aerial Vehicles

Unmanned Aerial Vehicles (UAVs) had previously been considered at a fairly high level. At this stage of the project, a more detailed assessment has now been carried out, whereby the potential impact (risks and effects) that UAVs could have on the IFA2 Facility and vice versa has been assessed in more detail, and is now included as part of the Hazard Identification and Risk Assessment [2 & 37].

This latest assessment has not identified any additional risks and mitigation measures that were not previously known, and there are currently no recommendations to add further controls, mitigations and actions not otherwise identified.

It is concluded that the proposed IFA2 Facility would not exacerbate the possible risks posed by UAVs themselves upon Solent Airport.

There is a potential for non-commercial, third party UAVs from external sources to enter the airport and IFA2 Facility boundaries, potentially causing damage or injury / death (depending on the type and size of UAV) to personnel. This is a generic external risk affecting all airports. Appropriate measures to prevent this need to be considered by the Airport Operator. There is no reason to believe why suitable measures should not be achieved within the programme for introducing UAVs to Solent Airport.

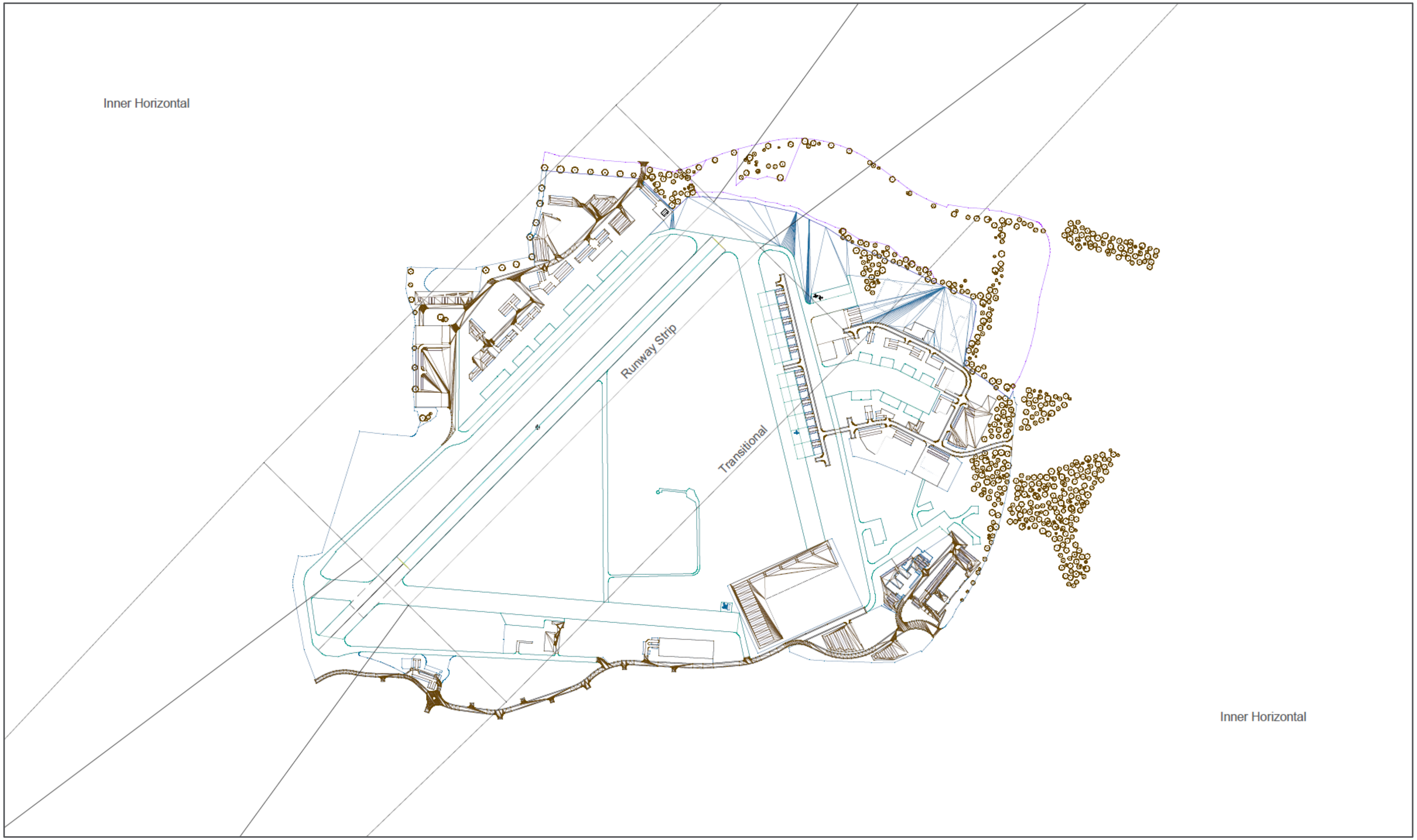
9 APPENDICES

APPENDIX A – APPENDICES RELATED TO SAFEGUARDING CHAPTER 2.0

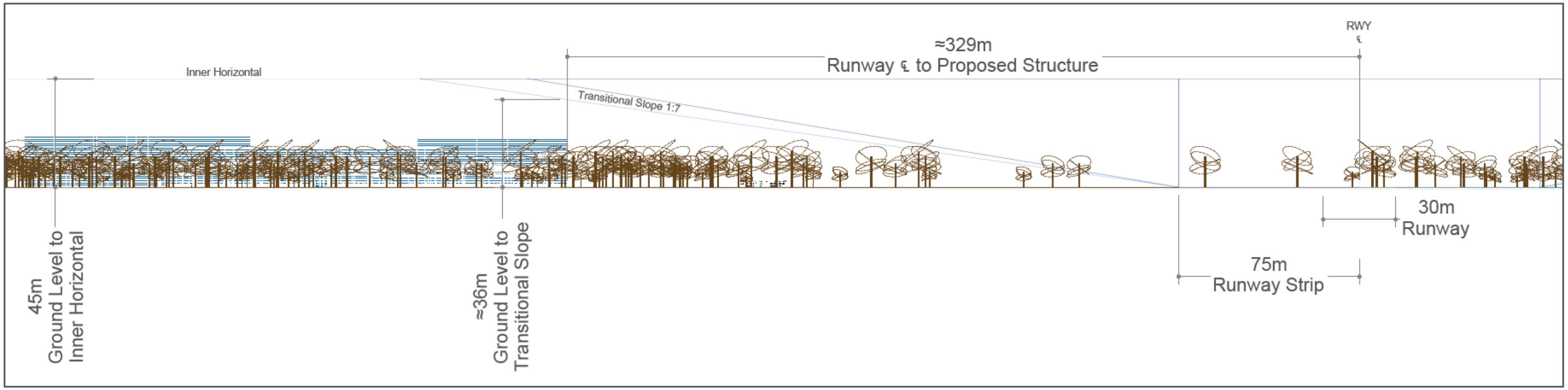
A.1 Position of Buildings in Relation to Airport and OLS

A.2 Position of Buildings in Relation to OLS with Background Image

A.3 Position of Buildings in Relation to OLS without Background Image



A.4 Position of Converter Station in Relation to the Relevant OLS



APPENDIX B – APPENDICES RELATED TO WIND ASSESSMENT CHAPTER 3.0

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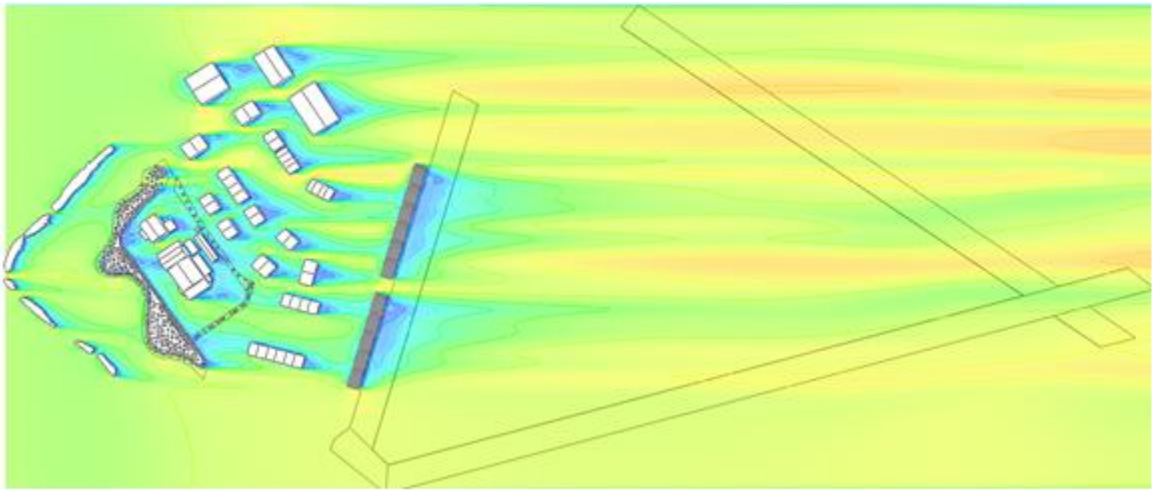

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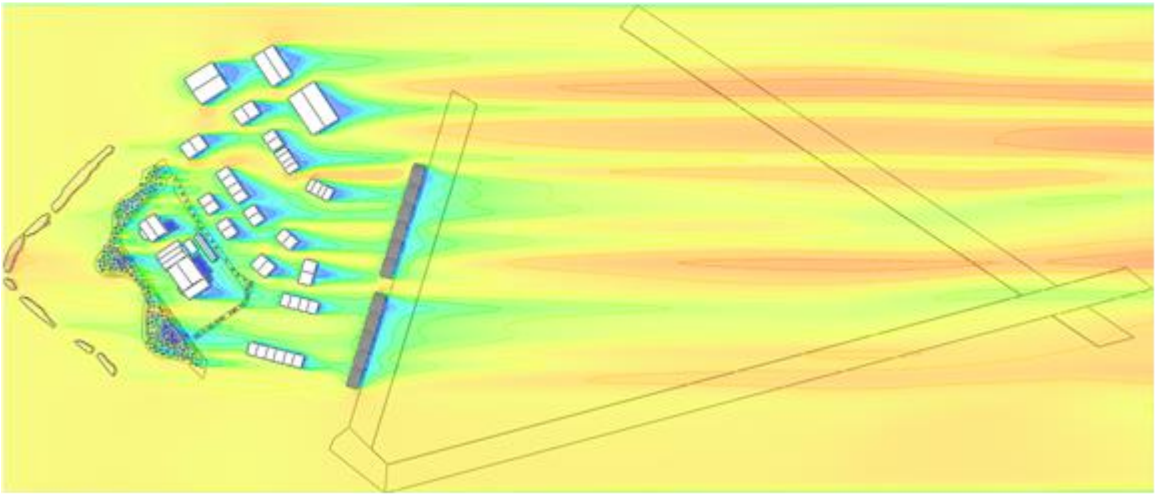

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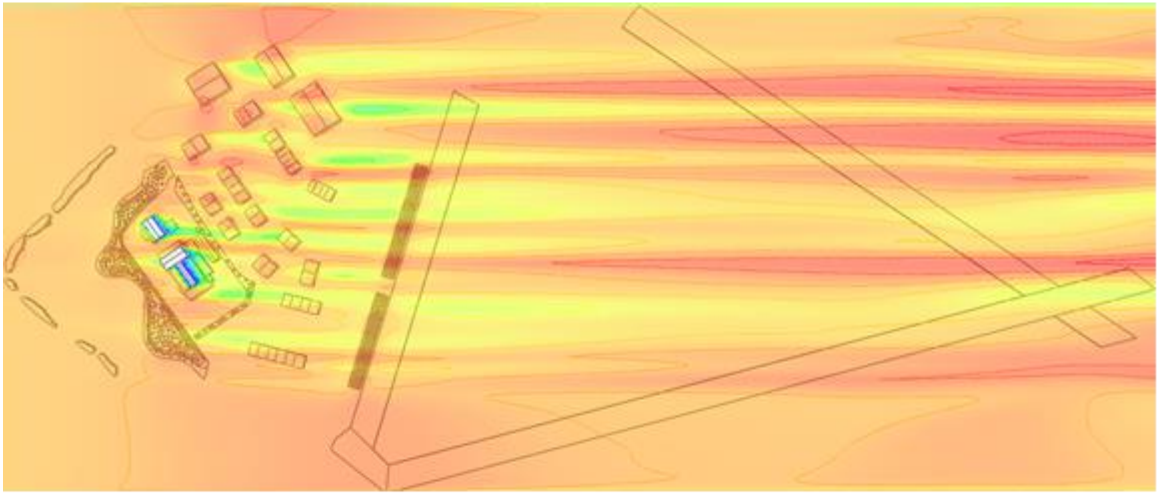

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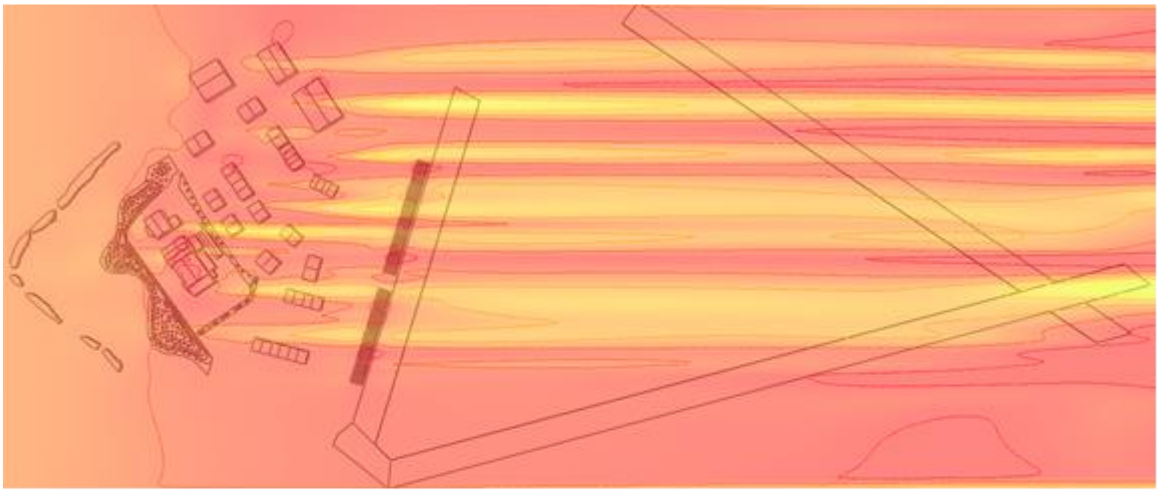

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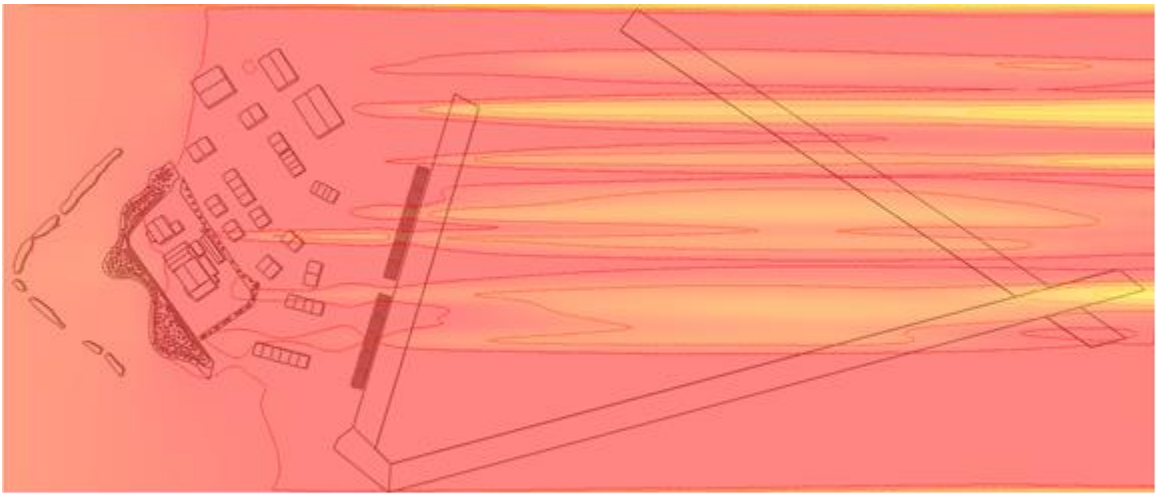

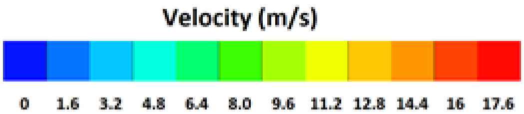

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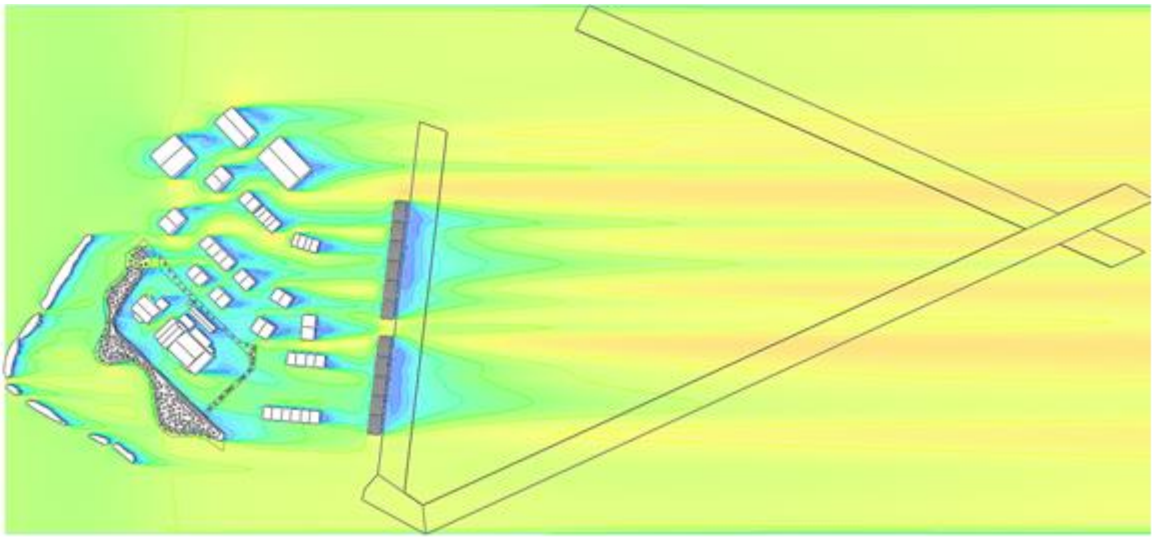

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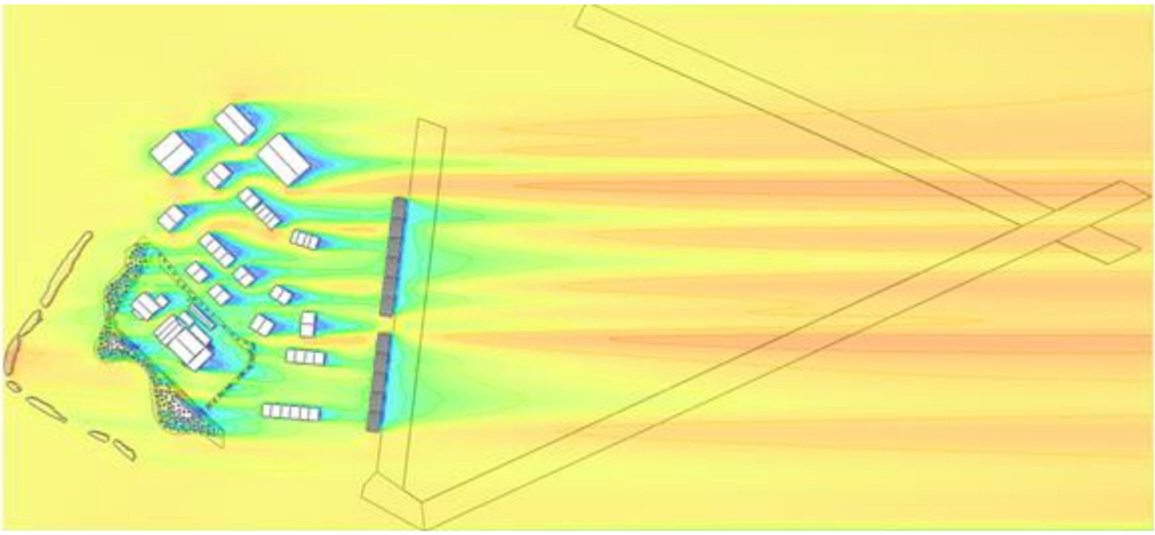

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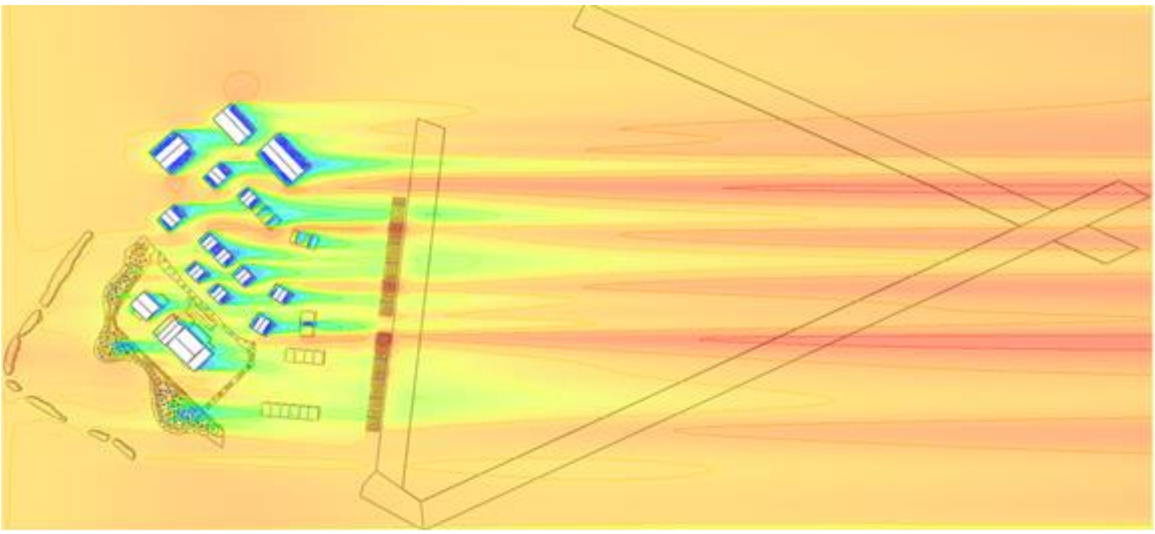

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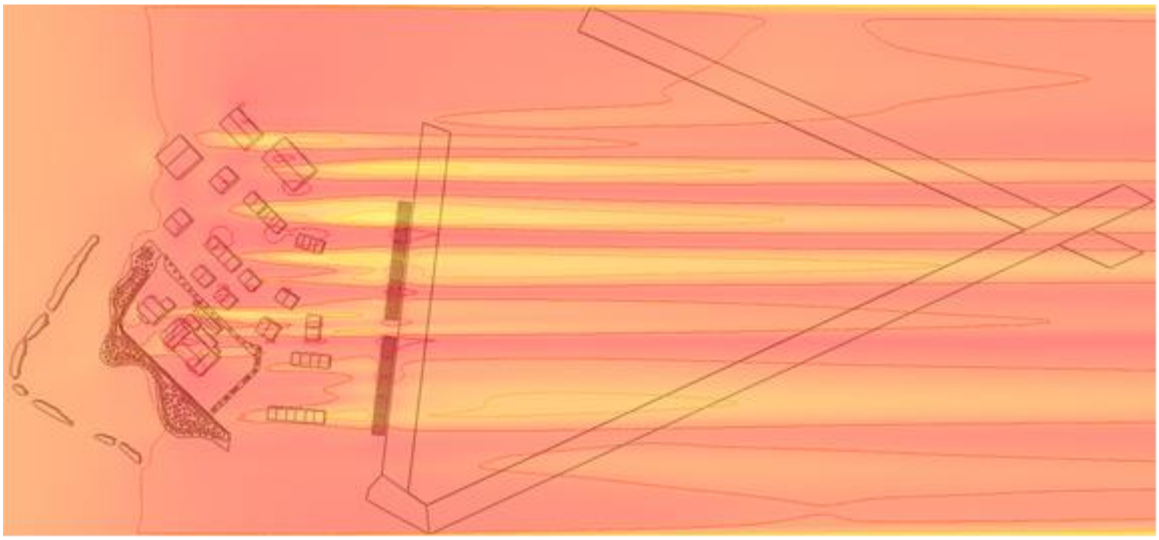

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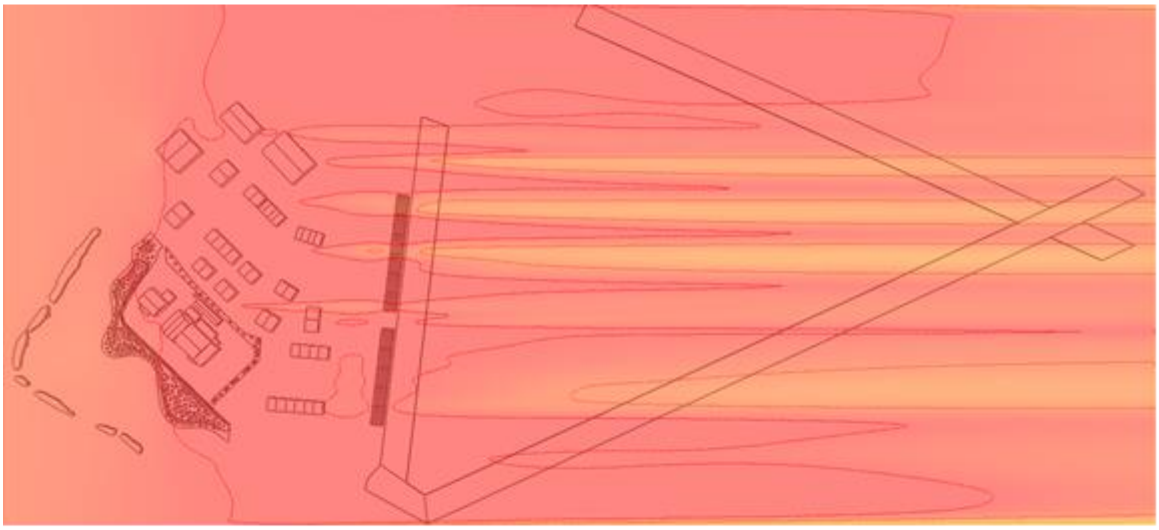

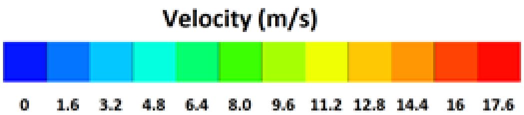

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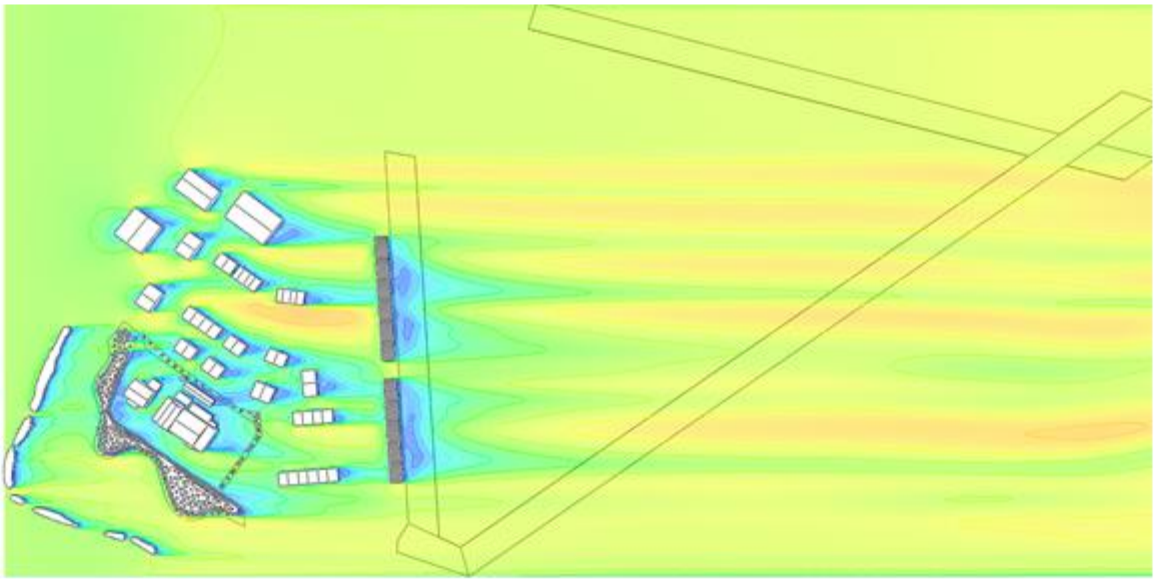

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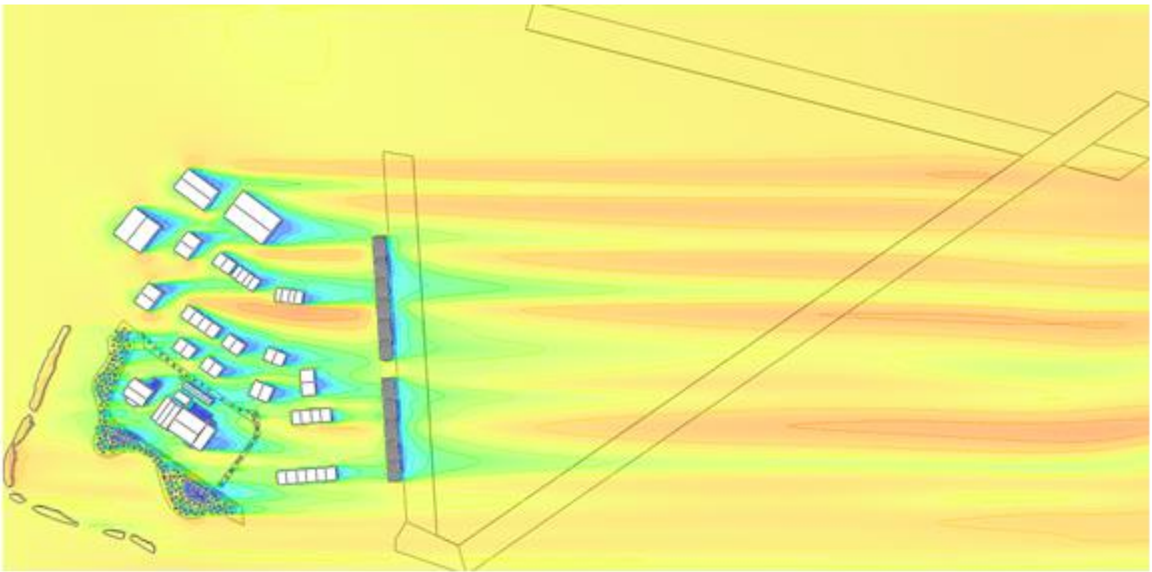

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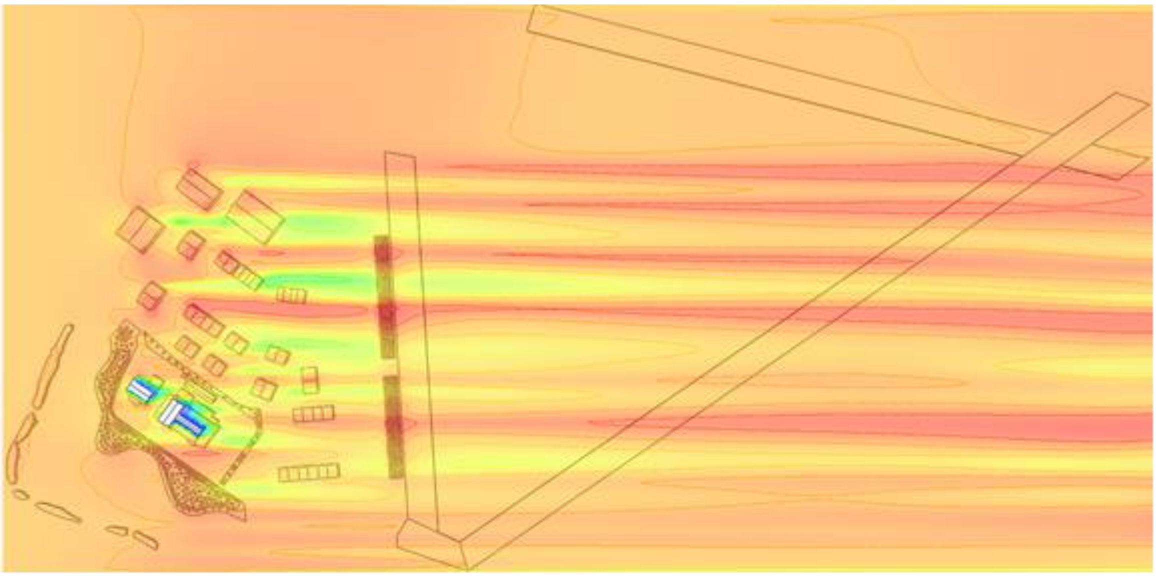

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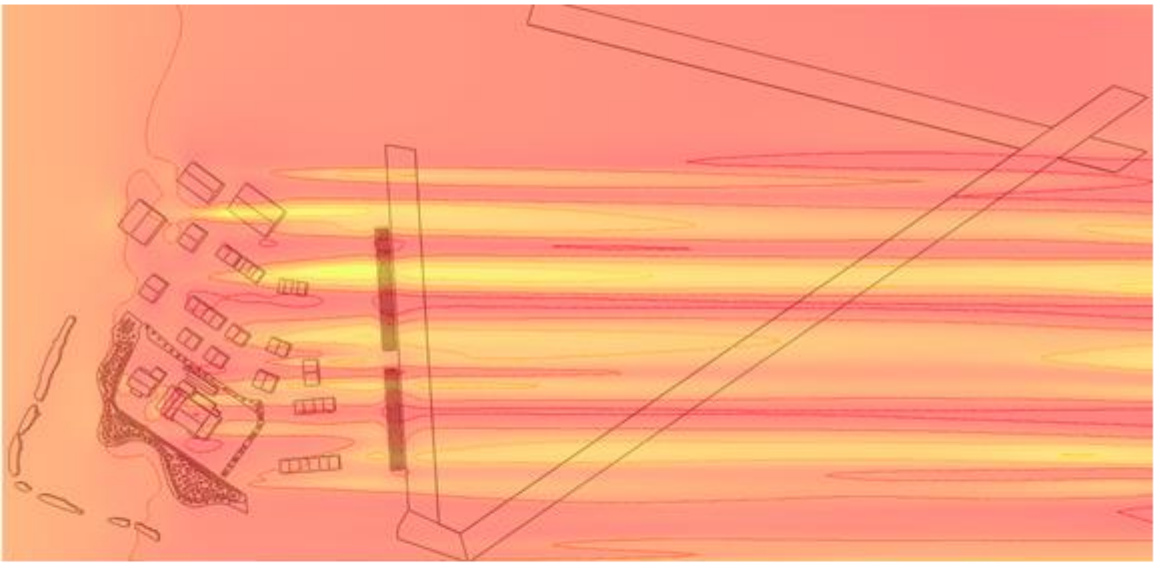

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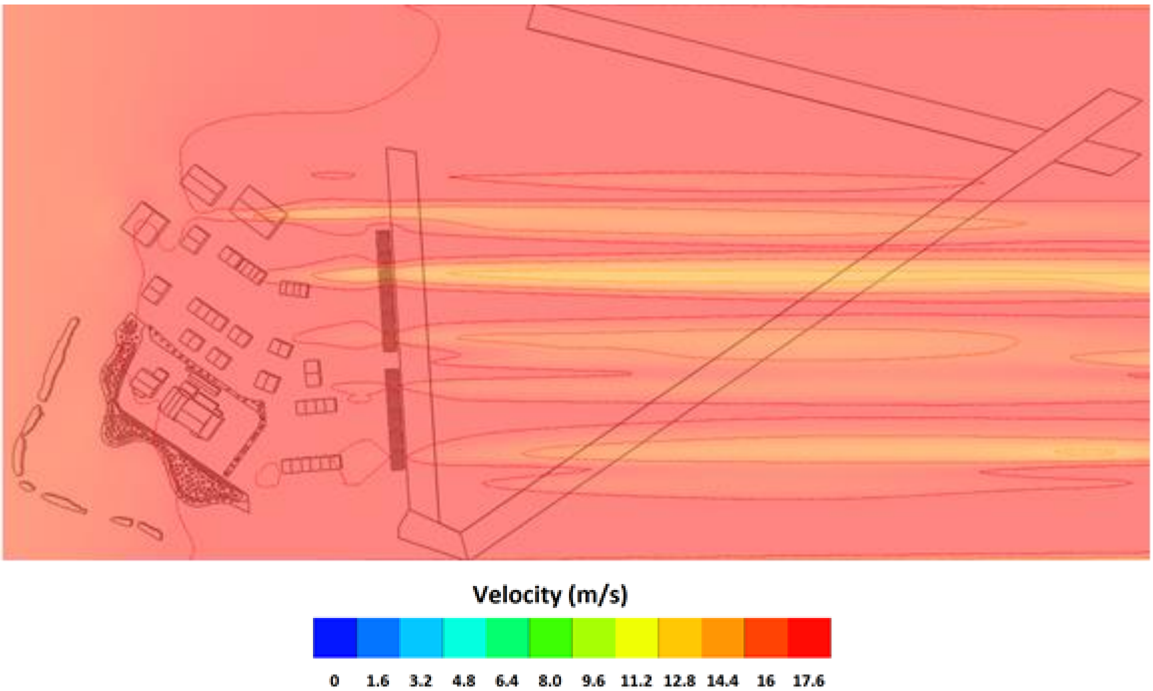

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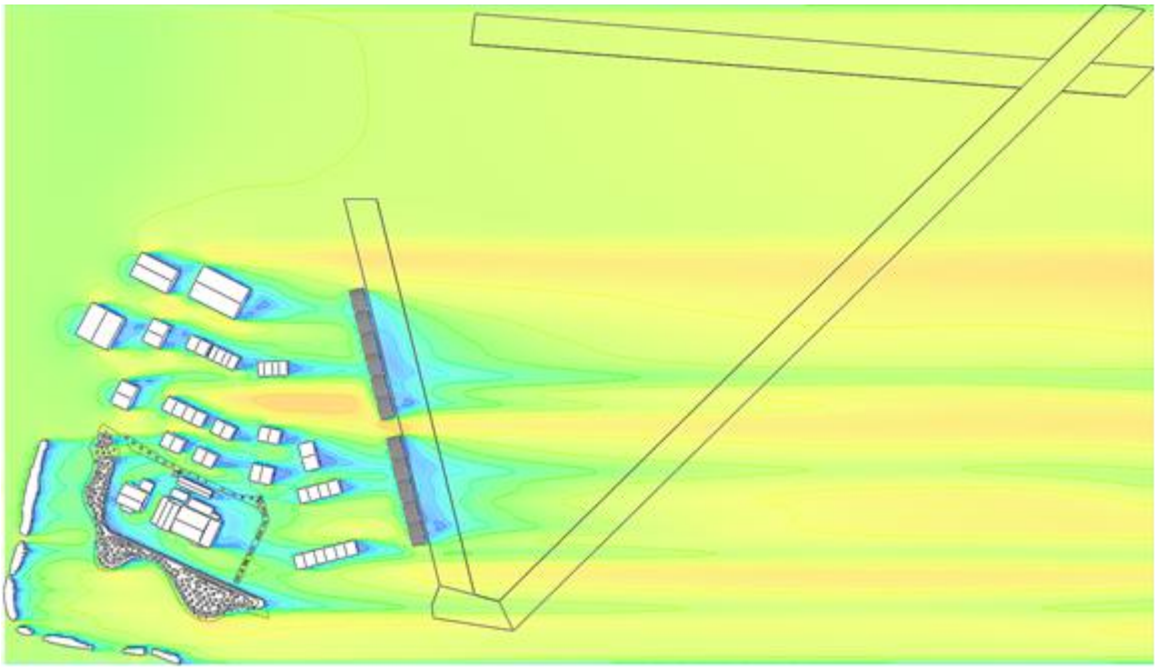

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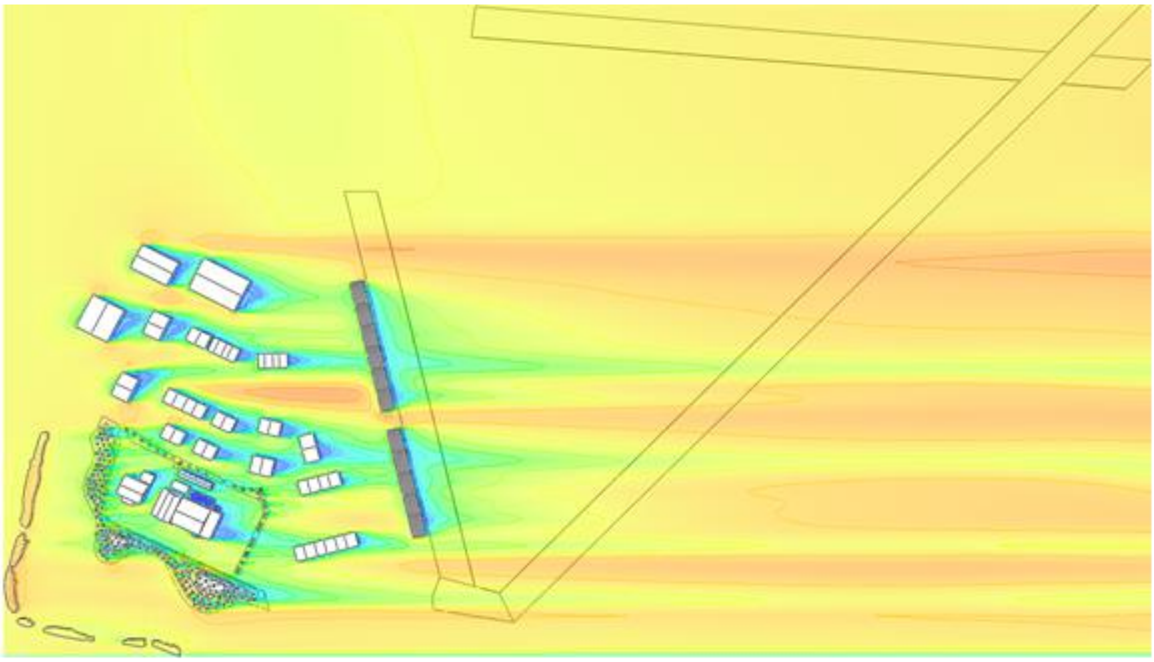

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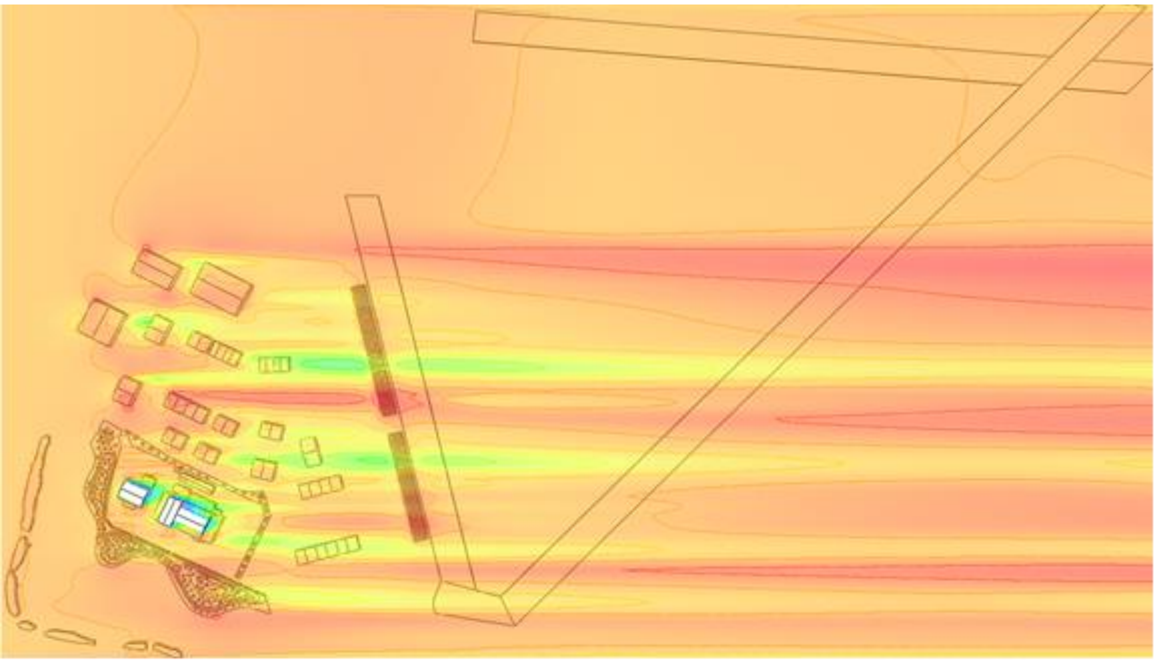

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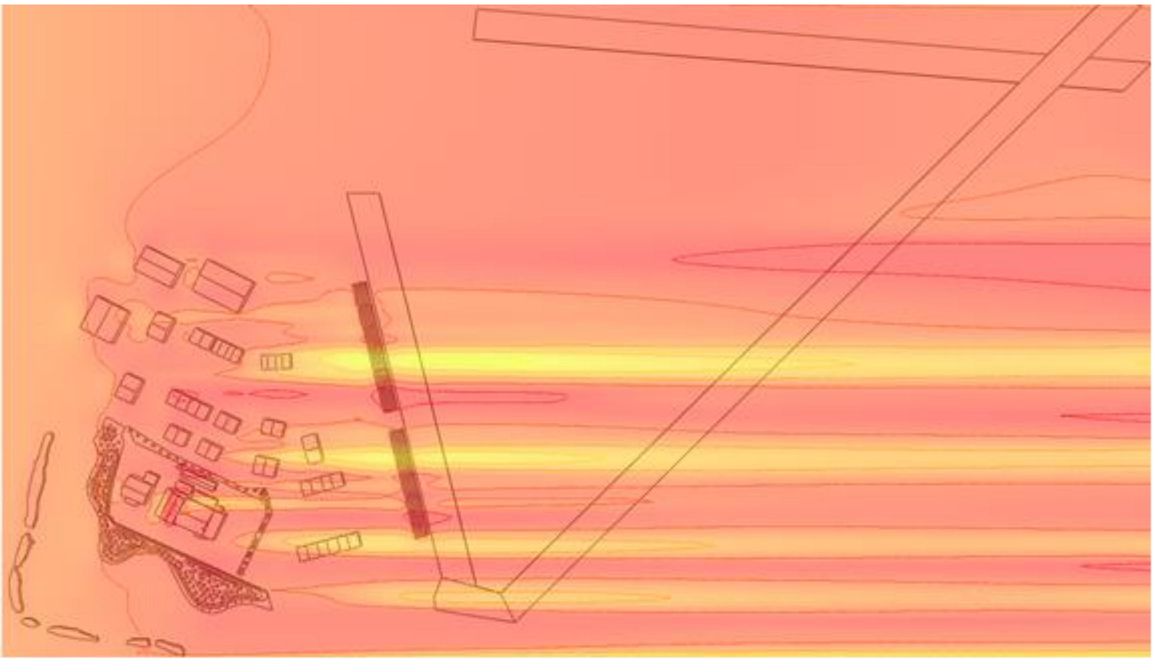

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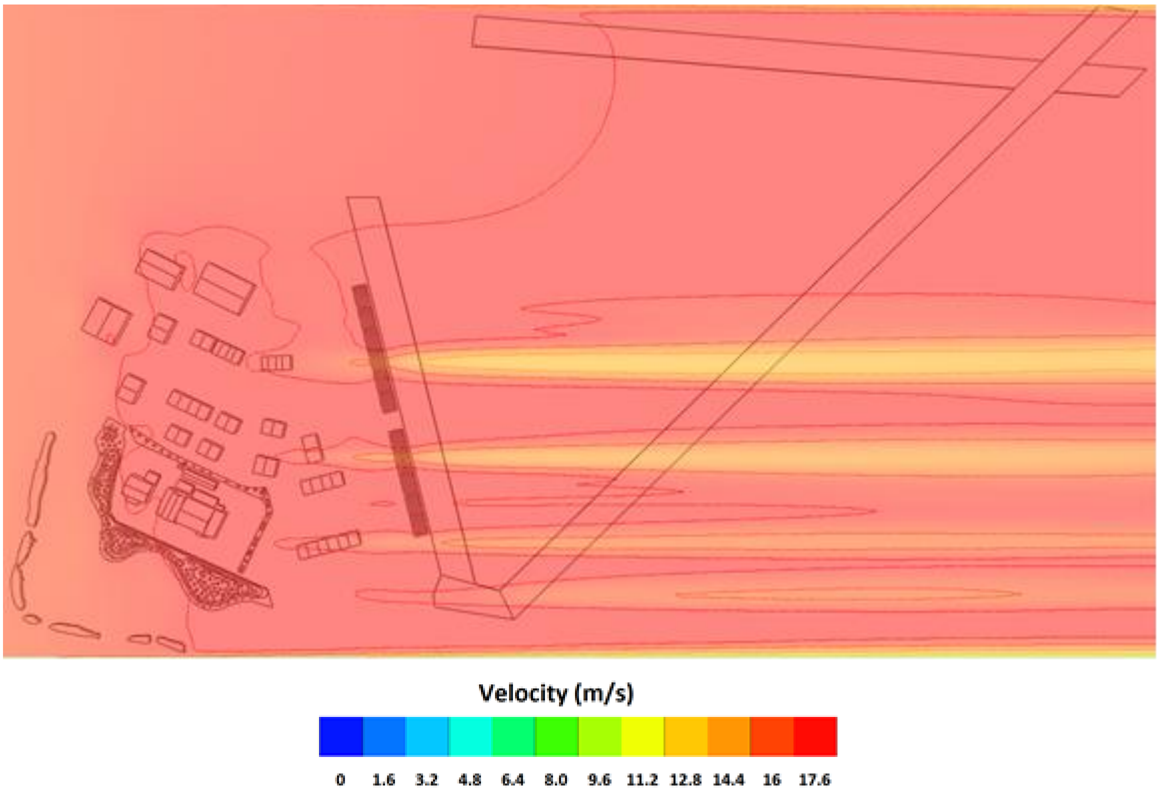

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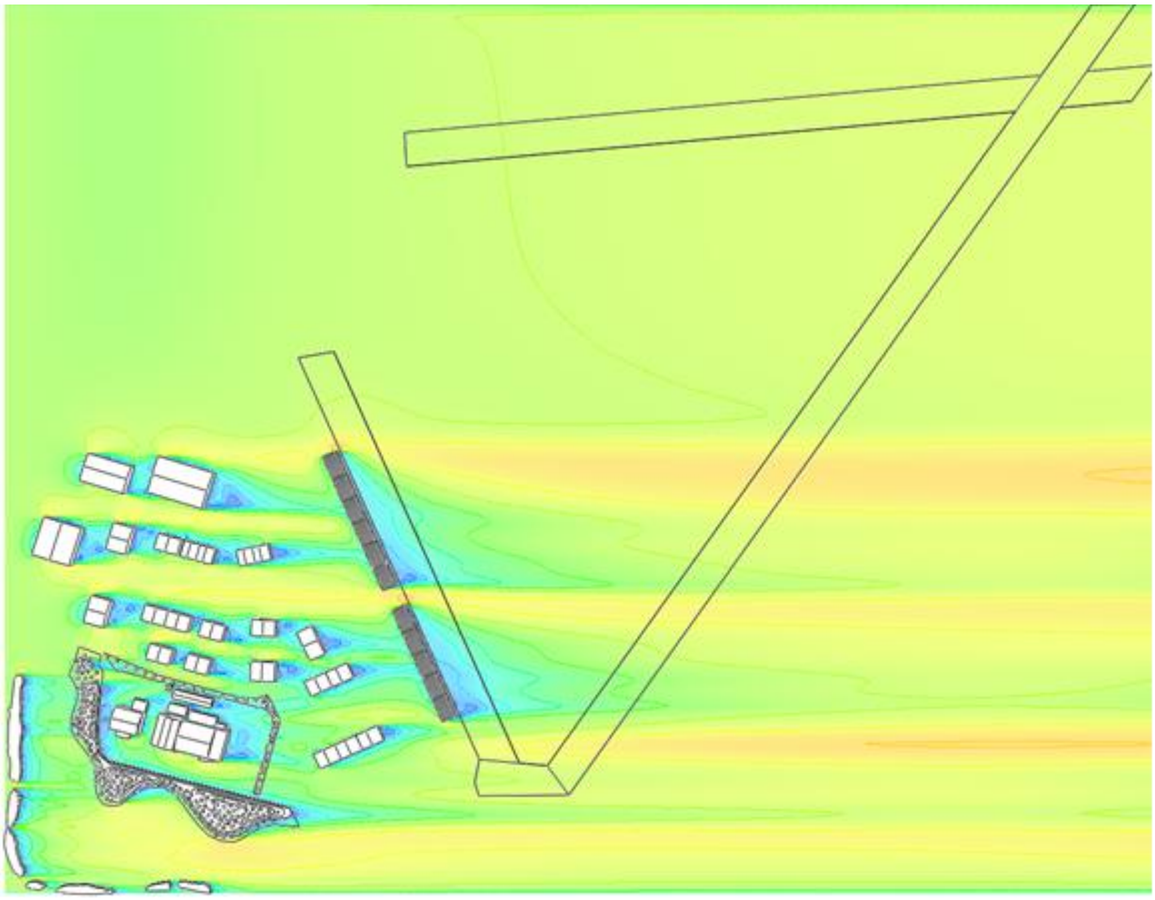

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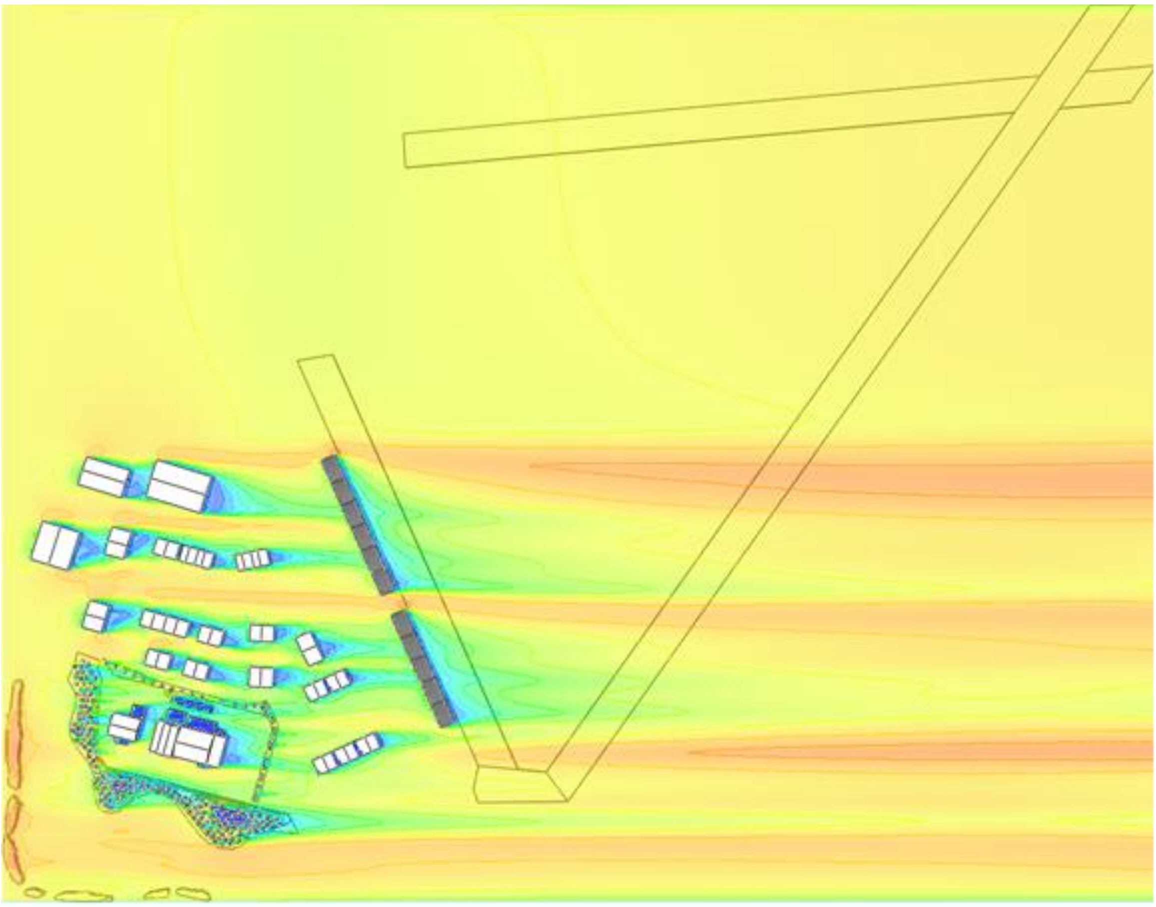

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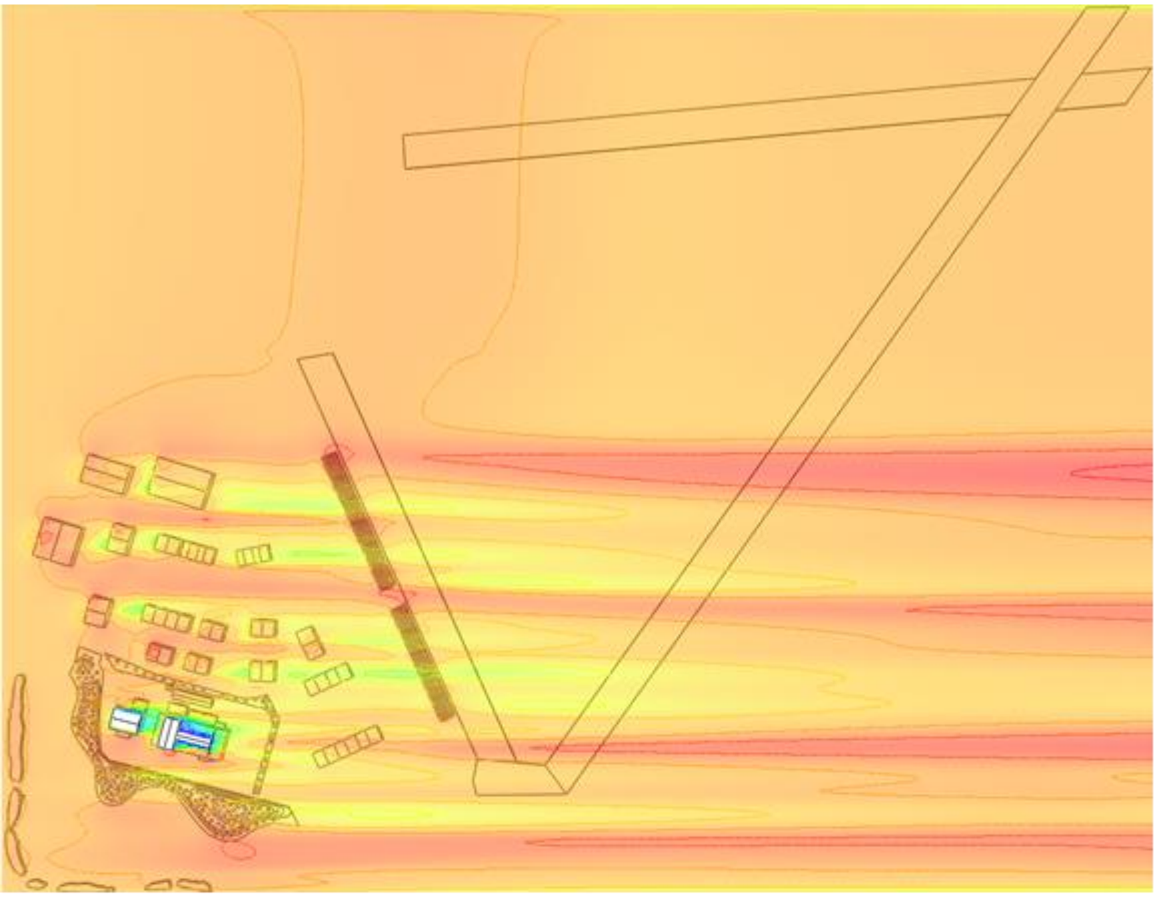

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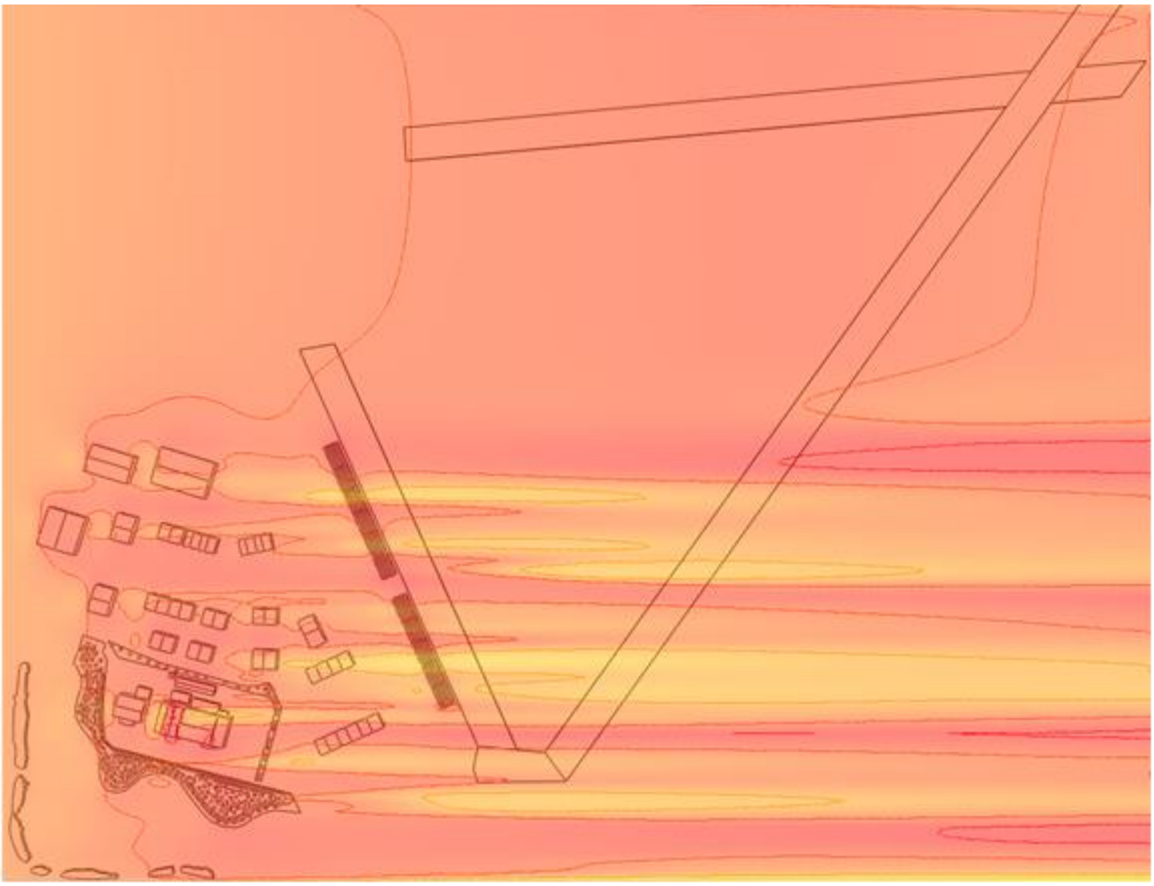

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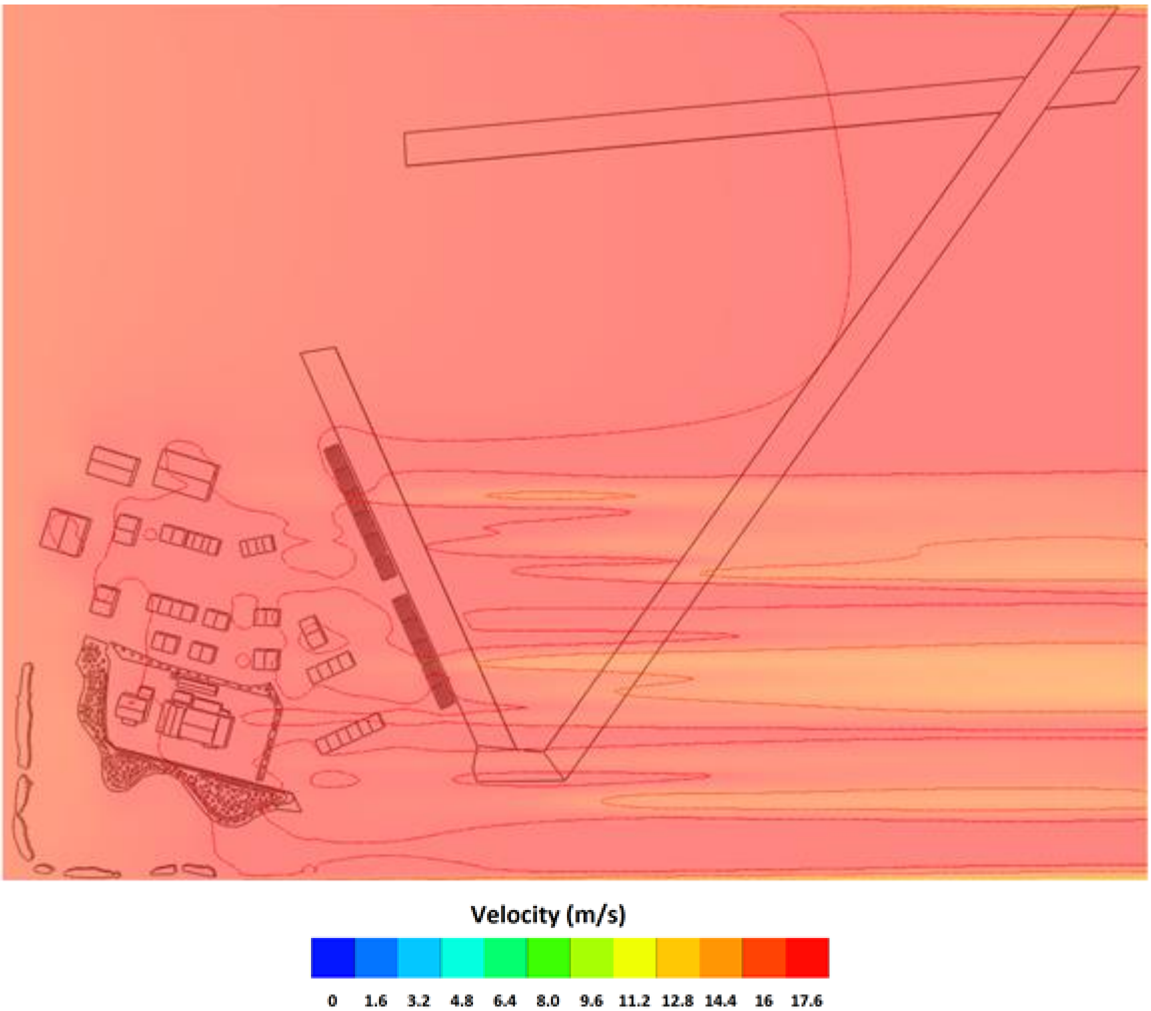

Arcadis UK

34 York Way
London N1 9AB

T: +44 (0) 20 7812 2000

arcadis.com