Appendix D.

Project Ark: Northolt Aerodrome

CAA Licence Compliance
Final Report

January 2012

Ministry of Defence

[redacted]

Mott MacDonald

Project Ark: Northolt Aerodrome

302141/Reports/Internally Produced/Issued

31 January 2012

CAA Licence Compliance
Final Report

January 2012

Ministry of Defence

[redacted]

Mott MacDonald, Mott MacDonald House, 8-10 Sydenham Road, Croydon CR0 2EE, United Kingdom
T +44(0) 20 8774 2000 F +44 (0) 20 8681 5706, W www.mottmac.com

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
A	19/01/2012	[redacted]	[redacted]	[redacted]	Draft Report
B	31/01/2012	[redacted]	[redacted]	[redacted]	Final Report

Mott MacDonald, Mott MacDonald House, 8-10 Sydenham Road, Croydon CR0 2EE, United Kingdom
T +44(0) 20 8774 2000 F +44 (0) 20 8681 5706, W www.mottmac.com

Content

Executive Summary

Northolt currently operates as a Government Aerodrome operated by the RAF handling movements by military, government and civil aircraft. The civilian movements are all by privately or commercially owned business aviation aircraft. There are no operations by conventional airlines. At present, facilities do not exist on site to handle those and process the related numbers of passengers and baggage. In addition, there is no free public access to any part of the aerodrome. All civil passengers and flight crew pass through the military security procedures before being allowed onto any part of the site.

This study is in the context of a possible disposal or lease of all or part of the site to a civil operator. The present Air Navigation Order (ANO) requires that specified flights for the purpose of public transport shall take place only at either a Licensed aerodrome, or a Government aerodrome. The Licence can either be a Public Use or an Ordinary Licence. An Ordinary licence allows the use of the aerodrome by the holder of the licence and persons specifically authorised by him, which controls those who have access. In general, the CAA's technical requirements for a Public Use License and for an Ordinary Licence are the same.

The runway has a paved length of 1,687m and is orientated approximately east west (actually 021°/251° from North). It divides the site into a northern enclave that mostly contains military facilities and a southern enclave that contains a mix of military and all the civil facilities. The aircraft parking apron is on the south side.

This report provides Mott MacDonald's opinion on the measures that are likely to be required for a civilian operator to obtain an aerodrome operator's Licence for Northolt from the Civil Aviation Authority (CAA). We also refer to the planned change to European Aviation Safety Agency (EASA) regulation from 1st January 2014 and the known or anticipated differences in the Certification requirements that will apply after that date.

This report considers those measures in two parts. Works necessary to:

- be granted a CAA Aerodrome Licence (or EASA Certificate) for the existing mix of civil and military operations; and
- develop the aerodrome into a commercial airport handling existing traffic and regional passenger airliners.

A Licensed Aerodrome

Our main conclusions are that there are a number of differences to the Licensing (or Certification) requirements that could be corrected in a relatively straight-forward manner. However, the proximity of the existing runway to the site boundary at each end:

- prevents the development of the required runway strip and runway end safety areas;
- results in a substantial number of obstacles infringing the obstacle limitation surfaces (OLS) on the approach, departure and to the runway sides, some by significant amounts; and
- results in aircraft crossing the public roads just outside the boundary at very low heights.

The obstacle environment is significantly worse at the east end, than at the west end of the runway. The traffic lights on West End Road are not effective as some drivers disobey them and congestion tailing back from adjacent traffic light controlled junctions means that vehicles may not be able to clear the area.

We consider the extent of these non-compliance issues to be sufficient to state that the aerodrome could not be licensed in its current form. That conclusion would apply with the existing operations and is not related to whether or not the aerodrome was to be developed as an airport.

For the same reason, we also consider the existing runway configuration unsuitable for airline operations even if it remains a Government Aerodrome.

In order to achieve a Licence (or a Certificate), these prime issues would need to be addressed. Some of the obstacles, such as lamp posts, aerials and trees could be lowered or removed. A considerable number of buildings penetrate the existing OLS and some are have listed building protection. It would be impractical, or not permitted and certainly very costly to remove all of these. If necessary, it might be possible to remove a small number of buildings that are significant obstacles. However, even in combination, these do not resolve the infringement issue.

It is necessary to raise the OLS at each end and re-assess the approach and departure procedures (by reference to the provisions of ICAO PANS-OPS).

This would be achieved by insetting the start and end points of those parts of the runway that are used for take-off or landing and in each direction.

The effect of such changes would to reduce the runway distances declared for landing and take-off. Of course, if these were reduced by too great an extent, then the runway would no longer be suitable for its intended uses. Indeed, any reduction would have some impact on operations that take place at Northolt today and in particular, those which require the full use of the distances available.

We have not been tasked with undertaking a detail design or consult with the CAA on suitable changes. However we have undertaken some detailed studies to indicate to our satisfaction that insetting the thresholds (the start of the landing distances) by 240m from the east end of the pavement (for westbound approaches) and 214m from the west end of the pavement (for eastbound approaches) will considerably improve the obstacle environment. That is not to state that there will no longer be any infringements of the new OLS. However there will be fewer infringements and they will be reduced in their amount. In addition, we have assessed the Rwy 25 3.5° glideslope approach in relation to a 2.8% approach OLS, the Rwy 07 departure against a 2.8% OLS and the Rwy 25 Cat 1 ILS approach in relation to the ICAO Obstacle Assessment Surface (OAS) for Code C[1] aircraft.

This proposed shortened runway would also more than double the height of aircraft as they pass over West End Road on the Rwy 25 approach. Reliance on the existing traffic control lights ceases and these could then be removed.

Some infringements remain, but these are small in number and extent. Those penetrations would be taken into account to adjust the minimum decision heights for aircraft on the approach. We anticipate that such adjustments would result in acceptable decision heights that would not significantly reduce the availability of

[1] Code C aircraft are those with a wingspan of less than 36m and apply to all but one narrow bodied type.

the runway when the visibility conditions are reduced (and indeed it may improve runway availability in comparison with the existing runway arrangement).

The resulting declared distances are tabulated below. These would be slightly more than those presently available at London City Airport and quite useable for civil airliners on regional routes.

Northolt Declared Runway Distances

	Runway	TORA	TODA	ASDA	LDA
Existing	07	1684	1768	1684	1592
	25	1687	1701	1687	1684
Proposed	07	1444	1504	1649	1435
	25	1526	1586	1594	1354

Source: AIP (existing) and MM (proposed)

The shortened runway may no longer be suitable for some existing business jet operators. We have not consulted with Netjets or any other bizjet users.

We have asked the MoD to review the impact of the shorter runway on military operations. This is work that is in hand, but at the time of writing, we have not yet had their response.

We have some concern regarding tailwind operations, particularly in relation to landing on Rwy 25. The required landing and take-off distances can increase significantly in tail-wind conditions. These do not occur at London City, but would have to at Northolt, due to the need to operate in the same direction as the Heathrow runways. Heathrow operations have a westerly bias for environmental reasons and due to the long runways available, Heathrow can readily accommodate tail-wind operations.

It will still also be necessary to provide arrestor beds at each end of the runway and improve the under-shoot RESA provision. We are of the opinion that the above proposals to shorten the runway were applied, then the CAA may accept the existing arrestor beds as being adequate for the existing traffic volumes and types. However, if commercial airliners were to operate in the numbers being considered, then we anticipate that the CAA would want the existing lightweight aggregate arrestor beds to be replaced with EMAS[2] arrestor beds.

These beds would then provide a predictable aircraft stopping performance that does minimal damage to an overrunning aircraft and protects the passengers, crew and the general public on the highways outside of the airport boundary.

A Regional Airport

Provision of additional facilities to handle airline passengers will require appropriate aircraft, passenger and baggage handling facilities and open public access to the south side of the aerodrome. Such facilities would generally be new and those that are relevant to licensing would be built accordingly. They will also require planning permission.

We have also identified areas where the pavement strength may not be adequate for the intended aircraft types.

The RAF also stated that a number of facilities located to the north of the runway may need to be relocated to the south and some military facilities to the south located to the north or moved off-site. These included the fire station, fire training ground and ATC control tower. In assessing the aerodrome against licensing requirements, some upgrades of these facilities may be required, but there is no specific need to move these.

That is not to suggest that there may not be other reasons for their relocation.

[2] EMAS is an Engineered Material Arresting System developed in the USA and comprising of crushable concrete blocks

1. Introduction

Northolt Aerodrome is an RAF airfield located in Ruislip, northwest London. It has been in continuous operation since 1915. It is notable for hosting several Polish manned squadrons during WWII.

The current layout has a single 1,687m long runway orientated 071/251 degrees from North (designated 07/25). The former Rwy 12/30 is closed, although parts are used as taxiway. To the north of the runway is the main military enclave, which contains numerous facilities. Some directly support aviation operations at Northolt, including the fire station and control tower, while others do not. Some additional facilities were developed between 2006 and 2010 to replace a number of functions that took place at other RAF sites in the London area when they were closed as part of the Project MoDEL. To the south of the runway is the main apron, with a small terminal, hangar and support facilities. The British Forces Post Office has a large warehouse and there are some other military facilities.

RAF Northolt

Source: Google Earth Image (GEPro Licence Nr *******3XZYA8QL)

[redacted]

Netjets and a number of privately owned aircraft are based at Northolt. London City Airport operates a small terminal to serve civilian passengers. At present access to the civilian facilities on the south side of the runway is controlled for security reasons.

Operating hours are limited to reflect the high density of residential property under the flight paths.

At present its status is that of an unlicensed Government Aerodrome.

Consideration is being given as to how Northolt might be developed in the future. Options include passing the operation of the runway and related facilities to the private sector. This would be to save operating costs and generate revenue or capital income. Under these circumstances, the aerodrome would need a civil Licence.

In order to be of value to the private sector, it must be possible to be able to develop the business, which would mean increasing the number of civil operations at the aerodrome. There is also a demand for regional airlines to be able to access the area. The volume of traffic is not a Licensing issue, although that and the nature of the traffic may have a influence on some aspects of the License operation. The commercial options are being considered in a separate report by Ernst & Young.

This is a technical report commissioned by the Ministry of Defence (MoD) to evaluate the existing facilities at Northolt Aerodrome in relation to the Civil Aviation Authority's (CAA's) requirements for a Licensed Aerodrome. In view of the impending change to aerodrome Certification by the European Aviation Safety Agency (EASA), where relevant, we have also considered the International Civil Aviation Organisation's (ICAO's) standards and recommended practices for the design and operation of aerodromes. This is because EASA have stated that their certification rules will be based on these. Draft rules have been recently published for comment. They are based on ICAO Annex 14 but some differences are apparent and it will be some months before the final EASA rules are confirmed.

In writing this report, we have come to conclusions as to what works would be necessary to:

- be granted a CAA Aerodrome Licence (or EASA Certificate) for the existing mix of civil and military operations; and
- develop the aerodrome into a commercial airport handling existing traffic and regional passenger airliners.

If the aerodrome were developed as an airport, there are other important operating issues that are outside of the CAA's Licensing provisions or the prospective EASA's Certification rules:

- If there are unusual technical or operational issues that relate to flying into Northolt, specific requirements may be made in relation to navigation equipment, pilot training and experience;
- The management of the local airspace and the control of aircraft using it are also critical safety and capacity issues. This will be a particular consideration in relation to the other airports in the vicinity of Northolt, not least, Heathrow. Denham and Luton Airports;
- The civilian side of the aerodrome will have to satisfy aviation security requirements that are implemented by the Department for Transport;
- Adequate power, drainage and other utilities will be required;
- Environmental impacts, including noise, air quality and surface access provision must be determined and addressed;
- Suitable passenger terminal and ground handling facilities will be required;
- Aircraft and passenger capacity limits may apply. If demand exceeds capacity, a system of slot management to regulate access to the airport may be required; and
- All the above are independent of any Government policy and LA Development Control requirements that may also apply, or be imposed.

These issues are outside the scope of this commission. We refer to these where they relate to Licensing matters and to provide Ernst and Young with indicative development costs, but are not otherwise being specifically addressed by this report.

2. Aerodrome Regulation

2.1 ICAO

International aviation is regulated by the International Civil Aviation Organisation (ICAO) and the ICAO Contracted States, which includes the UK, agree in the interests of safety and regularity to comply with the ICAO Standards and Recommended Practices (SARPs) for the regulation of aviation in their country and airspace. Each state enacts the ICAO provisions in accordance with local law and regulatory practices. Any material variation between local aviation regulations and the equivalent ICAO SARPs are to be notified to ICAO. Domestic civil aviation may not be covered by the ICAO provisions, but it is completely accepted that it is in the interest of the industry and public safety that the same provisions generally apply for domestic and international civil air operations.

Military facilities and operations are also not covered by the ICAO provisions, but apart from the specialised nature of some military equipment and aspects of its operation, it is again recognised that operating aircraft, providing facilities and undertaking operations in a manner that is consistent with international civil aviation is also in the interest of military and public safety. Most military air operations also take place in airspace that is also used by civil aviation and the control of both civil and military aircraft has to be safe and effective, which requires a considerable degree of consistency. Consequently, the technical requirements for military air operations are often similar to those required in the civilian environment. In the UK, military aviation requirements are also determined by NATO requirements. These are also made as consistent as is considered possible with the equivalent ICAO civil requirements, again to achieve a safe and consistent approach throughout NATO areas of operation.

In the case of civil aerodromes, ICAO publishes its Standards and Recommended Practices (SARPs) for aerodrome design and operations in Annex 14 to the Convention on International Civil Aviation. This describes the physical and operational requirements for an international civil aerodrome. Annex 14 makes no specific reference to Licensing or Certification. A Licence is a permission to operate and a Certificate is proof of compliance. A Licensing system provides a stronger means of control, because withdrawal of an aerodrome Licence would prevent that aerodrome from operating. Some states, including the UK, operate a Licensing system. They base their Licensing requirements on ICAO SARPs, but ICAO itself does not issue Licences.

2.2 CAA

In the UK, the Civil Aviation Authority (CAA) is charged with enacting most of the UK's obligations as an ICAO Contracted State.

Under UK law, the Air Navigation Order (ANO) Article 208 requires that specified flights for the purpose of public transport shall take place only at either a Licensed aerodrome, or a Government aerodrome. At present, Northolt is a Government Aerodrome and therefore does not require a Licence from the CAA to operate. The context of this study is in relation to any future sale or lease of all or part of the aerodrome to a private operator. In such circumstances, the anticipated use would (under present rules) require a Licence to be obtained.

The CAA's Licensing requirements are published in CAP 168 Licensing of Aerodromes. This may be considered the UK equivalent to ICAO's Annex 14, but the way it is written is different in its approach and several of its technical provisions are also different to the equivalent ICAO Annex 14 SARPs.

CAP 168 contains an option as to whether to apply for a Public Use Licence, or an Ordinary Licence. In the first case, the operating hours must be notified in the UK Aeronautical Information Publication (AIP) and the aerodrome must be available on equal terms and conditions to all persons permitted to use it. An Ordinary licence relates only to use of the aerodrome by the holder of the licence and persons specifically authorised by him. Generally, the CAA's technical requirements for a Public Use License and for an Ordinary Licence are the same.

Most aerodromes can only handle aircraft up to a certain size and operators of those aircraft will take into account the available landing and take-off lengths of the runway, the obstacle environment, pavement strength, spatial clearances and other relevant characteristics. In the case of Northolt, some of the required operating characteristics may be different for civilian operations and military operations.

Most options being considered for Northolt retain a mix of military and civilian operations. In law, these can continue to operate from a Government Aerodrome irrespective of the respective volumes of traffic. However, commercial airlines will expect the facilities and operations to be consistent with and equally safe as to those that would generally apply at a Licensed aerodrome. If the management of the operations passes to the private sector before 2014, a Licence will be required.

2.3 EASA

We are also aware that it is intended that the European Aviation Safety Agency (EASA) will take over the regulation and certification of aerodromes on 1st January 2014. The proposed division of responsibilities in the EASA system are that:

a. EASA will prepare the rules;

b. National Aviation Authorities (NAAs) will apply the rules; and

c. EASA will standardise NAA implementation.

The CAA will be an NAA and therefore remain responsible for implementing the EASA rules, but the Licence will change to a Certificate and the rules themselves will change.

EASA aerodrome regulations will be in the form of Implementing Rules (IR), Acceptable Means of Compliance (AMC) and Certification Specifications (CS). These are currently being drafted or under consultation. There will be a transition period following 1st January 2014 (likely to be 4 years) to allow aerodromes to convert to the new EASA certificate.

The CAA has had a significant input into the future EASA aerodrome requirements, but as this will apply to all countries in the European Union, the EASA requirements will be closer to the ICAO SARPs than the present CAA Licensing requirements. There will be:

- **Essential Requirements** (ER), which will be high level, legally binding requirements, contained in the Basic Regulation (BR);
- **Implementing Rules** (IR) which will be legally binding in their entirety and used to implement the ERs by specifying a high and uniform level of safety and uniform conformity and compliance. They have to be met exactly;
- **Certification Specifications** (CS) which will be non-binding technical standards adopted by the EASA to meet the essential requirements of the Basic Regulation. It is expected that the majority of the ICAO SARPs related to design will be transposed into a CS. Should an aerodrome operator not meet the CS, it may propose an Equivalent Level of Safety (ELOS) that demonstrates how the intent of the CS is to be met; and
- **Acceptable Means of Compliance** (AMC) which will be non-binding.

2.4 Current Aerodrome Licensing Requirements

Our brief was to assess Northolt aerodrome for an ICAO Licence. However, as stated above, the CAA presently license aerodromes and we have initially assessed Northolt against their requirements.

The physical and operational requirements for a UK Licensed aerodrome are stated by the CAA in their publication, CAP168. The latest addition applies and is presently published as Edition 9 including its amendment dated 2011/01. In this report, we have therefore assessed Northolt against these requirements, but due to the impending change to EASA certification, where significant, we have also considered the ICAO SARPS. We have not specifically considered EASA requirements, as their draft rules have only just been published for comment and it will be several months before they are finalised.

CAP168 also makes reference to a number of ICAO documents that may augment the CAA's published requirements. In addition, the distinction between an ICAO Standard (which is necessary and shall be complied with unless that is impossible) and an ICAO Recommendation (which is desirable and States should endeavour to comply with) are not followed through in the language and presentation of the CAA's CAP168 Licensing requirements.

In response to an application for a Licence for Northolt, we would expect the CAA to consider this as being an existing operating aerodrome and to review all aspects and identify any areas that do not comply with its requirements. The CAA would then request that the operator bring those facilities into compliance with the provisions of CAP168, or to demonstrate a safety case for retaining the existing situation, or some modification thereof.

We do not expect that the CAA would accept variations on the simple grounds of 'grandfather rights'. This could be a particular issue in relation to the obstacle environment at each end of the runway.

2.4.1 Permitted Variations

It is industry practice and the expectation of most regulators that the design of new aerodrome development is fully compliant with both the ICAO Standards and its Recommendations (in regimes where Annex 14 applies), or with all the provisions of the equivalent local regulations, which in the case of the UK, means full compliance with the provisions of CAP168.

Achieving full compliance with all Licensing requirements is the start point, but most aerodromes are constrained by space, obstacle and financial limits.

Consequently, both ICAO and the CAA recognise that it may be impractical, unaffordable, or even impossible to comply with every regulatory requirement at existing aerodromes and in some specific instances, at new sites. To the best of our knowledge, the CAA does not have any general policies that permit variations to their CAP168 Licensing requirements. Each situation is considered on its own merits. Any departure from the relevant requirements will generally be permitted only after an acceptable analysis of the additional level of risk due to the non-compliance and the potential consequences due to that risk. Various mitigation measures may also be required. Even then, the CAA will generally expect that over time, an aerodrome will seek to minimise or remove any such variations.

The EASA rules will provide for an alternative means of compliance.

The EASA Basic Regulation does not foresee the 'grandfathering' of existing deviations or non-compliances either. Instead, all existing aerodrome deviations or non-compliances (which we usually refer to the UK as variations) will need to be jointly reviewed during the acceptance procedure and compared with the new rules to identify suitable mitigation measures as appropriate. It is possible that any remaining deviations will be included in a Deviation Acceptance & Action Document (DAAD). The DAAD being produced jointly by the CAA and the aerodrome to document those existing deviations and non-compliances that remain after reviewing them with the new aerodrome rules, and should include an action plan describing the conditions that may result in the removal of those deviations.

2.4.2 Precedents Elsewhere

In general, the CAA does not accept an argument that a variation permitted at one aerodrome means that a similar variation should be permitted at another. A safety case must be made for each potential variation at each airport. However, it is probable that the method used to develop such cases at one aerodrome would also apply at another.

The issue of the definition of runway Code Number may be a particular issue at Northolt. Prior to 2001, the CAA would permit a runway with a take-off distance of up to 1,319m (1,199m + 10%) to be classified as a Code 2 runway. The additional 10% allowance was to accommodate the additional take-off length that may be required during a hot day.

CAP168 also stated that the runway Code Number was not intended to influence the runway length provided. However, the CAA would not permit any additional adjustment for adverse gradient or other factors at that time.

Since 2001, The CAP168 defines the Code Number classification as being determined by the greater of the Take-off Distance Available (TODA), or the Accelerate and Stop Distance Available (ASDA). For a Code 2 runway this distance must be between 800m and 1,199m.

Several UK runways with Code 2 clearances and obstacle limitation surfaces, but with take-off distances of between 1,200m and 1,319m continue to operate on a legacy basis. London City, Dundee and Gloucester are examples of airports with such runways. The most relevant of these is London City Airport (LCY).

It may be thought possible to develop an argument that the existing safety record of operations at such aerodromes meets the CAA's safety requirements and the nature of the intended operations at Northolt is sufficiently comparable that it would be equally safe if a Code 2 runway of similar length were provided at Northolt.

Such a comparison will not be acceptable to the CAA. Apart from the basic principle, which is to attempt to fully comply with its current requirements, a separate and distinct safety case would have to be made.

Similarly, arguments that the existing aerodrome has a good safety record will not provide an automatic justification for Licensing the existing facilities and method of operation. The existing safety record would be an element to be considered, as would any anticipated change in the nature of the operations, but compliance with CAP168 (or under EASA, their ICAO-based requirements for Certification) would still be the primary consideration.

Under EASA Certification, as a National Aviation Authority applying EASA's rules, the CAA will be obliged to follow EASA's standardised implementation requirements.

Ultimately, it will be for the CAA to decide if the aerodrome, its facilities and its operation are sufficient to be granted a Licence. In providing our advice in this study, we are basing that on published information and past experience of the CAA requirements. Except where full compliance can be clearly demonstrated, we cannot guarantee what the CAA's Licensing or Certification requirements will be.

2.4.3 Scope of Aerodrome Regulation

CAP168 and ICAO Annex 14 cover the following main areas of regulation:

- The Aerodrome Physical Characteristics;
- The Assessment and Treatment of Obstacles;
- Aeronautical Ground Lighting;
- Aerodrome Signals, Signs and Markings
- Electrical Power Systems;
- Birdstrike Management;
- Surface Movement;
- Ground Vehicle Operations and Aircraft Servicing;
- Aerodrome Pavement Maintenance and Inspection Procedures;
- Emergency Planning; and
- Rescue and Fire Fighting Service (RFFS)

In addition, CAP168 refers to additional Licensing requirements that include:

- The Licensing Process;
- The Aerodrome Manual;
- Evidence of Pavement Strength;
- Mapping and related data; and
- Air Traffic Control;
- Aeronautical Information

In addition, other documents (mostly ICAO documents) state related requirements for the operation of an aerodrome, such as:

- Radio Navigation Aids;
- Approach and Departure Procedures;
- Aviation Security Requirements

This last group may not be directly referred to as a Licensing Requirement, but are an equally essential set of operating requirements where compliance with their provisions is recommended by the regulator.

3. Aerodrome Physical Characteristics

3.1 Airfield Layout

The airfield layout shown in the satellite image in Chapter 1 is converted to a standard form and standard description in the Aeronautical Information Publication (AIP).

AIP Aerodrome Layout Chart

AERODROME **NORTHOLT**

Elev **124**	Var 2°W	ARP N51 33·18 W000 25·09 (WGS 84)	**15 DEC 11**	**D1**
NORTHOLT GND 121·575	NORTHOLT TOWER 312·35 120·675	APPROACH 344·975 126·45	DEPARTURES 129·125	ATIS 300·35 125·125

EGWU/NHT ENGLAND

Changes: GND Freq

RWY	SLOPE	LDA m/ft	APP LGT		RWY LGT
07 (069°T)	0·18%U	*1592*/5223	P3° (30)	CL–2B (H)	RTHL (H): REDL (H,U:L,O): STWL (R)
25 (249°T)	0·18%D	*1684*/5525	P3·5° (38)	CL–3B (H)	RTHL (H): REDL (H,U:L,O): STWL (R)

1. **CAUTION.** Rwy 25. Moderate turbulence/wind shear on approach if strong NW wind.
2. **CAUTION.** Exercise caution whilst taxiing via Twy C North & E South at night or during poor visibility as the twys are lit with unmonitored solar twy lights.
3. AD in urban area; obstacles on approach restrict LDA.
4. Rwy in use determined by LONDON/Heathrow; possible tail–wind component at Northolt.
5. Circuits – 1000. Rwy 25: RHC.
6. Practice/Simulated asymetric approach/landing **prohibited.**
7. Rwy 07/25. No tight turns on friction course surface.
8. The BRAVO/CHARLIE intersection is available to familiar hel for TKOF and landing. Taxi and parking as directed.
9. Acft are to remain with TOWER 120·675 when manoeuvring on the airfield.
10. Arrestor beds in overrun of each rwy *(700m²)*. Rwy 07 THR displaced *92m*/302ft.

NOISE ABATEMENT

11. The following procedures should be adhered to other than for reasons of acft safety or on ATC instructions:
    a. Pilots are to ensure that acft are operated so as to minimise noise disturbance in areas surrounding the airfield.
    b. As soon as practicable after TKOF reduce power to that compatible with crossing LONDON CTR at **3000** QNH.

COMMS FAILURE

12. See SPECIAL PROCEDURES charts.

No1 Aeronautical Information Documents Unit EGWUD1

NORTHOLT **AERODROME**
APATC–1

Source: MoD

3.2 Reference Code

CAP 168 states[3] that the CAA will determine the runway reference code in consultation with the aerodrome licence holder.

3.2.1 Definitions

Many of an aerodrome's physical characteristics are defined by its reference Code. This indicates two key aircraft-related characteristics. A number (1 to 4) is used to classify the runway length requirement and a letter (A to F) is used to indicate the largest wingspan (or under-carriage width) of the aircraft that it is intended to accommodate.

ICAO Annex 14 defines[4] the number element as the code number that corresponds to the highest value of the Reference Field Length (RFL) of the aeroplanes for which the runway is intended. The RFL is the take-off distance required at sea level, standard atmospheric pressure, zero wind, zero gradient and at maximum take-off weight. Under the ICAO SARPS, the determination of this RFL is solely for the selection of the code number and is not intended to influence the actual runway length provided.

Code 2 is where an RFL is between 800m and 1,199m, Code 3 applies where an RFL is between 1,200m and 1,799m. RFLs of 1,800m and over are classified as Code 4.

CAA CAP 168 defines[5] the number element as determined by selecting the higher value of declared Take-off Distance Available (TODA) or the Accelerate and Stop Distance Available (ASDA).

Code 2 applies where TODA or ASDA is between 800m and 1,199m. Code 3 applies between 1,200m and 1,799m. Code 4 is 1,800m or more.

Although the dimensions used in both definitions are the same, they are substantially different in meaning and in application. As far as we are aware, the CAA is the only regulator to use their definition. ICAO permits the actual runway length provided to be adjusted to allow for operating factors such as the effects of altitude, ambient temperature and longitudinal gradient on take-off and landing lengths required.

---

[3] Chapter3, Cl 2.2
[4] Chapter 1, Cl 1.7
[5] Chapter 3, Cl 2

As stated 2.3 above, EASA have indicated that they will base their rules on the ICAO SARPS, but their draft definition for the Code Number is not 100% clear. Even so, we expect the first definition to apply.

It is also of note that both definitions refer to aircraft take-off characteristics, but most of the requirements that are dimensioned in relation to the Code Number refer to aircraft landing facilities. This can lead to some inconsistent requirements.

The landing facilities are different to those required for take-off and also depend on which of the following types of approach are available:

- precision instrument;
- non-precision instrument; or
- non-instrument (i.e. visual) approach

The Code Letter usually reflects the maximum wingspan of aircraft that the aerodrome is intending to serve (in rare instances the code letter may be determined by the overall width of an aircraft's undercarriage). In this case, both ICAO and the CAA use the same method of classification. Wingspans of up to 15m are classified as Code A, 15m or more and less than 24m as Code B, those of 24m or more and less than 36m as Code C and those of 36m or more and less than 52m as Code D. With a single exception, (B757), narrow-bodied (or single-aisle) commercial civil transport aircraft are classified as Code A, B, or C and wide bodied aircraft are classified as Code D, E, or F.

The Code letter classification is primarily used to ensure adequate widths and clearances. Full compliance is necessary to allow for the self-manoeuvring of aircraft on taxiways or aprons.

While the standard Code letter groups are normally used, it is possible to provide for specific aircraft sizes where space is restricted and larger types in a size group are not intended to operate.

3.2.2 Current Aircraft Types

We understand that Northolt aerodrome currently commonly handles BN Islander, HS125, BAe146, Gulfstream 4 and Gulfstream 5 types. However, it also occasionally handles C-130s and C-17As. If operations are also required in the future by the Airbus A400M military transport aircraft, this has a wingspan of 42.4m. In addition, there are helicopter operations. The main rotor diameter is the principle dimensional characteristic of different types of helicopters.

3.2.3 Existing Declared Runway Distances

A runway has a physical paved length, but it is often the case that not all that length in available for take-off or for landing aircraft. In addition the lengths used in each direction may be different. This is dictated by the proximity of the site boundary to the runway ends and the existence of obstacles within or outside of the aerodrome. That is the case at Northolt. The paved runway is 1,687m long and 46m wide. The Runway 07 threshold (THR) is inset 92m. The Runway 25 THR is at the start of the paved runway, although the paved edge is not perpendicular to the runway centreline.

Four distances are declared for each runway direction. These are:-

- TORA: Take Off Run Available
  (even when the take off run required equals, or is only slightly less than the distance available, safety margins mean that aircraft usually lift off about 2/3rds along this distance and climb quickly)
- TODA: Take Off Distance Available
  (aircraft have to reach a height of 35 ft in this distance, even in the event of an engine failure just after take-off)
- ASDA: Accelerate and Stop Distance
  (distance aircraft have to accelerate, abandon the take-off and come to an emergency stop on the runway)
- LDA: Landing Distance Available

Each of these distances is declared in the Aeronautical Information Publication (AIP) for each airport. In undertaking their pre-flight payload and range calculations, pilots have to ensure that the landing distance required does not exceed the LDA, nor that each of the three take-off distances required exceeds those that are declared as available.

Northolt Declared Runway Distances

Runway	TORA	TODA	ASDA	LDA
07	1684	1768	1684	1592
25	1687	1701	1687	1684

Source: AIP

The distance between TORA and TODA is termed clearway and need not be surfaced, but must be clear of obstacles. The short 14m clearway declared for Rwy 25 does not meet the provisions of CAP168 or Annex 14.

The distance between TORA and ASDA is termed stopway and need not be paved, or paved to full runway strength, but must be suitable to support an aircraft and allow it to brake to a stop. No lengths of stopway are presently declared at Northolt.

The declared distances at Northolt are relatively short distances both for some of the military and for some of the civil types in use.

3.2.4 Existing Runway Code

If it were classified using its existing dimensions, and the above list of intended aircraft types, it would probably be classified as a Code 3D runway precision instrument approach. The military enclave would probably be sized for the C130, A400M and C-17A and the civil enclave would probably be sized just for Code C aircraft.

3.2.5 Future Aircraft Types

For the purpose of this report, we assume that this aerodrome will continue to handle both military and civilian traffic.

On the military side, most existing types will remain in operation, but we anticipate that operations may also be required in the future by the Airbus A400M military transport aircraft (with a wingspan of 42.4m).

The future of the civilian side is a much more complex issue that will be determined by Government policy, the Development Control process and commercial demand. An expansion of the present civilian use by the business aviation sector is not the only technically viable option. Demand is exceeding the capacity of nearby Heathrow Airport, a situation forecast to continue. Heathrow's role is as the UK's primary international hub airport and it also serves London, the Thames Valley and the Southeast in general. In addition, the trend at Heathrow is in favour of long-haul routes and away from short-haul routes – a process that has resulted in the loss of access for many UK regional airports to Heathrow. Northolt could satisfy some of that demand.

The types of civilian aircraft that could use Northolt would be constrained by the runway length that is available. That completely rules out long-haul and wide-bodied types[6].

---

[6] the large military transports that presently access the site have short field characteristics, which are generally not offered in the civilian commercial air transport sector and probably operate with a restricted payload/range

If it becomes necessary to shorten the runway's declared distances, the degree of constraint is increased. However, we anticipate that future civilian aircraft will continue to be Code B or Code C narrow-bodied types.

All Code C turboprop transports can operate from the Northolt runway at its present length, and most could also operate from a shorter length, if that becomes a necessary consequence of obtaining a civil operating Licence. The capacity of most turboprop aircraft is in the range of 30 to 70 seats. The largest is the Bombardier Dash 8 Q400 with 78 seats. Flybe is the UK main regional air services provider and they have a significant fleet of Dash 8 Q400 aircraft. ATR 42, ATR 72 and Dash 8 Q300 turboprops are also in UK service with several other operators and in significant numbers.

A few specialised jet aircraft could also operate from the existing, or again, a shorter runway. Apart from the specialised types that operate from the shorter (1,319m) runway at London City Airport, such as the BAe 146/RJ family, some of the smaller models of the Airbus A320 family (the A318 and A319), the Boeing B737 family (B737-500 and B737-600) and the Embraer 170/190 family could also operate from this runway length. However, some of these would be payload/range restricted, particularly in hot weather. Operations by the larger of these common types would be more commercially viable and provide more passenger capacity. The exact runway distances that can be declared at a Licensed Northolt are critical in determining the potential nature of operations in this sector and the number of passengers that could be handled per runway movement.

Other UK airports with similar runway lengths offering commercial air services are Southend, Jersey and Southampton. The aircraft types operating at these airports, along with London City, are a further indication of the types that could operate commercially at Northolt.

A more extensive range of UK regional airports is tabulated below in order of increasing paved runway length.

In making comparisons we have to be aware that the range of many of the flights from these airports is limited and that demand at some of these airports is also limited, due to a size of their catchment. This may be the reason why an airline may select a smaller aircraft type and that may not necessarily be solely due to the runway length available.

Comparable UK Airport Runway Data

Aerodrome (dims in m)		Paved Runway Length	TORA each way	TODA each way	ASDA each way	LDA each way	ILS Cat each way
NORTHOLT		1687 x 46	1684/1687	1768/1701	1684/1687	1592/1684[7]	NP/Cat 1
PLYMOUTH	(closed)	1160 x 30	1108/1101	1169/1169	1108/1101	1125/1140	NP/Cat 1
SCATSTA		1360 x 31	1253/1262	1319/1319	1319/1319	1138/1155	NP/NP
DUNDEE		1400 x 30	1319/1319	1319/1319	1400/1400	1400/1400	Cat 1/NP
KIRWALL	(main rwy)	1426 x 46	1428/1368	1428/1428	1428/1468	1268[7]/1326[7]	Cat 1/Cat 1
GUERNSEY		1463 x 45	1463/1462	1601/1639	1463/1462	1458/1458	Cat 1/Cat 1
GLOUCESTER	(main rwy)	1431 x 37	1271/1317	1311/1319	1271/1317	1153/997[7]	NP/NP
SUMBURGH	(main rwy)	1500 x 45	1319/1319	1319/1319	1319/1319	1245/1260	ILS/Cat 1
LONDON CITY		1508 x 30	1199/1199	1319/1385	1319/1319	1319[8]/1319[8]	ILS/ILS
SOUTHEND	(main rwy)	1605 x 37	1459/1531	1544/1591	1459/1546	1285/1399[7]	NP/Cat 1
JERSEY		1706 x 46	1706/1645	1889/2469	1706/1645	1645/1554	Cat 1/Cat 1
SOUTHAMPTON		1723 x 37	1723/1650	1831/1805	1723/1650	1650/1605[9]	NP/Cat 1
BIGGIN HILL	(main rwy)	1802 x 45	1778/1670	2174/1802	1778/1670	1558/1670	NP/Cat 1
CARLISLE	(main rwy)	1837 x 30	1659/1714	1777/1824	1659/1714	1321[10]/1469	NP/NP
INVERNESS	(main rwy)	1887 x 46	1887/1820	2037/1970	1887/1820	1827/1820	Cat 1/Cat 1
KEMBLE		2009 x 45	1724/1724	1724/1724	1724/1724	1724/1724	Non-Instr
BRISTOL		2011 x 45	2011/2011	2071/3016	2011/2011	1938/1881	Cat 1/Cat 3
EXETER		2083 x 46	2047/2073	2263/2653	2047/2073	2037/2037[7]	Cat 1/Cat 1
FARNBOROUGH		2440 x 46	2000/2063	2060/2123	2590/2440	1800[7]/1800[7]	Cat 1/Cat 1

Source: MM from NATS published data (Jan 2012)

The standard approach has a 3.0 degree (5.24%) glideslope. The selection of a steeper glideslope will have been determined by the need to clear obstacles under the approach.

Most offer a precision approach (ILS) in at least one direction.

[7] 3.5 degree (6.1%) approach
[8] 5.5 degree (9.6%) approach
[9] 3.1 degree (5.4%) approach
[10] 3.26 degree (5.7%) approach

The Boeing B737-BBJ is used in the business aviation sector and in that guise carries relatively few passengers and a light payload (depending on the fuel required to meet the range). This aircraft has long winglets giving it a wingspan of a fraction under 36m. In this report, we consider this type the largest potential civilian type.

In addition, we anticipate that there will continue to be helicopter operations.

3.2.6 Future Declared Runway Distances

Lengthening the runway is not possible within the existing site boundary and in this report, we do not propose any expansion of the site. In Chapter 4, we consider the obstacle environment. We will see that the number and degree of infringements of the CAA/ICAO obstacle limitation surfaces is such that we do not believe that the CAA would License or EASA would Certify Northolt as suitable for Public Transport use based on its existing declared distances and method of operation.

Although the existing declared distances may be considered relatively short for several of the military and civil types in use, to reduce the number and degree of obstacle infringements, the runway declared distances may have to be shortened.

In subsequent Chapters, we also identify other features that would require modification to achieve a CAA Licence or EASA Certification. A few of these could also affect the declared runway distances.

3.2.7 Future Runway Code

Using the proposed new runway dimensions and the extended list of aircraft types tabulated on the next page, it would still be classified as a Code 3D precision instrument approach runway, although classification as a Code 2C runway is also considered elsewhere in this report.

Several of the civil and military types that are expected to be in operation have a RFL of less than 1,200m. These include the BN Islander (Code 1), ATR 42, Dash 8 Q300 and BAe 146-100/RJ70. Applying the ICAO definition, the A400M is a Code 3 type and the Boeing C-17A a Code 4 type (albeit with a very short landing distance). These would be the largest types. The best use of space would be to limit the civil enclave to Code C aircraft. The military enclave would be sized for the C130, A440M or the C-17A types. These would then either be parked on a new apron to the north, or handled under special procedures to the southern apron to ensure adequate clearances.

Code 2 Aircraft Types

Type	Seats (approx)	Engine	Use
ATR 42-500	42 to 50	turboprop	regional
BAe 125 or Hawker 400	<=9	turbofan	military or bizjet
BAe Jetstream 31/32	<=19	turboprop	regional
BAe 146-100/RJ70	70 to 82	turbofan	military or regional
Beechcraft King Air 200	<=9	turboprop	regional
Beechcraft King Air 350	11 to 17	turboprop	regional
Beechcraft King Air Premier	6	turbofan	bizjet
Bombardier Dash 8 Q200	37	turboprop	regional
Bombardier Dash 8 Q300	50	turboprop	regional
Let 410	19	turboprop	regional
Lockheed C130: [marginal as Code 2]	military	turboprop	military

However other types that could operate from this runway have an RFL of >1,200m and are classified by the ICAO method as Code 3 aircraft.

Code 3 Aircraft Types

Type	Seats (approx)	Engine	Use
ATR 72-500	66	turboprop	regional
BAe 146-200/RJ85	85 to 112	turbofan	regional
BAe 146-300/RJ100	100 to 128	turbofan	regional
Boeing B737-600 or -700	110 or 126	turbofan	regional
Bombardier Dash 8 Q400	70 to 78	turboprop	regional
Bombardier CRJ200 (Challenger 800/850)	50	turbofan	regional or bizjet
Bombardier CRJ700	68	turbofan	bizjet
Bombardier BD700 Global Express		turbofan	bizjet
Bombardier Global 5000		turbofan	bizjet
Bombardier C Series	100 to 135	turbofan	regional
Hawker 800/850/4000	<=9	turbofan	bizjet
Embraer ERJ135 or ERJ140	37 or 44	turbofan	regional
EMB170/EMB175/EMB190	70/78/108	turbofan	regional
Learjet 40/45/60		turbofan	bizjet
Airbus A400M	military	turboprop	military

3.3 Runway

3.3.1 Dimensions

3.3.1.1 Licensing Requirements

Runway Length

There are no Licensing requirements that state the length of runway to be provided. ICAO recommends that the runway should be adequate to meet the operational requirements of the aeroplanes for which the runway is intended and should be not less than the longest length determined by applying the corrections for local conditions to the operations and performance characteristics of the relevant aeroplanes.

This shows another notable difference between the CAA and ICAO requirements.

It is for pilots to determine if the runway lengths available meet the landing and take-off lengths required for their aircraft in the meteorological conditions that apply and at its operating mass.

On approach, missed approach or take-off an aircraft must also clear all obstacles in its path, even with an engine failure.

Runway Width

The minimum width of a Code 3C runway is 30m and for a Code 3D runway is 45m. Code D runways should have shoulders to bring the overall width of runway and shoulders up to 60m.

(CAP168 Ch 3, Cl 3.2 & 3.7 and Annex 14 Ch 3, Cl 3.1.10 & 3.2)

3.3.1.2 Compliance

The declared distances have been discussed above and the possible need to modify those is discussed in Chapter 4 Assessment and Treatment of Obstacles below.

The 46m runway width satisfies the Licensing requirements for a Code 3C runway.

Additional shoulders may be required if it is intended to continue to operate Code 4D aircraft.

3.3.2 Vertical Alignment

3.3.2.1 Licensing Requirements

These describe some fairly complex geometrical rules for the longitudinal and transverse profile of the runway.

(CAP168 Ch 3, Cl 3.5 to 3.6 and Annex 14 Ch 3, Cl 3.1.13 to 3.1.19)

3.3.2.2 Compliance

We assess that the runway complies with the longitudinal gradient limits for a Code 3C or 3D runway. We have insufficient level information to confirm that the slope change and sight line requirements are met, but from the levels we do have, we consider compliance with this aspect to be very likely. We also have insufficient information to confirm compliance with the requirements for transverse slopes, but have no indication that this aspect does not comply.

3.3.3 Runway Strip

3.3.3.1 Licensing Requirements

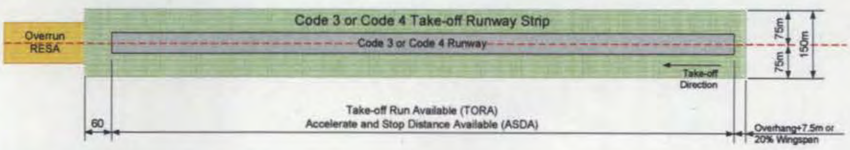
A runway strip is an area enclosing a runway and any associated stopway. Its purpose is to protect aeroplanes by reducing the risk of damage to an aeroplane:

d. flying over it during landing, balked landing, or take-off by providing by providing an area, which is cleared of obstacles (except permitted navaids); and

e. running off the runway by providing cleared an graded area.

For Code 3 runways, the required width of the runway strip for that part intended for take-off is 150m. CAP168 also allows this to be reduced at the start of a take-off run.

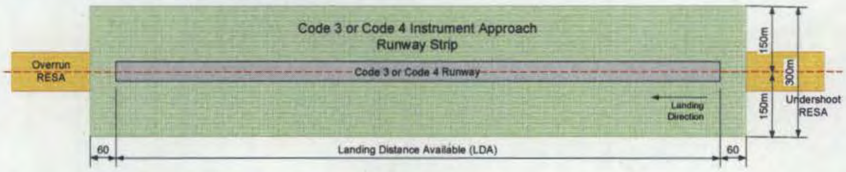
Take-off Runway Strip



Source: Based on CAP 168

Rwy 07 and Rwy 25 are instrument approach runways and the required width of the runway strip for that part intended for landing is 300m.

Landing Runway Strip



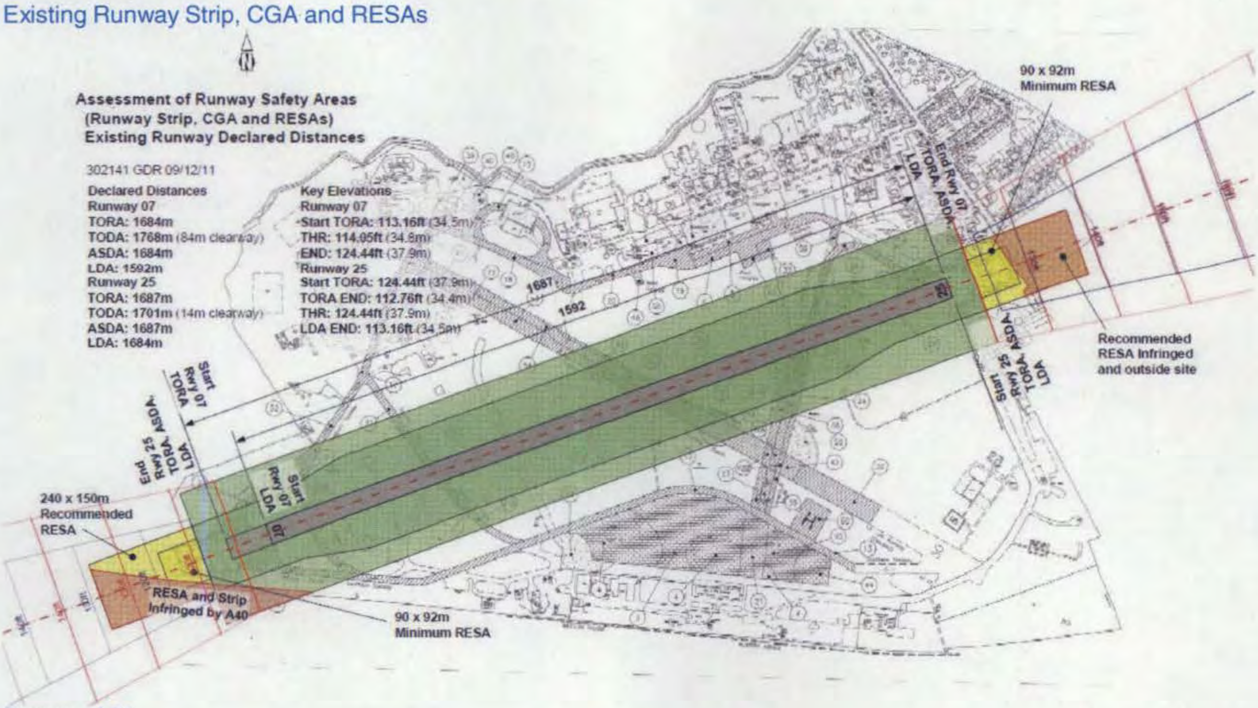
Source: Based on CAP 168

The strip should extend 60m beyond the end of TORA or ASDA for a take-off runway and 60m beyond each end of the LDA for a landing runway. The final strip is the envelope that contains the take-off and landing strips in each direction.

(CAP168 Ch 3, Cl 4 and Annex 14 Ch 3, Cl 3.4)

3.3.3.2 Compliance

Existing Runway Strip, CGA and RESAs



Source: MM

For most of its length, a 300m wide runway strip is provided. However, the strip extends outside the site boundary and across the A40 at the west end and across the West End Road at the east end. There are also infringements by buildings, lamp posts, trees and other objects at the northeast end of the strip. It is non-compliant.

Compliance would require a shorter strip and thus a shorter runway.

The strip width for a Code 2 take-off runway reduces to 80m and that for a Code 2 instrument approach landing runway reduces to 150m, so this may offer an alternative means of compliance. This is a significant step change that is not reflected in any particular aspect of the performance characteristics of relevant aircraft.

CAP168 also allows the landing strip to be 210m wide if TODA or ASDA are more than 1,200m and less than 1,500m. ICAO makes no similar provision.

These options are discussed during consideration of the obstacle environment in Chapter 4 and Chapter 9 Options to Improve Compliance.

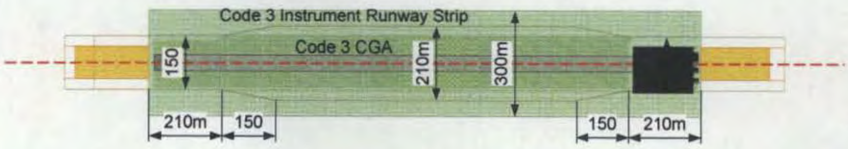
3.3.4 Cleared and Graded Area

3.3.4.1 Licensing Requirements

The width of the runway strip to be cleared and graded (the CGA) relates to the strip width and type of approach.

The width of the CGA for a Code 3 take-off, non-instrument, or non-precision approach runway is 150m. For a precision approach runway, apart from at the ends, the CGA shall be 210m wide.

Code 3 Runway Strip, CGA and RESa



Source: Based on CAP 168

(CAP168 Ch 3, Cl 4.4 and Annex 14 Ch 3, Cl 3.4.8 and Attachment A, Section 8)

CAP168 also requires that part which is required to be graded should be so prepared as to be capable of supporting any aeroplane at maximum certificated weight that the runway is intended to serve, without the aeroplane suffering significant damage.

3.3.4.2 Compliance

The sketch in 3.3.3.2 above shows the extent of the infringements of the runway strip and CGA when applied to the existing runway.

The full area of CGA can be provided for the existing runway except for a very small corner that extends outside the southern site boundary and onto the A40 verge. Any shortening of declared distances for other reasons would achieve full spatial compliance.

There are detailed requirements in relation to objects that are permitted within the CGA. In general these must be essential navaids, frangible and de-lethalised. We have not inspected the runway strip in this regard. We would expect most items to meet the Licensing requirements, but allowing a small contingency budget for works such as the de-lethalisation of foundations would be appropriate.

RAF Northolt could not confirm that the bearing strength of the graded area could support an aircraft. We were told that in one area an airport fire appliance had become bogged down in the past. Furthermore, commentary in the URS Scott Wilson Airfield Maintenance Report (June 2011) included that the subsoil drainage regime at RAF Northolt was previously reported to be poor, with a high water table and waterlogged clay.

It is therefore envisaged that some ground improvement work to the graded portion of the runway strip would be necessary. Without detailed information, the nature and extent of those works is unclear. A contingency sum will be required.

3.3.5 Runway End Safety Areas

3.3.5.1 Licensing Requirements

RESAs are intended to minimise risks to aircraft and their occupants when an aeroplane overruns or undershoots a runway.

The minimum RESA dimensions for a Code 3 runway are a length of 90m and a width equal to twice the runway width. The recommended dimensions are 240m long and the width of the CGA. We expect the

CGA width at the runway ends to be determined for the landing part of the runway and for a Code 3 runway is 150m wide. These provisions are the same under CAP 168 and Annex 14.

However, CAP 168 gives additional explanation as to the application of these dimensions and the provision of the minimum dimensions will not necessarily be sufficient. We anticipate that ICAO may strengthen their requirement to provide RESAs to the recommended dimensions. We must also take into account that the existing overrun risks have been recognised and mitigated by the provision of the lightweight aggregate arrestor beds at each end of the runway.

New developments are designed to the full recommended RESA dimensions unless the necessary land is not available.

As part of their system for the management of safety, the CAP 168 states that licence holders should review and determine on an annual basis the RESA distance required for individual circumstances, taking into account in their risk assessments factors.

These include:

a. the nature and location of any hazard beyond the runway end;

b. the type of aircraft and level of traffic at the aerodrome, and actual or proposed changes to either;

c. aerodrome overrun history;

d. overrun causal factors;

e. friction and drainage characteristics of the runway;

f. navigation aids available;

g. scope for procedural risk mitigation measures; and

h. the net overall effect on safety of any proposed changes, including reduction of Declared Distances.

Factors b and e often vary over time. Factors a, c and f may change as a result of specific development. Factor b will be expected to change if the Northolt aerodrome is developed.

It should be noted that while an annual review enables changes in the risks to be taken into account, if that resulted in a reduction in declared distances, that could have significant consequences to the aircraft size, type or routes that could then continue operate and thus the role and business of the aerodrome.

RESAs need to be free of hazardous obstacles and strong enough to support overrunning aircraft in the same way as the runway strip CGA.

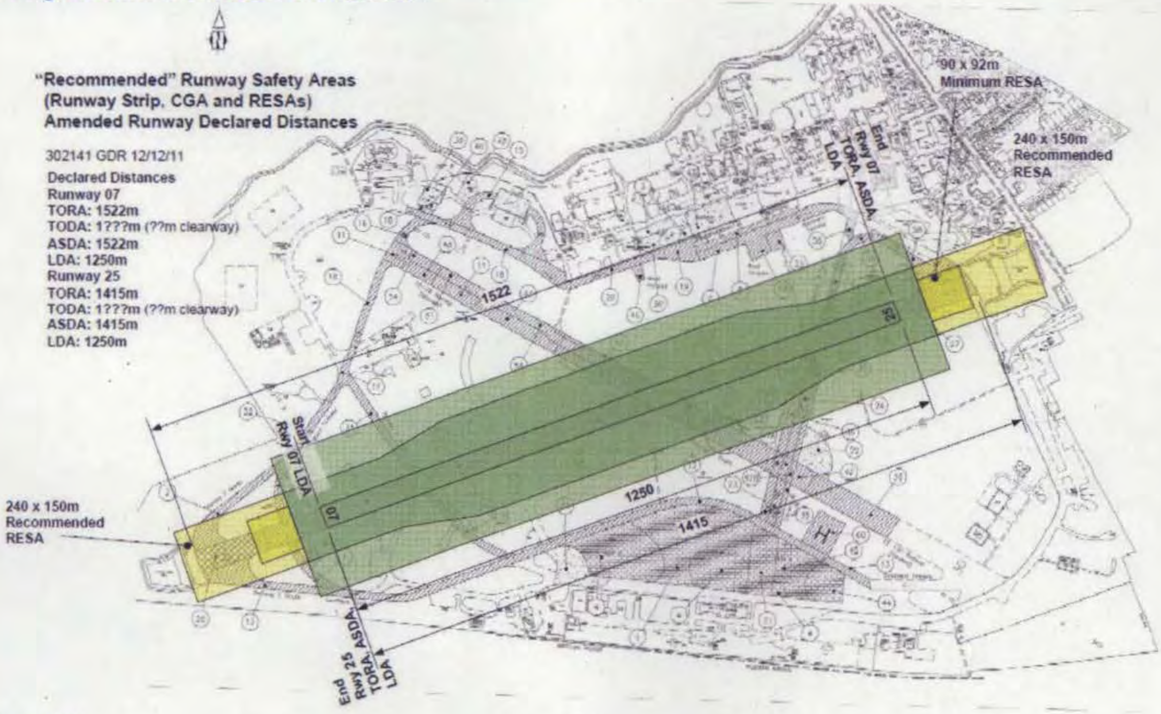
(CAP168 Ch 3, Cl 5 and Annex 14 Ch 3, Cl 3.5)

3.3.5.2 Compliance

The existing RESAs do not comply with the recommended length and width. The existing RESAs are also slightly less than minimum dimensions. The sketch in paragraph 3.3.3.2 above shows the extent of the existing RESA. CAP 168 states[11] that if a RESA beyond the 90 m minimum is deemed necessary, but there are physical constraints to achieving the desired distance, Declared Distances should be reduced unless other mitigation measures can be demonstrated to achieve an equivalent safety result for the same set of operational circumstances.

We have examined the consequences of reducing the declared distances to provide the recommended dimensions.

Providing Recommended RESA Dimensions



Source: MM

[11] Chapter 3, Cl 5.5

The resulting 1,250m runway landing distances would not be suitable for many of the military and business jet operations, nor for the anticipated civil airport use.

With major public roads at each end of the runway, it is necessary to address the overrun and under-shoot risks.

CAP 168 refers to the installation of suitably positioned and designed arrestor beds, to supplement the minimum RESA requirement, taking account of other risks that they may introduce.

Mitigation in the form of lightweight aggregate arrestor beds have been provided at both ends of the runway. These serve to provide overrun protection, but not under-shoot protection. The performance of the material is not well established, emergency vehicles cannot travel over it and it can absorb spilt aviation fuel, adding to the fire risk.

In 2010, the CAA has published its policy on the use of an arrestor bed constructed from an Engineered Material (EMAS). This system was developed by an American Company under the auspices of the Federal Aviation Authority (FAA) and is in use in many airports in the USA and a small number in other countries. It has a more predictable performance in all weathers and stops overrunning aircraft with the minimum of damage to the aircraft or injury to its occupants. To date in all actual overrun incidents it has performed as predicted.

We describe this system in detail in Appendix A, where we conclude[12] that for Licensing purposes:

- the existing lightweight aggregate arrestor beds could remain while the nature and volume of the traffic at Northolt remains similar to that operating today; but
- EMAS arrestor beds would probably be required if scheduled airline services were to be developed at the aerodrome.

The EMAS overrun RESA based on the FAA Standard solution would be 120m long (180m from the end of LDA, TORA or ASDA) and equal to the runway width (46m). The bed of blocks would be placed at the rear of the RESA on a paved area that extends 10m outside the EMAS blocks. The blocks would be designed for the particular aircraft mix.

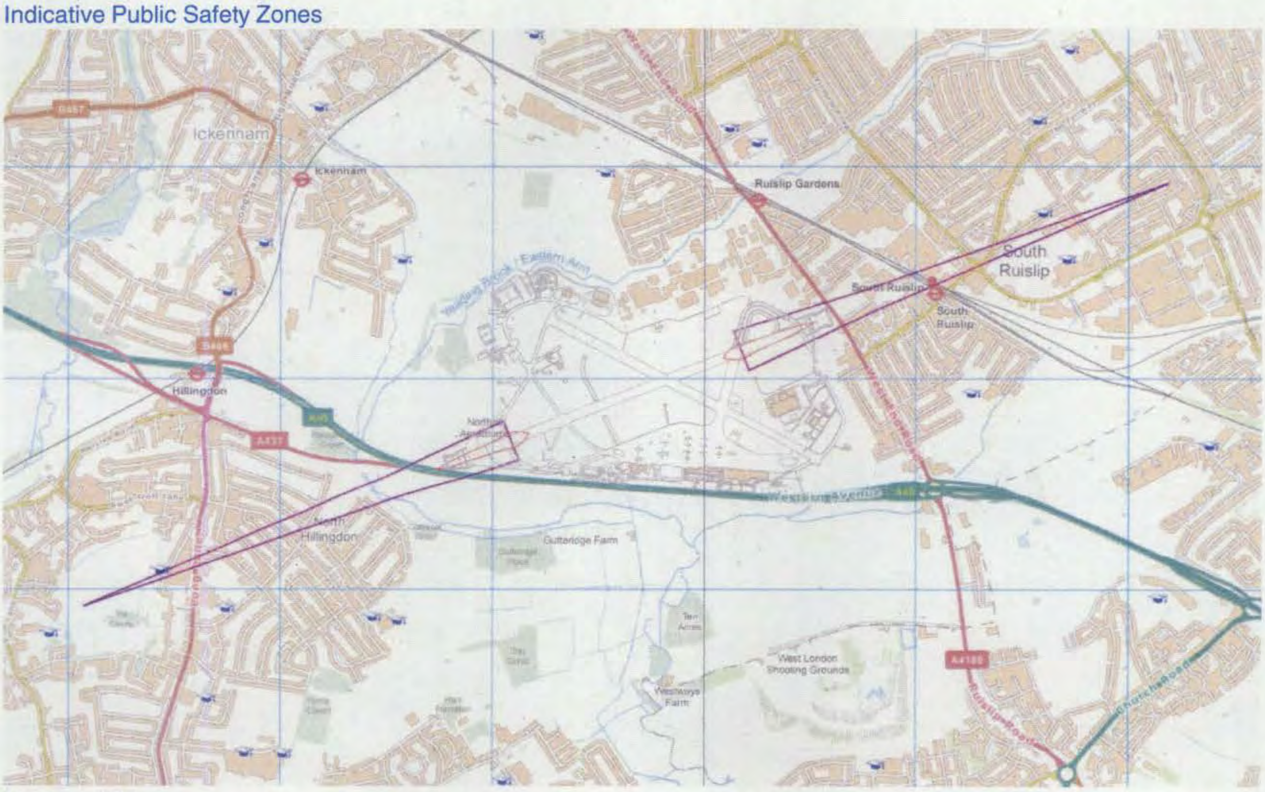
[12] As with all our assessments of compliance with the CAA's Licensing requirements, we have not discussed these with the CAA's Safety Regulation Group. Our conclusions are based on published requirements and experience of CAA requirements elsewhere.

3.3.6 Public Safety Zones

Public Safety Zones (PSZs) are promulgated at each end of a runway to protect the public from an unacceptable level of risk associated with an overrunning or undershooting aircraft. They are development control[13] and not aerodrome licensing requirements, but they are factors that must be considered by any future developer of the aerodrome. We have been asked to provide information regarding potential PSZs at Northolt. These may be expected to apply if scheduled airline services are developed as envisaged.

PSZs are individually calculated to reflect the anticipated type and volume of air traffic and their required dimensions can only be approximated at this stage.

Indicative Public Safety Zones



Source: MM

[13] Set out in DfT Circular 1/2010

For the purposes of this report, we have used the dimensions of those generated for Southampton Airport as an approximation of the likely future PSZ requirements. However, the traffic at Northolt will generate a similar shape, but of different dimensions.

From this we estimate that no property would be within the 1 in 10,000 risk contour and thus need to be removed to comply with PSZ provisions.

However, the outer 1 in 100,000 risk contour is an isosceles triangle in shape on plan. Its base would be approximately 200m wide and located at the threshold. The length shown is approximately 2.2km. To the west, such a shape would encompass some residential areas in Hillingdon, although the nearest will be about 1km from the existing Rwy 07 threshold. To the east, such a shape would encompass some commercial and residential properties and South Ruislip Rail Station. In this case, the nearest will be about 350m from the existing Rwy 25 threshold (about 600m from the relocated Rwy 25 threshold).

3.3.7 Jet Blast Protection

The sketch in paragraph 3.3.5.2 above shows the proximity of the southwest end of the runway to the A40 Western Avenue. The taxiway (Taxiway D) on the south side that connects to the western end of the runway runs parallel and close to the boundary fence between the site and the A40 (see below).

A40 Site Boundary

Source: Google Earth Image (GEPro Licence Nr *******3XZYA8QL)

When an aircraft taxiing to join the runway at this end turns clockwise onto the runway, there is a risk that wind velocities from turboprop and turbofan (jet) aircraft may sufficiently high to be a hazard to users of the adjacent highway. For part of its length a low earth bank provides some protection, but this is not continued across the end of the runway.

Elsewhere, we consider insetting the runway by moving the threshold and altering the declared distances. This will not alter the location of the start of the take-off run in each direction. However, it will alter the obstacle limitation surfaces and permit this bank to be extended across the runway end, providing some protection against propwash or jet blast.

This matter will need a design study to demonstrate the most appropriate solution, but we are assuming that some improvement in the protection of highway users will be necessary.

3.3.8 Airfield Pavement Strength

3.3.8.1 Licensing Requirements

ICAO Annex 14 contains a section describing the aircraft pavement strength classification number (ACN) and pavement classification number (PCN) and requirements to regulate the use of pavements where the ACN exceeds the PCN.

CAP168 requires pavements forming part of the movement area to be of sufficient strength to allow aircraft to operate without risk of damage to either the pavement or to the aircraft. It also states that it is an operational requirement that all pavements forming part of the movement area should be of adequate bearing strength for the types of aircraft expected to use the aerodrome.

In addition, evidence of pavement strengths and surface textures etc., relating to the site and its environs, must be provided by the applicant as required by the CAA.

(CAP168 Ch 1, Cl 4.2 and Annex 14 Ch 2, Cl 2.6)

3.3.8.2 Compliance

The URS Scott Wilson Airfield Maintenance Report (June 2011) gives Pavement Classification Numbers (PCNs) of the airfield pavement areas. PCN is the strength the pavement reported in terms of the load rating of aircraft which the pavement can accept on an unrestricted basis. Provided the PCN for a pavement is equal to or greater than the Aircraft Classification Number (ACN), which is a number expressing the relative effect of an aircraft on a pavement for a specified subgrade strength, and the operating tyre pressure does not exceed the PCN limitation, then "unrestricted use" of the pavement by that aircraft (or those with lower ACNs) is permitted.

Overload operations can substantially reduce the design life of the pavement, but unless overloading is extreme, it is unlikely that the pavement will fail suddenly or catastrophically. Each aerodrome operation in the UK is free to decide on its own criteria for permitting overload operations as long as pavements remain safe for use by aircraft. The Construction Support Team, Defence Estates, Ministry of Defence provides guidance on overload operations in their publication "Design & Maintenance Guide 27 - A Guide to Airfield Pavement Design and Evaluation".

It must however be understood that regular overload can substantially reduce the design life of a pavement, resulting in high rehabilitation costs and the inconvenience of a main runway or taxiway out of action. Regular inspections will be necessary and operations should stop as soon as pavement distress becomes evident.

Noting the type of aircraft that could operate with the proposed declared distances and the assumed atms/hr, we can only make a high level assessment on pavement strengthening works that the Aerodrome Operator may wish to implement to avoid regular overload operations. It is important to recognise that without a forecast traffic mix, our suggestions should in no way be construed as a design.

The ACN classification of the Airbus A318 on low subgrade strength is 37.4 for rigid and 40.6 and flexible pavements. Similarly, the respective ACN values of the Embraer 190 are 42.6 and 43.5. This means that these aircraft will be overload operations on the existing pavement structure, which can substantially reduce the design life of the pavement.

The PCNs reported in the URS Scott Wilson Airfield Maintenance Report (June 2011) allow us to propose indicative areas for potential strengthening:

- 100mm asphalt overlay on 840m length of runway where PCN is 30 or lower
- 100mm asphalt overlay on Taxiway C, DA, and H. Reported PCNs are less than 25
- Remove apron block paving and replace with 300mm Pavement Quality Concrete (PQC). The ACNs of the civil jet aircraft are greater than the existing pavement PCNs.

Taxiway Bravo was resurfaced in 2007/08, but the PCNs are not reported. An additional 50mm asphalt overlay on top of the 2007/08 resurfacing layers provides a conservative strengthening allowance.

It is also worth noting that Taxiway Foxtrot and a section of Taxiway Alpha between the runway taxi-hold position A1 and the runway were resurfaced/ strengthened in 2011 to achieve PCN 33 and 32 respectively. Whether it is necessary to further strengthen these pavement areas can only really be determined with a forecast traffic mix and design work, and also the aerodrome's own criteria for permitting overload operations.

In our opinion, we would not expect the airfield pavements to be a problem for obtaining a CAA Licence. However, the aerodrome operator shall ensure that pavements forming part of the movement area are of sufficient strength to allow aircraft to operate without risk of damage to either the pavement or to the aircraft and that all pavements forming part of the movement area are of adequate bearing strength for the types of aircraft expected to use the aerodrome, albeit under overload operations.

An allowance for pavement strengthening will need to be made.

3.3.9 Runway Frictional Characteristics

3.3.9.1 Licensing Requirements

CAP683 'The Assessment of Runway Surface Friction Characteristics' criteria applies to all paved runways with an ASDA of 1,200 metres or greater and used for public transport operations by aeroplanes with a maximum take-off weight (MTOW) in excess of 2730 kg. On paved runways where prescribed public transport operations are not carried out, the application of the procedures is at the discretion of the aerodrome operator.

3.3.9.2 Compliance

The primary function of runway pavement is to provide a safe and comfortable surface for aircraft to takeoff and land. Pavement friction must be maintained above a certain level in order to provide a safe ride for the aircraft. This required friction level is more critical when the pavement is wet, since water membrane will decrease the friction coefficient and may even cause hydroplaning.

We understand from the URS Scott Wilson Airfield Maintenance Report (June 2011) that the main length of Runway 07 - 25 was resurfaced in 1997 with a 50mm thick Marshall asphalt wearing course with 4mm x 4mm grooves sawn at 25mm centres. The surface has been treated with a spray of "Rhinophalt" asphalt rejuvenator liquid in 2011. There is a section of recently constructed stone mastic asphalt surface course, which the RAF station reported as having little difference in frictional properties on their dry test Mu meter results.

The runway friction classification test of RAF Northolt runway 25-07 was performed in August 2011 by Cranfield Aerospace for URS Scott Wilson. The test was carried out in accordance with JSP 554 which has slightly different specified Minimum Friction Level than CAP683.

According to CAP683, for Mu-Meter test equipment, the Maintenance Planning Level (MPL) is 0.57 and the Minimum Friction Level (MFL) is 0.50

- The overall reading for runway 25-07 was 0.56, which is just below the CAA's MPL of 0.57.
- The average reading for the central portion of the runway was 0.55 also just below the CAA's MPL.
- The average reading for the outer left and outer right portion of the runway (when viewed from 07 threshold) is 0.57, which is equal to equal to the MPL.

As the friction level is below the MPL, maintenance to restore the friction level could comprise:

- Rubber removal to restore the inherent friction characteristics. Every aircraft landing creates rubber deposits. Over time rubber deposits accumulate, primarily in the touchdown and braking area of a runway. As a result the texture is progressively reduced.
- Applying surface dressing using high quality crushed aggregates and modified polymer binder for better adhesion of granularities on the surface and for minimizing loose aggregates

We do not expect that the CAA would consider runway friction to be a licensing issue. CAP683 states "If the friction level is below the MPL, maintenance should be arranged to restore the friction level, ideally to a value equal to or greater than the MPL." however this work is not urgent because the friction level is not below the MFL.

3.4 Taxiways

3.4.1 Existing Layout

The taxiway routes to and from the southern apron do not follow the ideal routes to the runway ends and from the likely preferred runway exit points. At the east end aircraft have to either track a short distance along the runway and turn around or cross the runway and hold and or turn using the loop to the north. This increases runway occupancy time. At the west end there is the need to undertake an acute turn.

This arrangement will limit movement capacity, but does not infringe any licensing requirements. The widths are adequate for Code C aircraft with a wheelbase of less than 18m. Routine use by Code D military aircraft would require some taxiways to be widened to 23m.

3.4.2 Operational Improvements

These may become necessary for capacity reasons, but we have not determined such a need for either the existing level of operations, or the proposed airport option, which is based on a limit of 4 movements in a 15 minute period.

3.5 Aprons

3.5.1 Civil

Pavement strength issues have been discussed elsewhere. There are not licensing issues. We do not anticipate any need to increase the size of the southern apron.

3.5.2 Military

A new area of apron may be required on the north side of the runway to accommodate military aircraft. If these remain up to Code D in size, then commensurate taxiway enhancements will also be required.

3.5.2.1 Licensing Requirements

The military area will probably remain an unlicensed area.

4. Assessment and Treatment of Obstacles

4.1 Background to Runway Operations

In the case of a departure, prior to take-off, the pilot will have had to calculate his predicted climb rate based on aircraft mass (or weight) including payload and fuel, flap settings, engine power available (which may be influenced by a number of technical factors), meteorological conditions including runway altitude, temperature, wind, wet or dry runway, runway friction and slope. That predicted climb rate must ensure that he can clear all obstacles on departure by a specified margin (and any obstacles en-route and at the intended and alternate destinations, where relevant) and includes numerous safety factors.

Those calculations must also show that he can take-off within TORA, reach a stated height (usually 35ft) within TODA and if necessary abandon the departure and come to a stop within ASDA.

In the case of an arrival, the pilot of an inbound aircraft must be able to safely set the aircraft up for its descending approach, which for commercial aviation means initially using just instruments to guide the aircraft to the runway. The pilot must then reach the prescribed point where he can either see the runway or its approach lights, or if not abandon the landing and undertake a missed approach. The height above the runway when that decision has to be made is called the Decision Height (DH). This is determined by the type of approach navigation aid and the minimum obstacle clearance height (OCH).

If the required visual acquisition of the runway has been made, the aircraft can proceed to land and then must then be able to stop within the LDA. Again factors such as flap settings and meteorological conditions determine the LD required.

If the approach is abandoned, sufficient power must be available to attain the missed approach climb gradient by the required point.

In all these calculations, the aircraft performance requirements must be capable of being achieved with one engine having failed and totally inoperative. That is an exceptional, not a normal situation.

The OLS surfaces are designed to ensure that the intended types of aircraft can land, depart or manoeuvre and at all times maintain an adequate clearance above those surfaces.

In normal operations, aircraft fly well above those surfaces.

4.2 Existing Scenario

In 3.3.3, 3.3.4 and 3.3.5 above, we consider the runway strip, CGA and RESA safety areas that are approximately at the same level of the runway and provided to safely accommodate an aircraft running off the runway on the ground, or flying at very low altitude to one side or the other of the runway.

There are a number of infringements of those areas, or they do not comply with the recommended dimensions. Mitigation is proposed by a combination of altering the runway declared distances and the use of enhanced arrestor beds.

A final recommendation on the position of the runway thresholds needs to take the infringements of the runway strip and the RESA provision into account, but in this section we consider the obstacle environment in relation to the standard Obstacle Limitation Surfaces (OLS), which extend upwards and outwards from the runway. As we will see, these prove to be a more dominant factor.

We first examined the OLS associated with the existing declared distances and its classification as a Code 3D runway (Appendix B). We later examined how the number and extent of OLS infringements could be reduced by displacing the runway thresholds (Appendix C). This included examining the Obstacle Assessment Surfaces (OAS) for the Cat 1 ILS approach too Rwy 25. We also examined some options using Code 2 OLS in case they offer a substantial reduction in the number and extent of the infringements.

In the case of the final phase of an approach, aircraft follow a nominal glide path to the runway touchdown point. The normal and strongly preferred angle of approach is 3.0°(5.24%). However, glide paths of between 2.5°(4.4%) and 5.5°(9.6%) can be applied under more limited circumstances and where necessary.

At Northolt, the approach to Rwy 07 has a standard 3° glide path. However due to the proximity of Heathrow, it cannot be a straight-in approach over the normal distance from the runway. In order to clear Harrow Hill (about 5.2 km to the east), it has been necessary to adopt a 3.5°(6/1%) glide path to Rwy 25. This is the steepest permissible angle of approach for an Instrument Landing System (ILS) and limits that to Category 1. It is a straight-in approach and due to the prevailing wind direction, it is the most frequently used approach.

A standard 2.5% missed approach gradient is used in both directions.

4.2.1.1 Licensing Requirements

Both CAP 168 and Annex 14 promulgate the same (or very similar) approach, take-off climb and transitional Obstacle Limitation Surfaces. They also promulgate an inner horizontal surface at a height of 45m above the runway and an outer horizontal surface above that. These latter surfaces are not examined in detail in this report as they are not expected to prevent a Licence (or Certificate) being obtained.

The dimensions of each OLS are determined by the runway Code Number and in the case of the approach OLS, the type of approach available, which may be a precision instrument approach (requiring a PAOS), a non-precision approach (requiring a NPAOS) or a non-instrument (or visual) approach (requiring a VAOS).

The take-off climb surface is referred to as a TOCS.

The transitional surfaces are surfaces that run along both side of the runway strip and slope upward and outward away from the runway up to the height of the inner horizontal surface. These contain the missed approach surface and will be discussed later.

If an obstacle penetrates any of these surfaces, it does not imply that the runway cannot be given a Licence. However, the approach and departure procedures will have to be designed to reflect and mitigate the risks associated with those obstacles. That usually means increasing the Obstacle Clearance Height (OCH) and thus, for a given set of circumstances and visibility conditions, the frequency that pilots may have to undertake a missed approach.

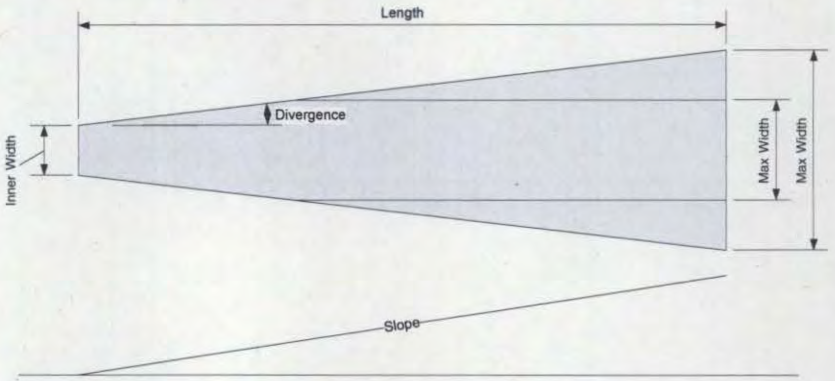
Reliable runway availability is an important factor for commercial airlines and well as for all types of passengers.

The shape of the various AOS and TOCS[14] is that of an inclined trapezium. They have an inner end located at the end of the runway strip (i.e. 60m from the relevant runway start or end point) and at the same level as the runway centreline at that point. The have a stated width and slope and widen at a stated rate for a defined distance.

[14] The TOCS may also start at the end of TODA and commence at a greater distance from the end of the take-off runway. This is when TODA does not equal TORA and clearway is declared.

The shape of the TOCS is as follows:

Take-off Climb Obstacle Limitation Surface (TOCS)



Source: Based on CAP 168 (not to scale)

The dimensions for the relevant surfaces for Northolt are tabulated below:

Code 2 and Code 3 TOCS Dimensions

Dimension	Code 2	Code 3
Inner Width	180 m	80 m (150 m with clearway)
Distance from inner edge Take-off Run or at end of clearway	60 m	60 m
Divergence (each side)	10%	12.5%
Maximum Width	580 m	1200 m (if heading change <15°)
Length	2,500 m	15,000 m
Slope	1 in 25 (4%)	1 in 50 (2%)

Source: . Based on CAP 168

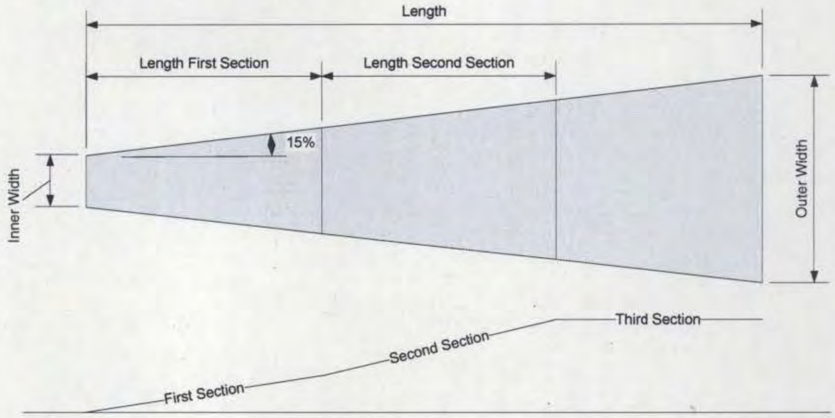
The width of the Code 3 TOCS ceases to increase once it reaches a width of 1,200m.

The elevation of the inner edge of the TOCS equals the elevation of the runway at the end of the take-off run or the elevation of the end of the clearway.

ICAO Annex 14 dimensions are the same.

The shape of the AOS is as follows:

Approach Obstacle Limitation Surface (TOCS)



Source: Based on CAP 168 (not to scale)

The dimensions for the relevant surfaces at Northolt are tabulated below:

Code 2 and Code 3 Approach OLS Dimensions

	Non-Instrument (Visual)		Non-Precision		Precision	
Dimension	Code 2	Code 3	Code 2	Code 3	Code 2	Code 3
Inner Width	80 m	150 m	150 m	300 m	150 m	300 m
Distance before Threshold	60 m	60 m	60 m	60 m	60 m	60 m
Divergence (each side)	10%	10%	15%	15%	15%	15%
Maximum Width	580 m	750 m	900 m	4800 m	4650 m	4800 m
Length First Section	2500 m	3000 m	2500 m	3000 m	3000 m	3000 m
Slope First Section	1 in 25 (4%)	1 in 30 (3.3%)	1 in 30 (3.3%)	1 in 50 (2%)	1 in 40 (2.5%)	1 in 50 (2%)
Length Second Section	-	-	-	3600 m	2500 m	3600 m
Slope Second Section	-	-	-	1 in 40 (2.5%)	1 in 33 (3%)	1 in 40 (2.5%)
Overall Length	2500 m	3000 m	2500 m	15 km	15 km	15 km
Slope	-	-	-	Level	Level	Level

Source: Based on CAP 168

The elevation of the inner edge of the AOS equals the elevation of the runway at the threshold.

ICAO Annex 14 dimensions are the same.

4.2.1.2 Compliance at West End

At the west end, the Rwy 25 Code 3 TOCS has a 2% slope and is penetrated by a number of obstacles. These are shown on the Type-A chart and govern the payload/range that can be achieved by each aircraft type.

In the reverse direction, the Rwy 07 Code 3 NPAOS also has a 2% slope, but is wider than the TOCS. Although the threshold (THR) is slightly inset, there are still a number of obstacle penetrations. The close-in penetrations relate to lampposts and road vehicles on the A40.

We judge that the CAA would want to see some adjustment to the TOCS and NPAOS positions to reduce these infringements. We also expect that they would want to see some of the infringing obstacles lowered or removed.

Insetting the Rwy 07 THR to 214m from the west end of the paved runway, combined with the removal of some obstacles would significantly improve the obstacle environment.

4.2.1.3 Compliance at East End

At the east end, the Rwy 07 Code 3 TOCS has a 2% slope and is penetrated by a numerous obstacles, including several buildings, numerous trees, the airfield boundary fence and the A4180 West End Rd immediately outside. These are shown on the Type-A chart and govern the payload/range that can be achieved by each aircraft type.

In the reverse direction, the basic Rwy 25 Code 3 PAOS has a 2% slope and is wider. There are numerous obstacle penetrations inside and outside of the airport boundary.

The close-in penetrations relate to numerous hedges, trees, buildings, lampposts and road vehicles on the A4180. The public road is estimated at about 5m above the Rwy 25 THR elevation, but the THR is only about 160m from the airport boundary. The Officers Mess is a listed building and two other listed building also infringe the PAOS. It is unlikely that these could be removed. In addition, there are several residential and commercial buildings that also infringe the PAOS. The approach lights are also infringements, although these are of frangible construction and are supported at an elevation that is necessary to ensure they are visible on the approach.

The existing glide path passes over the A4180 West End Road at only 17.5m above ground level. At present there are no runway touchdown markings and reports that pilots head for the threshold markings once they are visible. If true, that would mean aircraft pass over this road at an even lower height.

It is our assessment that the CAA would not Licence the existing runway configuration due to the substantial number and degree of obstacle infringements at the east end of the runway.

To obtain a Licence, they would require significant adjustment to the TOCS and PAOS positions to reduce these infringements. We also expect that they would want to see some of the infringing obstacles lowered or removed.

The church and some trees on Harrow Hill are about 5.2 km from the THR and cannot be removed. Hence the 3.5° angle of approach, which we do not expect to be changed. We have examined a PAOS and TOCS at a 2.8% slope. This slope maintains the same vertical clearance from a 3.5° glide path as a 2% slope provides under a standard 3° glide path. This is not a standard solution to reflect a steeper glide path (the 2% slope on the PAOS is not altered by Annex 14 or CAP 168 to reflect variations in the glide slope), but can give an indication that the relevant adjusted OCH should be at a reasonable value. However, because many of the obstacles are close to the threshold, this surface still suffers from many infringements.

In Chapter 9 and Appendix C we discuss insetting the Rwy 07 THR 240m from the east end of the paved runway. Combined with the removal of some obstacles, this would considerably improve the obstacle environment. We have also developed an Obstacle Assessment Surface (OAS) to ICAO PANS-Ops for a 3.5° Cat 1 ILS approach serving Code C aircraft. When combined with the 240m inset THR, this is free of all but a few small infringements. We are therefore reasonably confident that a design using similar dimensions and if necessary, the ICAO Collision Risk Model would show an acceptably low level of collision risk and an operationally acceptable OCH value.

We have chosen this option as the basis for a licensable civil airport and derived the declared runway distances from this possible option.

This would not be the only solution, but we expect that a detailed design and consultation process would lead to a similar, if slightly different arrangement.

5. Aeronautical Ground Lighting

5.1 Licensing Requirements

CAP168 Chapter 6 Aeronautical Ground Lighting sets out the basic licensing requirements and detail of what to implement. ICAO states their SARPs in Annex 14 Chapter 5, from paragraph 5.3 onwards.

These are numerous and detailed requirements and we only make a specific reference to these in this report where necessary.

5.2 Compliance

Compliance is discussed under each sub-heading.

5.3 Shortened Runway

In 3.3.3, 3.3.5 and Chapter 4, we discuss the works that would be necessary to manage the number and extent of infringements of the safety areas around the runway and the obstacle limitation surfaces. We are advising that those works would need to be undertaken to enable the airport to be Licensed (or Certificated). Key to the resolution and mitigation of those issues will be insetting the threshold positions in both directions and altering the end positions of the take-off and landing distances. The declared runway distances will be reduced as a consequence.

All the above changes will require changes to the runway lighting, irrespective of whether the existing facilities do or do not comply with the regulator's Licensing (or Certification) requirements. These are therefore referred to under each sub-heading in this Chapter.

5.4 Airport Development

Elsewhere, we discuss the works that would be necessary to handle commercial airliners and convert the aerodrome into a civil airport. There is also an option to provide a new apron and taxiway links to the north of the runway for the exclusive use by the military. There will be a need for some adjustments and additional airfield ground lighting specifically associated with these developments.

5.5 AGL Facilities

5.5.1 Precision Approach Path Indicators

5.5.1.1 Existing Provision

- Two PAPI wing bars are provided for both approaches on Runway 07-25.
- Each of the four wing bars is on a dedicated circuit.
- A full description of this service can be found in Annex B6 of the URS Scott Wilson Airfield Maintenance Inspection Report (June 2011).

5.5.1.2 Compliance with CAP 168

The existing provision complies with the requirements of CAP 168.

5.5.1.3 Impact of changes to the declared distances

- If either threshold on Runway 07-25 is moved significantly, Appendix 6B of CAP 168 sets out the design criteria for the installation of PAPI units.
- The existing units are circa 22 years old but still serviceable. However it may be worthwhile replacing them with newer models at this point.

5.5.2 Runway 25 Approach Lighting

5.5.2.1 Existing Provision – Runway 25

- A high intensity 3 bar coded centreline approach. The lights are interleaved over two circuits which also include the threshold wing bars. In addition low intensity omnidirectional red approach lighting is provided.
- A full description of this service can be found in Annex B7 of the URS Scott Wilson Airfield Maintenance Inspection Report (June 2011).

5.5.2.2 Existing Provision – Runway 07

- A high intensity 2 bar coded centreline approach. The lights are interleaved over two circuits which also include the threshold wing bars. In addition low intensity omnidirectional red approach lighting is provided.

5.5.2.3 Compliance with CAP 168

- The approach lighting does not comply with CAP 168
- The threshold wing bar fittings will need to be moved to the threshold circuits.
- The provision of the low intensity red approach lighting complies with the requirements of section 3.6.1 (Circling Guidance) in Chapter 6 of CAP 168.

5.5.2.4 Impact of changes to the declared distances

- If either threshold on Runway 07-25 is moved significantly, the approach lighting would need to be redesigned using new fittings, seating furniture, masts, primary secondary and earth cables.
- Some savings may be possible if the existing mast locations can be re-used
- Refer to section 3.2 of Chapter 6 of CAP 168 for the requirements of a high intensity approach lighting system.
- The low intensity approach lighting may still be required on both approaches however this will need to be confirmed.

5.5.3 Threshold and Runway End Lighting

5.5.3.1 Existing Provision – Runway 07 Threshold/ Runway 25 End Bar

- The threshold lights are 120m from the edge of the pavement, while the end lights are at the end of the pavement.
- The threshold lights are on a single dedicated circuit.
- The end lights are interleaved over the two low intensity edge circuits on the runway.
- A full description of this service can be found in Annex B8 of the URS Scott Wilson Airfield Maintenance Inspection Report (June 2011).

5.5.3.2 Existing Provision – Runway 25 Threshold/ Runway 07 End Bar

- The threshold lights are 120m from the edge of the pavement, while the end lights are at the end of the pavement.
- The threshold lights are on a single dedicated circuit.
- The end lights are interleaved over the two low intensity edge circuits on the runway.

5.5.3.3 Compliance with CAP 168

- The current layouts do not comply with the current guidance in CAP 168.
- Ideally the threshold lighting should be interleaved over two dedicated circuits.
- Ideally the runway end lighting should be interleaved over two dedicated circuits however having them on the same circuit as the runway edge lighting is widely used.

5.5.3.4 Impact of changes to the declared distances

- If the declared distances are changed the threshold and runway end fittings will need to be relocated.
- The fittings are circa 15 years old but are no longer in production therefore it may be advisable to replace them.
- The existing primary cables for threshold circuits may need to be replaced.

5.5.4 Runway Edge Lighting

5.5.4.1 Existing Provision

- High intensity unidirectional runway edge lights are provided in pairs (facing opposite directions) every 30m. Low intensity omnidirectional lights are provided every 90m.
- The high intensity lights are interleaved over four circuits. Two from each B centre.
- A full description of this service can be found in Annex B6 of the URS Scott Wilson Airfield Maintenance Inspection Report (June 2011).

5.5.4.2 Compliance with CAP 168

- The existing provision complies with the requirements of CAP 168.

5.5.4.3 Impact of changes to the declared distances

- Changing the declared distances will impact on the existing layout of the runway edge fittings.
- The existing fittings are circa 15 years old but are no longer current production models.

- It is possible to replace existing unidirectional and omnidirectional fittings with new bidirectional ones.
- In addition it would be possible to reduce the number of circuits used on the runway edge by two.

5.5.5 Taxiway Lighting

5.5.5.1 Existing Provision

- A combination of taxiway edge (inset and elevated) and taxiway centreline fittings are provided on the various taxiways.
- The lights has been installed over a period of time and it is clear that some of sections are non compliant with current guidance.
- The taxiway lighting is provided over a 7 circuits.
- A full description of this service can be found in Annex B10 of the URS Scott Wilson Airfield Maintenance Inspection Report (June 2011).

5.5.5.2 Compliance with CAP 168

- The existing provision does not comply with the requirements of CAP 168.

5.5.5.3 Impact of changes to the declared distances

- Changing the declared distances should have minimal impact on the taxiway lighting.
- There is however a need to review all the lighting that is provided and propose changes on the non compliant sections.
- Following comment on the practicality the solar lights it may be necessary to consider whether they need to be moved.

5.5.6 Obstruction Lighting

5.5.6.1 Existing Provision

- Low intensity Group A, obstruction lighting is installed at a number of locations across the airfield.
- Some lights are controlled by photocell and others from a local distribution board.
- A full description of this service can be found in Annex B11 of the URS Scott Wilson Airfield Maintenance Inspection Report (June 2011)

5.5.6.2 Compliance with CAP 168

- The existing provision complies with the requirements of CAP 168.

5.5.6.3 Impact of changes to the declared distances

- None

5.5.7 Runway Visual Range Lighting

5.5.7.1 Existing Provision

- Runway visual range systems have been installed for both Runway 25 and Runway 07.
- A full description of this service can be found in Annex B10 of the URS Scott Wilson Airfield Maintenance Inspection Report (June 2011).

5.5.7.2 Compliance with CAP 168

- The existing provision complies with the requirements of CAP 168.

5.5.7.3 Impact of changes to the declared distances

- None

5.5.8 Other Comments

The following observations have been made from reviewing the existing provisions at the aerodrome:

- The primary current on the runway related services circuits is 12 A. This is not typical on a civilian aerodrome where values of 6 or 6.6 A are more common. It appears that the secondary current for all fittings in use though is the standard 6.6A.
- All but one, of the constant current regulators were installed between 1990 and 1992. While they appear to be working well, they are approaching the end of their design life.
- The taxiway circuits are run of TMSEs. They are operational however, they are not generally used on non military installations.
- There are no Runway Guard Light or Stop Bar Lights installed. These would be needed to permit operations below an RVR of 550 under CAP 168.

6. Signage and Marking

6.1 Signage

6.1.1 Existing Signage

6.1.1.1 Licensing Requirements

Aerodrome signs and markings provide guidance and information to pilots and assist them in complying with the Rules of the Air Regulations 2008 (the Rules).

Mandatory Signs should be provided on the manoeuvring area of an aerodrome in order to identify by a sign any location beyond which an aircraft or vehicle should not proceed unless authorised by ATC.

Information Signs should be provided where there is an operational need to provide additional guidance to pilots manoeuvring aircraft on the ground.

6.1.1.2 Compliance

We have reviewed the signage layout drawing by Edward Dewhurst dated December 2010 and marked as construction status.

The information tells us that the mandatory signage comprises:

- visual runway taxi-holding position signs,
- CAT I runway taxi-holding position signs
- no entry signs.

Information signage comprises:

- taxiway location signs
- taxi-holding location sign (taxiway location Sign co-located with a runway taxi-holding position)
- direction signs bearing the letter designating each taxiway leading out of the intersection along with an arrow oriented to illustrate the direction and degree of the turn
- runway destination signs

The signage colours comply with the style in CAP168, e.g. mandatory signs display white characters on a red background. The character size to be used for letters and numbers is compliant with the requirements for operations conducted in RVR < 800m. The height of the sign faces also comply with CAP168.

All airfield signage is illuminated with the exception of two no entry signs which are reflective signs.

The signage layout drawing also indicates that signs are located in accordance with CAP168. Taxi guidance signs are positioned at right angles to runway or taxiway centreline. Runway taxi-holding position signs are sited on both sides of the taxiway as required for operations in RVR less than 1500 m. Information Signs are located, whenever practicable, on the left side of a taxiway or runway.

From this high level assessment, the existing signage would remain in place and is likely to be accepted by the CAA.

6.2 Signals

6.2.1 Licensing Requirements

We have not examined the runway and runway strip itself. The CAA report states that illuminated windsleeves are required.

(CAP168 Ch 7, Cl 2 and Annex 14 Ch 5, Cl 5.1.1)

6.2.2 Compliance

This may have already been corrected, but if not, it would be a relatively simple item to provide.

6.3 Marking

6.3.1 Licensing Requirements

There are no precision approach side stripes, aiming point or touchdown zone markings on the existing runway.

(CAP168 Ch 7, Cl 4 and Annex 14 Ch 5, Cl 5.2)

6.3.2 Compliance

These are also relatively simple items to provide.

6.4 Shortened Runway

In 3.3.3, 3.3.5 and Chapter 4, we discuss the works that would be necessary to manage the number and extent of infringements of the safety areas around the runway and the obstacle limitation surfaces. We are advising that those works would need to be undertaken to enable the airport to be Licensed (or Certificated). Key to the resolution and mitigation of those issues will be insetting the threshold positions in both directions and altering the end positions of the take-off and landing distances. The declared runway distances will be reduced as a consequence.

The above changes are not expected to require any significant changes to the runway signage. However, the missing precision approach side stripes, aiming point or touchdown zone markings would be provided, along with re-located threshold and new pre-threshold markings in positions to suit the shortened declared runway distances.

6.5 Airport Development

Elsewhere, we discuss the works that would be necessary to handle commercial airliners. There is also an option to provide a new apron and taxiway links to the north of the runway for the exclusive use by the military. There would be a need for some adjustments or additional signage associated with these developments. Any new markings would relate to the new taxiway and apron developments.

7. Rescue and Fire Fighting

7.1 Existing RFFS Facility

7.1.1 Licensing Requirements

Condition 2 in the Public Use and Ordinary aerodrome licences makes it mandatory for licence holders to provide a Rescue and Fire Fighting Service (RFFS) appropriate to their aerodrome. The scale and standards of RFFS to be provided at licensed aerodromes in the United Kingdom shall accord with the International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPs).

7.1.2 Fire Station

CAP168 states:

- "All rescue and fire fighting vehicles should normally be housed in a fire station. Satellite fire stations should be provided whenever the response time cannot be achieved from a single fire station."
- "The fire station should be located so that the access for rescue and fire fighting vehicles into the runway area is direct and clear, requiring a minimum number of turns.

RAF Northolt has a modern purpose built 4-bay fire station. Although in the event that the airport operation passed into the civil sector, the RAF stated their proposal for a complete separation of military and civil enclaves, the fire station could remain from a Licensing point of view.

However, we note that the CAA's report entitled "Assessment of RAF Northolt against ICAO standards" (March 2009) stated that the route leading from the fire station onto the runway consisted of three 90-degree turns. CAP168 requires that access for rescue and fire fighting vehicles into the runway area is direct and clear, requiring a minimum number of turns. Consequently, a new access road to the runway for RFFS vehicles may be necessary if the fire station remains at its current location.

7.1.3 Airport Development

Elsewhere, we discuss the works that would be necessary to handle commercial airliners. There is also an option to provide a new apron and taxiway links to the north of the runway for the exclusive use by the military. In the following paragraphs we consider the possible need for some adjustments or additional equipment associated with these developments.

7.1.4 RFFS Aerodrome Category

The existing RFF facility is provided and operated to military standards. We assume that the fire cover provided will continue to meet the military standards required for any ongoing use by military aircraft.

Civilian licensing requirements relate to aircraft size and these are grouped into Categories specific to this purpose. The aerodrome category is based on the longest aeroplanes normally using the aerodrome and their fuselage width. At RAF Northolt, it is assumed that the largest aircraft used in civilian operations will be the Embraer 190. This means that RFFS provision will need to meet Aerodrome Category 6 (aeroplane overall length 28m up to but not including 39m; maximum fuselage width 5m) requirements set out in CAP168.

CAP168 requirements for Aerodrome Category 6 and if using performance level B foam, the aerodrome shall have:

- not less than 2 no. foam-producing appliances/vehicles
- discharge rate of foam solution of 4,000 litres per minute
- 2 appliances with a total of 7,900 litres of water
- 948 litres of foam concentrate (two shots)
- 1,896 litres of foam concentrate in reserve (200% of 948)
- The total foam concentrate required on the aerodrome is 2,844 litres

RAF Northolt currently has two appliances; a rapid intervention vehicle and a major foam vehicle with total 9,100 litres of water tank capacity (2275 litres and 6825 litres), and total 1,095 litres of foam tank capacity (275 litres and 820 litres). The foam meets ICAO level B and each vehicle can discharge foam at rate of 5,300 litres per minute.

Principal agents are provided for permanent control, i.e. for a period of several minutes or longer. Complementary agents may provide rapid-fire suppression but generally only offer a transient control, which is available during application. Complementary agents can be 225kg of dry powder, gaseous agent or combination, or 450kg of CO_2. Each vehicle also carries 2 X 50kg of dry powder. This is slightly below the minimum usable amounts of extinguishing agents in CAP168, but to provide the additional quantity is not thought to be a problem.

RAF Northolt Fire Section hold a minimum stock of 90 x 25 litre drums of FFFP foam, which gives two complete refills as required for a Category 6 aerodrome.

If handed over to a civilian operator, these existing facilities would meet the CAA's Licensing (or Certification) requirements.

7.1.5 RFFS Staffing Levels

The minimum staffing and supervisory levels resulting from a Task Resource Analysis (TRA) shall be agreed with the CAA, should be detailed in the Aerodrome Manual.

We understand that the RAF Northolt fire section manning is for 32 fire personnel, incorporating a 3 watch system. The minimum requirements per watch comprise 1 x Watch Manager, 1 x Crew Manager, and 4 x Crew Members. Should the RAF continue to provide the RFFS for Northolt, it could reasonably be assumed that services can be tailored as necessary for agreement by the CAA.

If handed over to a civilian operator, these facilities would be manned to meet the CAA's Licensing (or Certification) requirements.

7.1.6 Communications and Alerting Systems

CAP168 describes a number of Communications and Alerting Systems that should be in place by licence holders. We understand from the CAA's report entitled "Assessment of RAF Northolt against ICAO standards" (March 2009) that three non-complaint communication points were identified in the safety survey.

CAP168 requires that a discrete communication system should be provided linking a fire station with the control tower, any other fire station on the aerodrome and the rescue and fire fighting vehicles. the CAA's report notes that at the time of the survey, the direct line communication system between the Fire Station control room and ATC was found to be "unserviceable". A new communication line between the two facilities would likely remedy this problem.

CAP168 requires radio facilities to enable the RFFS to communicate with responding Local Authority Fire Services. The CAA report noted that there was no facility was available to ensure effective communications between the OIC of the RFFS and the Local Authority Fire Service. Some form of reliable communication between the two locations would need to be set up.

Finally, the CAA report noted that there was also no facility to ensure effective communications between the OIC of the RFFS and the Commander of an aircraft via radio frequency 121.6. CAP 168 states that radio telecommunications (RTF) equipment shall be provided to enable the airport fire officer(s) to communicate with the aircraft flight deck. An aeronautical radio frequency, 121.600 MHz, is to be used for this purpose. If this frequency is not in conflict with Military communications, then this standard provision should not be too difficult to provide.

8. Aviation Security

Aviation Security is covered by ICAO Annex 17, although these refer to rather general provisions.

In the UK this subject is managed by the Department of Transport and to their requirements.

An area where compliance may be difficult to achieve is in relation to the required separation of public roads and forecourts from terminal buildings. The distance between the southern edge of the existing apron and the southern site boundary is limited.

The Licensing process has minimal involvement in this. The main area of CAA concern would be in relation to the secure boundary and ensuring that the physical and procedural requirements are at least met.

We have not examined the security facilities in detail. The airfield security at Northolt has been provided to meet the military need and appears to at least meet or be better than the civil aviation requirements. If the management of the aerodrome was split between into military and civil areas, it will be necessary to ensure that the boundary and any other areas of joint security interest remain effective provisions. The runway and runway strip will remain common use areas. It will be for the MoD or RAF and any civil operator to negotiate an arrangement that is acceptable to both sides. Other areas of formal co-operation will probably be required and included in the required airfield operating manual.

9. Options to Improve Compliance

9.1 Strategies to Raise OLS

9.1.1 Obstacle Clearance Height Adjustments

ICAO publishes Procedures for Air Navigation Services – Aircraft Operations. Volume I describes Flight Procedures and Volume II describes the Construction of Visual and Instrument Flight Procedures. For convenience these are referred to as PANS-OPS and also known by its ICAO reference number as ICAO Doc 8168.

Both volumes present coverage of operational practices that are beyond the scope of Standards and Recommended Practices (SARPs), but with respect to which a measure of international uniformity is desirable.

Volume II covers the design of procedures for visual flight and for instrument flight. In the latter case it considers radio, radar and satellite based navigation aids. It is supported by a computer programme to calculate the Obstacle Assessment Surfaces (OAS) associated with Precision Instrument approaches (ILS guided approaches) and another to calculate the overall collision risks associated with any particular obstacle environment – the Collision Risk Model (CRM).

A considerable amount of detailed information is required to develop PANS-OPS procedures. Not all the necessary information is available to us and such detail design work is beyond the scope of this commission. However, in order to answer the basis question as to whether Northolt could be granted a CAA Licence (or an EASA Certificate), we have found it necessary to examine in outline whether or not approach procedures based on PANS-OPS could be produced that would be acceptable for commercial aviation.

We were also made aware late in our study that NATS have been commissioned to design new approach and departure procedures for all RAF airfield in accordance with PANS-OPS. We were given some draft figures in relation to those studies, but not the draft report and so are not aware of their conclusions. We were however told that the procedures were based on the existing declared runway distances.

The key output for an approach is the Decision Height. This is the lowest height above the threshold that a pilot must be able to see the runway or its approach lights. If he cannot see the runway by that point, he must instigate a missed approach. The height varies depending on the type and accuracy of the approach and each aircraft's approach speed, which is banded into groups.

It is also determined in relation to the number and proximity of obstacles to the approach path. This generates an obstacle clearance height (OCH). From this the obstacle clearance altitude (OCA) is calculated (THR elevation plus OCH), which is the value used by pilots when coming into land. This may be adjusted upwards for other operational reasons to arrive at the final decision altitude.

Given that the glide path is always a relatively shallow angle (usually 3° to 4°), the value of the OCH will generate a significantly longer horizontal distance for any given height prior to the THR. The higher the OCH, the more frequently a pilot will have to instigate a missed approach. That also depends on the visibility conditions, but can be expected to be a potential concern to airline operators at Northolt.

There must only be one approach procedure for each type of approach.

9.1.1.1 Rwy 25 Cat 1 ILS OAS

Having identified a difficult obstacle environment, particularly at the east end of the runway, we have assessed the key Cat 1 ILS approach to Rwy 25 in relation to PANS-OPS requirements.

Rwy 25 Approach Lights

Source: MM

PANS-OPS provides three methods for assessing a Precision Instrument approach in relation to the obstacle environment. The first assessment is to examining the basic ILS surfaces, which generally correspond to the Annex 14 OLS for a Code 3 or 4 precision approach, with the addition of a 2.5% missed approach surface commencing 900m beyond the threshold.

As we have already identified, the basic approach surface is subject to numerous obstacle infringements. Insetting the threshold does not materially alter this situation, because many are to each side of the runway centreline.

The second method is to construct the applicable Obstacle Assessment Surface (OAS) with the THR inset 240m. This we have constructed for the 3.5° glideslope, a standard (2.5%) missed approach, aircraft with a wingspan of up to 36m (Code C), a glide path height above the THR (RDH) of 16.6m (which equates to an touchdown aiming point 300m from the THR) and a wheel to GP antenna height of 4m. This is drawn in Appendix C. Examination reveals only a few small infringements by comparison.

The third method is to use the Collision Risk Model. This would be an appropriate course for an owner to undertake, but beyond our scope.

9.1.2 At West End

We propose insetting the threshold by a further 122m east to 214m from the west end of the paved runway. This is in order to remove or reduce infringements of the runway strip and the Rwy 07 NPAOS by obstacles along the A40 that are close to the THR (see Appendix C).

This inset also permits the provision of a 180m long by 150m wide undershoot RESA. The Rwy 25 overrun RESA in the reverse direction is 180m long by a minimum of 46m wide supported by an EMAS arrestor bed (see 3.3.5 and Appendix A). Because of its reduced width, it can be located further west, permitting the end of Rwy 25 ASDA and LDA to be as far west and thus as long as possible.

The Rwy 25 TOCS is not co-located with the Rwy 07 NPAOS as it is narrower and can be located further west and still clear the A40 obstacles. This determines the proposed TORA and TODA distances.

There are a small number of other obstacles further west including an aerial that should be addressed. These may need to be removed or lowered.

9.1.3 At East End

We examined the existing obstacle infringements. These were significant in magnitude and substantial in number. The Transitional Surface and the Runway Strip are also infringed (Appendix B).

Eastern Boundary from within Airfield

Source: MM

The level of A4180 West End Road is not stated on any of the survey drawings provided. We estimate from other sources that it is about 5m above the elevation of the existing Rwy 25 THR. The road and airport boundary fence are infringements of the existing PAOS.

The existing aiming and touchdown points are not marked on the runway. However, it is possible to estimate their positions from the location of the PAPI lights. This places the aiming point approximately 200m from the east end of the paved runway. Subtending the 3.5° glidepath from the runway at that point means that the glidepath would be about 17.5m above the surface of the A4180 West End Road under the extended runway centreline. Allowing for the difference in the pilot's eye height to that of the aircraft undercarriage (in the range 3m to 4m) and height of road vehicles (up to 4.8m) and the vertical tolerance is less than 9m. In addition, the road level rises quite quickly to the north.

West End Road, Eastern Boundary Fence and Runway viewed from East

Source: MM

Note slope on road in above photograph.

The length of road across the runway end is protected by red wig-wag traffic lights from each direction. Such lights are not always obeyed by drivers. In addition, there are sets of traffic lights at junctions a short distance north and south of the runway.

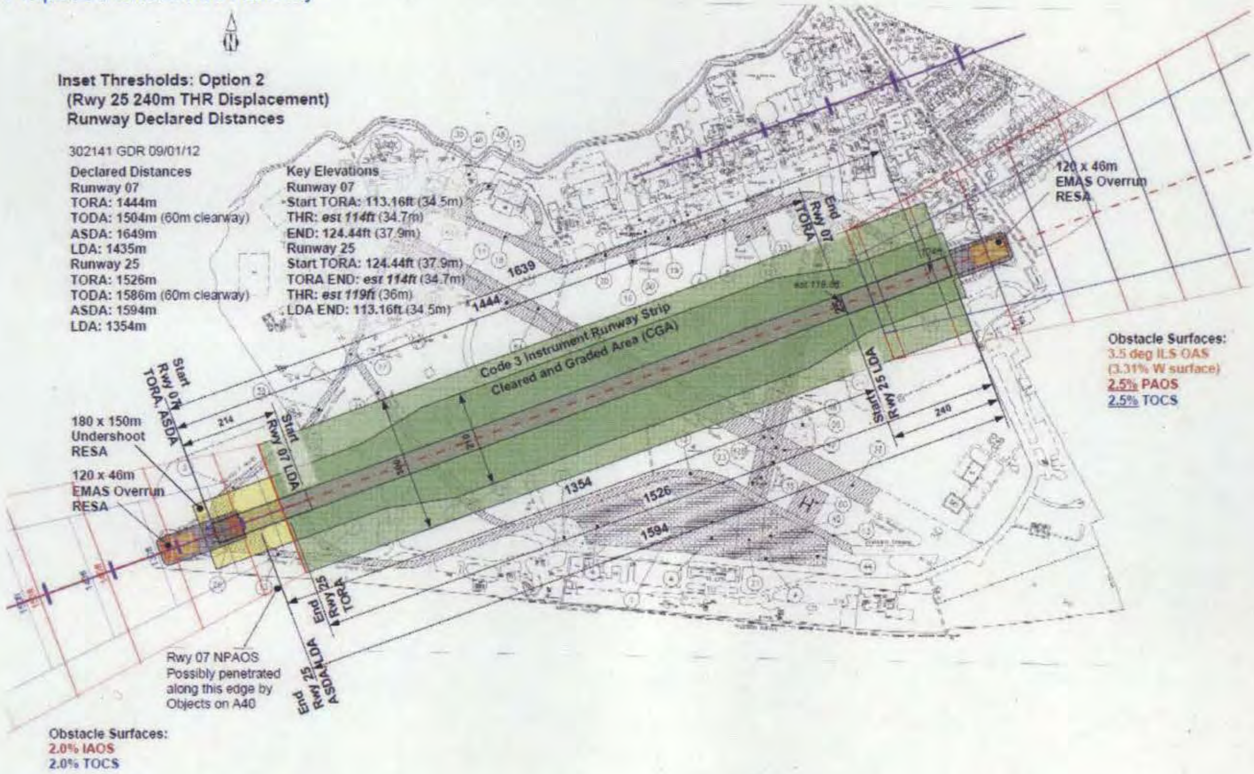
At times traffic can queue back from those lights, be within the protected zone, unaware that the stop lights may have been activated and in any event, unable to move clear of that zone. We expect that the CAA would not consider this a satisfactory system.

It would therefore be necessary to significantly raise the OLS. We have considered the following options (see Appendix C):

- Inset Threshold 240m with Code 3 classification
- Inset Threshold 300m with Code 3 classification
- Inset Threshold with Code 2 classification

9.2 | Runway 25 with THR Inset 240m

Proposed Shortened Runway



Source: MM

This is our proposed option. It shortens the declared distances significantly, but the OAS generated for the 3.5° Cat 1 ILS approach for Code C aircraft is not infringed by most of the existing obstacles of concern. This includes:

- the Officers Mess (a listed building);
- the nearest block of flats and most adjacent obstacles;
- the houses at the west end of Trenchard Avenue (which are just north of the grassed area east of West End Road and under the glidepath); and
- the houses on the north side of Cavendish Avenue (which are to the south of the grassed area under the glidepath).

A small number of infringements of the OAS remain with this option.

These would include:

- a number of trees (various penetrations);
- a few lamp posts;
- 4.8m high road vehicles in the A4180 West End Road in an area to the north of the existing arrestor bed (penetrates this OAS by around 1.5m);
- A corner of the garage canopy to the south of the approach (penetrates by up to 0.5m).

It may be possible to lower or remove the first two items, however, the latter cannot be treated in that way and the Obstacle Clearance Heights (OCH) would have to be adjusted in accordance with the provisions of PANS-OPS to reflect these. Similar calculations will be required for non-precision approaches.

We expect that an analysis using the ICAO Collision Risk Model (CRM) would be appropriate and probably show an acceptable level of risk for these obstacles. PANS-Ops also requires OCA/H calculations to take into account any dense obstacles beneath the OAS.

The Rwy 07 TOCS is co-located with the Rwy 25 PAOS as it is infringed by many of the same obstacles. However, both have been promulgated at a slope of 2.8%. This is not standard, because neither Cap 168 nor Annex 14 adjusts these slopes to reflect steeper approach glidepath or take-off climb rates that may be necessary (as in this case) to clear obstacles. This steeper surface provides the same vertical clearance as a 2% slope provides under a standard 3° approach glidepath. This determines the proposed TORA and TODA distances.

9.3 Resulting Declared Distances

If the above proposals were adopted, the resulting declared distances would be as tabulated below.

Proposed Declared Runway Distances

Runway	TORA	TODA	ASDA	LDA
07	1444	1504	1649	1435
25	1526	1586	1594	1354

Source: MM

9.4 Runway 25 with THR Inset 300m

This further improves the obstacle clearances at the east end, but at the expense of a further 60m reduction in Rwy 25 LDA – a particular concern in tailwind conditions – and the Rwy 07 take-off distances.

As stated in 9.2 above, we anticipate that a detail design using the CRM will demonstrate a satisfactory obstacle environment with acceptable OCA/H values and therefore we have not selected this option as the proposed option. Indeed a CRM calculation and consideration of other factors may allow a slightly reduced inset to the Rwy 25 THR.

We have therefore decided not to included our calculations of this option with this report.

If the concept of insetting the thresholds were adopted, the optimum resolution of declared distances and obstacle clearances would be the subject of a detailed design and the actual distances for a similarly modified runway would vary from these values.

9.5 Runway 25 with CAA Code 2 Classification

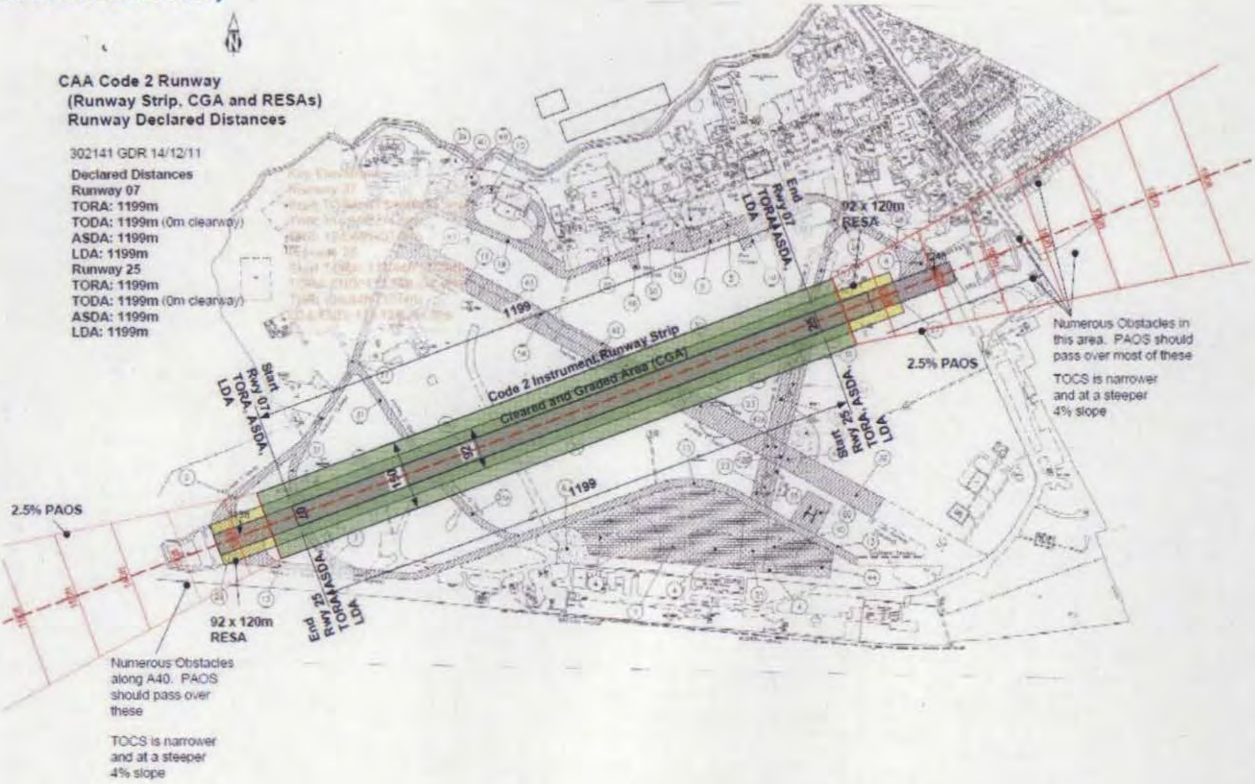
This option was investigated at an initial stage in this study.

The Licensing (or Certification) requirements for a Code 2 runway permit a narrower runway strip and narrower approach and take-off surfaces. In addition, the approach surface is at a slope of 2.5% although this cannot be considered for certain PANS-Ops OCA/H calculations.

As discussed in Chapter 3, under the existing CAA CAP 168 requirements the maximum ASDA or TODA value (and hence in practice the maximum TORA and LDA) is 1,199m. A sketch of this option is shown on the next page.

This would not meet the anticipated needs of commercial airliners and the RAF have informed us that it would not meet their needs either.

CAA Code 2 Runway



Source: MM

9.6 Runway 25 with Adjusted ICAO Code 2 Classification

A Code 2 runway, adjusted to provide tolerance for operations on hot days and/or with 5 knot or 10 knot tailwinds would have take-off lengths of between 1,350 and 1,450m. This would be similar in length to the proposed option with a similar inset to the threshold positions.

In practise, such an option would have very similar aircraft approach and departure procedures to those for the proposed Code 3 runway and a very similar obstacle environment. However, under ICAO rules (which are expected to be applied by EASA for Certification), it should only be used to determine obstacle clearances at a runway intended for Code 2 aircraft (see the tabulated list in 3.2.7 above) and this is again considered too limiting for commercial operators or military operations.

10. Cost of Works

We have been commissioned to also provide the estimated costs for the works necessary to meet the Licensing requirements and to provide Ernst & Young with the cost of works to provide facilities to handle schedule airline traffic.

The following cost estimates are divided into three groups to reflect:

1. The minimum works required to achieve a Licence for the existing operation;
2. The additional works required to develop a regional airport facility to handle up to 50,000 scheduled airline movements per year; and
3. Some additional works that may optionally be required.

These are construction related costs and do not include tendering, Licensing, legal, staff and other business costs, nor any operating costs (see also 10.4 below).

10.1 [redacted]

[redacted]

[redacted]

Mott MacDonald

10.2 [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]	
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
	[redacted]
[redacted]	
[redacted]	
[redacted]	
[redacted]	

[redacted]

10.3 [redacted]

[redacted]

[redacted]

[redacted]

[redacted]	
[redacted]	[redacted]
[redacted]	
[redacted]	
[redacted]	
[redacted]	
[redacted]	
[redacted]	

Source: MM

[redacted]

10.4 Generic Exclusions

(Applicable to all Phases and Proposed Options):

- Value Added Tax / Business Tax
- Legal Fees
- Planning Costs / Consultancy Fees & Charges associated with obtaining a CAA Licence
- Land Acquisition
- Capital Allowances allocation
- Client, Stakeholder and Operator costs
- Inflation
- Fit-Out of Retail / Food & Beverage areas within Terminals (assumed by Concessionaire)
- Aviation Fuel Facilities & Fuel hydrant system - Works to be undertaken and funded by Concessionaire
- Specialist fit-out of the VCRs by CAA/NATS (c. £1.5m)
- Vehicles/mobile equipment
- Additional Hangars
- Flight Catering Facilities
- Passenger Boarding Bridges & fixed links
- Additional new Stands / Aprons & associated equipment to new Terminal Building
- Fixed Ground Power
- Fire hydrant system
- Major works or contributions to external highway system
- Safeguarding for future expansion
- Write-offs/accelerated depreciation/capitalised interest
- Tenant decant costs/re-location expenses
- Compensation payments to tenants

11. Overall Conclusions

The present legal position (from the ANO) is that public transport operations can only operate from a Licensed or a Government Aerodrome. The legal position after 1st January 2014 when EASA takes over Certification of aerodromes is unclear. We assume that some equivalent provision will apply, but we have not seen the specific new provisions to date. Licensing does not relate to the annual number of movements and we do not expect Certification to do so either.

We have been tasked with answering the question, can Northolt be Licensed? In the end it is obviously for the CAA to say. However, as a result of studying the information we have been given, our assessment is that the CAA would not Licence the existing runway configuration. This is primarily due to the substantial number and degree of obstacle infringements at the east end of the runway. These fall well short of our experience of regulators' requirements at civil aerodrome in the UK and overseas. There are some other technical issues, but these can be resolved with little impact on potential operations.

The obstacle environment can be improved by insetting the thresholds (start of landing distances) and end of take-off runs from the ends of the paved runway. This raises the approach glide path and the take-off climb path and thus increases the tolerance for aircraft to deviate below these and thus reduces the risk of a collision. The effect of these measures is to reduce the take-off and landing distances declared for the runway. ASDA can remain similar to the existing distances.

Some other mitigation measures may help. Such as improved navigation aids and/or monitoring of the approach procedures. However, there are also infringements of the runway strip and the runway end safety areas (which do not meet the recommended dimensions) and such measures would not mitigate these issues.

A fully compliant runway would require the runway to be shortened to such an extent that it would not be useable for most military purposes, or of interest to potential operators and airlines as a commercial regional airport.

A Code 2 runway would also suffer from having declared distances that are too short to be of much use in the military or civil sectors.

Consequently, we have spent some considerable time assessing whether a Licensable and useful solution exists. We believe that it does, but that still requires the thresholds to be inset and the declared runway distances to be shortened.

The inset for Runway 07 would be increased from 92m to about 214m and the inset for Runway 25 would be about 240m.

The CAA would have to be satisfied with the resulting safety case, but that should be achievable in compliance with the provisions of ICAO PANS-OPS procedures and provide a useable approach decision height. This proposal would also improve compliance with the runway strip and RESA requirements.

Only a detailed design in consultation with the CAA can finalise those numbers, but for a working model, we have proposed a solution where the declared distances should be of the correct order of magnitude. That would be suitable for most, but not all, military uses (we have not been given much information on that aspect) and it would be suitable for a commercial airline operation similar in nature to that at London City, but will slightly fewer operating restrictions. It would be the larger civil and military aircraft that would be the most restricted and we understand that fast jets could no longer operate at Northolt.

If the airport remains a Government aerodrome and retains the existing declared distances, it does not follow that airliners of the type described could necessarily operate from the existing runway. It is not directly a licensing issue. What would be clear to airlines, the MAA, the CAA if asked, the LA when considering the necessary planning applications and well advised objectors is that the obstacle environment does not meet the standards set by ICAO and the CAA for civil aerodromes. It is our judgement that this may not only lead to a failure to obtain any necessary approvals, but that choice may result in airlines declining to operate and various forms of pressure may arise relating to the "safety" of the runway.

A potential commercial owner or operator of the airport would want a reasonable degree of certainty on this issue before committing to a major investment.

In conclusion, we would expect a commercial airline operation to be based on a shortened runway, whether or not it is Licensed.

CAA/ICAO compliant runway markings, pavement strengthening and in our judgement, improvements to the runway end safety areas (including the type of arrestor bed) may also be required for civil airliner operations. Again this would probably be independent of the need for a Licence.

Appendix A. EMAS

A.1. Background

Most aircraft accidents occur during the landing or take-off phases of flight and the probability of such an event is highest near to the runway ends. Regulation requires a number of clearances to be provided on the ground and in the airspace around a runway to allow an aircraft to safely manoeuvre and to mitigate the consequences of such accidents or incidents when they occur. The particular issues of concern that are being addressed in this section of this report are where aircraft overrun the runway end on landing or take-off, or undershoot the start of the runway on landing.

Overrun and undershoot protection is conventionally provided by the provision of cleared and graded areas at each runway end. These are known as Runway End Safety Areas (RESAs), which are provided to at least the minimum dimensions, but wherever practical, to the recommended dimensions of the regulator. RESAs need not be paved. They are normally grassed, but must be capable of supporting an overrunning or undershooting aircraft without causing significant damage. These can be substantial areas, usually a minimum of 150m wide, which often extend at least 300 m beyond the runway ends.

The existing runway at Northolt and the airport land around it does not provide RESAs to the CAA's or ICAO's minimum or recommended dimensions. However, an alternative to a grass RESA exists in the form of an arrestor bed, which is designed to bring an overrunning aircraft to a controlled stop in a shorter distance. Lightweight aggregate arrestor beds have been installed at each end of the Northolt runway in recognition of the risks of an overrun, which include the presence of two major public highways that cross each runway end. However, there are concerns about the predictability of the performance of this system and its safety in use. An aggregate bed can cause significant damage to an overrunning aircraft, difficult access for emergency vehicles and it provides an open textured bed that would accommodate spilt fuel, which adds to the fire risk.

A more effective and safer arrestor system that has been developed in recent years called an Engineered Material Arresting System (EMAS). It uses an area of crushable aerated concreter blocks to bring an aircraft to a controlled stop. EMAS was developed in the United States by a private company under the auspices of the Federal Aviation Authority (FAA) and in 2010, the UK Civil Aviation Authority (CAA) published its policy for the use of EMAS enhanced RESAs in the UK.

A.2. CAA EMAS Policy

The CAA's published policy is:

a. to permit the installation of EMAS at UK licensed aerodromes as an alternative where a 240 m RESA cannot be achieved;

b. to accept the FAA performance specification and guidance material as suitable for use in EMAS design in the UK, subject to a suitable safety assessment by each aerodrome on their own circumstances (i.e. where to site the system, dimensions, operating conditions etc.);

c. to permit EMAS to be located within the runway strip or RESA as determined by the design assessment;

d. to permit an increase in runway declared distances that can be achieved from the installation of EMAS only where installation of EMAS has provided the equivalent to a 240 m RESA and 60 m strip end (a full length EMAS for the design size aircraft).

The CAA also state that they will develop guidance material on the assessment and oversight of EMAS as required, based on existing (FAA) information, data from the system manufacturers and experience as UK applications are examined.

Point a above clearly states that an EMAS enhanced RESA is only accepted where a 240 m long RESA cannot be achieved. We understand that means cannot reasonably be achieved. Therefore the CAA would not permit its use merely as an alternative to a conventional (grass) RESA. **We have shown that 240m long by 150m wide RESAs cannot reasonably be provided at each end of the runway at Northolt** because the resulting runway would be too short for its intended purpose.

We note there is no reference to the RESA width in the CAA's policy statement.

In Point b, the CAA accepts that an EMAS installation shall be based on the FAA requirements. As we explain later in Appendix A, the FAA have a "standard solution" and a sub-standard solution. The latter is only permitted if the former cannot be achieved. We understand from Point d, that the CAA will only accept the FAA's standard EMAS solution. Otherwise declared distances may be adjusted to achieve the recommended RESA length.

In paragraph 3.3.5.1 above, we stated the CAA's Licensing requirements, which included an annual review of the specific circumstances. The first two stated factors are:

a. the nature and location of any hazard beyond the runway end;

b. the type of aircraft and level of traffic at the aerodrome, and actual or proposed changes to either;

The first item primarily refers to the public roads at each end of the runway (the A40 to the west and the A4180 West End Rd to the east). These will remain in place and the risks associated with those are not expected to change over time.

However, the second item may be the subject of significant future changes. We are not tasked with undertaking detail design work or risk assessments in this report. In considering their prospective Licensing or Certification requirements, we are certain that some form of arrestor bed will be required by the CAA at Northolt.

It is our judgement that the CAA may accept the ongoing use of the existing arrestor beds while the traffic at Northolt remains similar to that operating today in both nature and volume. Elsewhere we discuss the need to reduce the declared distances in response to the need to reduce the obstacle-related risks. Those amended runway characteristics will also have to be taken into account in an annual assessment. In our opinion, it is less certain if the CAA would continue to accept the existing arrestor beds in these changed circumstances, even if the traffic at Northolt remains similar to that operating today.

However, an option being considered is to permit the development of scheduled regional airline services. This would significantly increase the number of runway movements and considerably increase the numbers of flight crew and passengers at risk from an overrun or undershoot event. While airports such as Southampton operate such flights and continue to rely on the older concept of a lightweight aggregate arrestor bed, it is our judgement that the CAA would then want the Northolt arrestor beds to be changed to an EMAS design.

In this report we have concluded that for Licensing purposes:

- the existing lightweight aggregate arrestor beds could remain while the nature and volume of the traffic at Northolt remains similar to that operating today; but
- EMAS arrestor beds would probably be required if scheduled airline services were to be developed at the aerodrome.

A.3. FAA Requirements

A.3.1. Runway Category

Although a Contracted State, the USA has their own aerodrome design requirements, which vary from those in ICAO's Annex 14. In AC 150/5300-13, the FAA classifies the size of aircraft in the same six wingspan bands as ICAO (Code A to F), but refers to these as Airplane Design Groups (ADG) and assigns these with Roman numerals (I to VI). Thus Group I is equivalent[15] to Code A, Group III is equivalent to Code C and Group IV is equivalent to Code D.

The FAA do not classify runways by the reference field length, nor the actual runway length, but by an aircraft approach speed category. The FAA designate their approach speed categories by the letters A to E, which has the obvious potential to be confusing in this report.

FAA Aircraft Approach Speed Category

Approach Category	Minimum Speed	Maximum Speed
Category A	-	90 knots
Category B	91 knots	120 knots
Category C	121 knots	140 knots
Category D	141 knots	165 knots
Category E	165 knots	-

Existing operations at Northolt mean that the runway presently serves up to category C-IV aircraft.

In considering possible future aircraft types in operation at Northolt, turbo props such as the Dash 8 Q400 are classified by the FAA method as having an Airport Reference Code (ARC) of A-III and the ATR 72 as B-III. Jets such as the Avro RJ/BAe 146 are classified as B-III, A318 as C-III, Citation V as B-II, Citation VI as C-II and CRJ-200 as C-II. Embraer do not publish on their website the approach speed of their E-Jet range of aircraft, which vary by weight. These types may be expected to have approach speeds between 91 knots and 140 knots and will be considered as Category C-III for the purposes of this report.

Assuming that operations by the military Code D transports continue, the runway for future operations would continue with an ARC of C-IV for the purpose of developing the related FAA EMAS requirements.

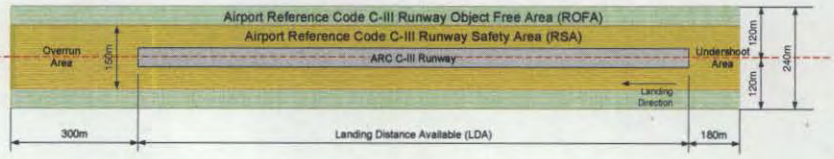
15 the FAA also consider tailfin height in these classifications

A.3.2. Runway Strip Requirements

In 3.3.3 we state the CAA's and ICAO's runway strip requirements, in 3.3.4 their CGA requirements and in 3.3.5 we state the required RESA dimensions.

The FAA adopt a different approach, combining the CGA and RESA areas into a single Runway Safety Area (RSA), which is surrounded by an Object Free Area (OFA).

FAA Runway Protection Areas



Source: Based on AC 150/5300-13

The Runway Object Free Area is the largest of these. It is a rectangular area extending 1,000 ft (300 m) beyond the runway end with an overall width of 800 ft (240 m). The OFA may be considered the nearest equivalent of the ICAO runway strip, although this is 300m wide.

The RSA may be considered the equivalent of a combined CGA and RESA. The length prior to the landing threshold is 600 ft (180 m)[16] and the length beyond the runway end is 1,000 ft (300 m). Its overall width[17] is 500 ft (150 m) throughout. This compares with the 210m width of the main part of the CGA for a precision approach runway, although this can be reduced to the same 150m width at each end.

Different undershoot and overrun lengths can apply in the FAA's regulations. In the above case, the RSA dimensions provide a 240m long overrun RESA, but a 120m long undershoot RESA[16].

16 If vertical guidance is provided

17 Where overall widths are stated, they are symmetrically disposed about the runway centreline.

A.3.3. ACRP Report 3

In considering runway end safety, the US Transportation Research Board's Airport Cooperative Research Program was sponsored by the FAA and Report 3 (published in 2008) is the result of their Analysis of Aircraft Overruns and Undershoots for Runway Safety Areas.

The report makes clear that there were a number of limitations in the data used to help formulate its conclusions. Notably the position an aircraft came to a halt and the circumstances surrounding the event was not always recorded in a manner that was useful for their research. There are also many events that are not reported because there were no consequences, but which would otherwise help establish a truer picture of the probability of an event and the degree that an aircraft undershoots its touchdown point, or the extent it overruns its intended landing or take-off distance. Information on the lateral position of the aircraft was not always recorded either. Another aspect is that the landing or take-off lengths required were not recorded to enable any comparisons to be made or any patterns to be established with the respective distances that were available.

Events involving helicopters, light aircraft, training, armed services, single engined, or piston engined aircraft, those that resulted in veer-offs or accidents more than 600m from the runway ends were all also excluded from this study's results.

The authors identified a total of 459 events to analyse. Most occurred in the US. Of the 459 events, 93 were undershoots on landing (0 in the UK), 274 were overruns on landing (24 in the UK), and 92 were overruns on take-off (5 in the UK). Analysis was broken down by accident and incident. The data was also "normalised" to a level runway at sea level, ISA conditions, level terrain and an infinitely long hard runway.

Of particular interest were the probable scatter of undershoot and overshoots relative to the runway ends and the respective patterns of lateral distance from the runway centreline. Approximately 75% occurred within 45m, 88% occurred within 75m.

The study only identified a low level of correlation between the longitudinal and lateral position of the events. Consequently, the study concluded that the transverse location distribution of undershoot accidents is fairly constant along the longitudinal locations from the threshold.

Takeoff overruns were about 20% of the sample. Approximately 45% occurred within 180m, 60% occurred within 300m. Approximately 70% occurred within 45m, 85% occurred within 75m.

The report does not attempt to correlate events to aircraft type or size.

Specific studies for the probability of incidents or accidents within RESAs at other airports follow this general pattern, with a substantial majority of events occurring within the minimum areas, but with a significant proportion occurring outside these areas.

If it is intended to develop commercial airline services at Northolt, then the Airport would need to commission a calculation to determine the applicable public safety zones (PSZs). This would take into account the planned mix of aircraft types and the planned number of aircraft movements. The risk of an overrun or undershoot at Northolt within the RESA area could be produced as a sub-set of those calculations and would be more specific to the local operating conditions. It should also relate longitudinal and lateral events.

A.4. EMAS Enhanced RESA

The aerated soft concrete product that has been developed in the United States by Zodiac ESCO Aerospace will reliably and predictably crush under the pressure of the tyres from an overrunning aircraft. This energy absorbing material increases the drag on the undercarriage and is designed to achieve a rate of deceleration of about 1g (about 10 m/s^2) in a fairly controlled manner and to do so with minimum damage to the aircraft itself.

The development and testing of this is Engineered Material Arresting System (EMAS) has been overseen by the FAA and the research programmes and actual aircraft overruns have demonstrated its effectiveness in arresting aircraft overruns. It has therefore been accepted for use by the FAA (subject to technical and financial criteria) as a means of improving the runway safety area (RSA) where a standard FAA overrun area within their RSA is difficult to provide.

Contained Overrun at Yeager Airport, Charleston, West Virginia

Source: Zodiac Aerospace

To date, the Zodiac ESCO EMAS has been installed at 51 runways in over 30 commercial US airports and there are 2 installations at airports in Spain and China. Apart from development testing, there have been 7 overrun incidents in which all the aircraft in question were stopped within the arrestor bed, preventing significant injury to passengers or significant damage to the aircraft.

A.4.1. EMAS Construction

EMAS is constructed of a cellular concrete material that is manufactured as numerous precast blocks of defined strength and dimensions. These are laid on a paved area. About 30% are bonded to the pavement. The height of the blocks varies, to provide a shallow entry ramp and get deeper the greater the distance into the bed. The sides and far end are also ramped to facilitate access by emergency vehicles and egress by passengers. The top and side surfaces are sealed.

EMAS Bed Construction at Barajas Airport, Madrid

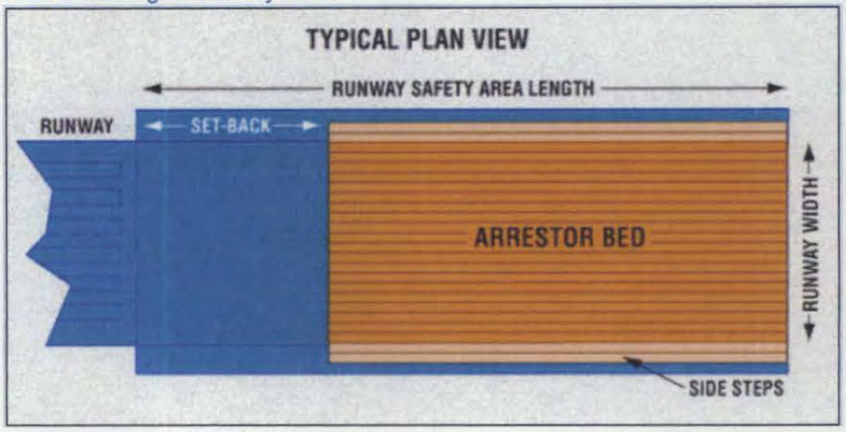
Source: MM

The following figures diagrammatically indicate the plan shape and cross sections of an EMAS installation.

In the FAA's "standard" EMAS design, the Runway Safety Area Length is at least 180 m. The set back must be sufficient to avoid jet blast damage from aircraft departing in the opposite direction.

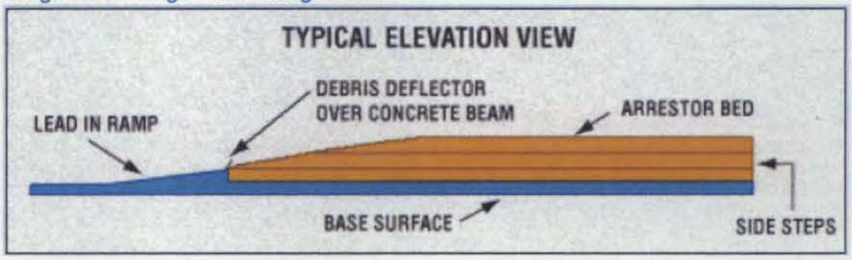
The base surface is designed to support the weight of an aircraft, but as with runway shoulders and blast pads, on the basis of infrequent use. Part of the set-back area will also need to be paved as a blast pad. If the set-back distance is greater than that, we are of the opinion that the entire set-back area between the runway end and the start of the EMAS bed should be paved in this way and none of the intervening distance left as grass. Otherwise the risk of damaging an overrunning aircraft (or undershooting aircraft in the reverse direction) is high for a relatively small cost saving. Zodiac, the manufacturers are of the same opinion.

Plan Indicating EMAS Layout



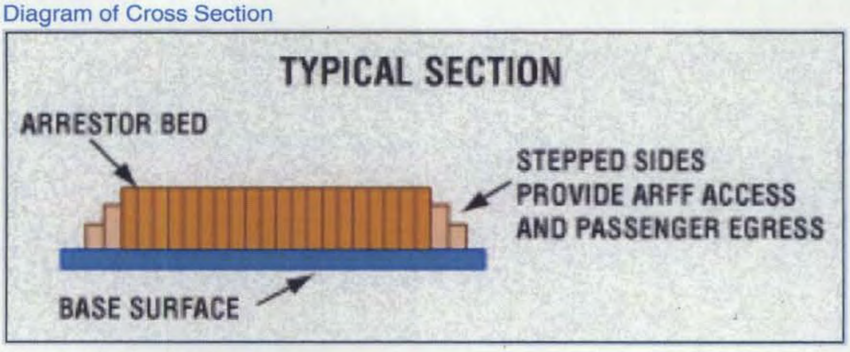
Source: Zodiac Aerospace

Diagram of Longitudinal Long Section



Source: Zodiac Aerospace

Diagram of Cross Section



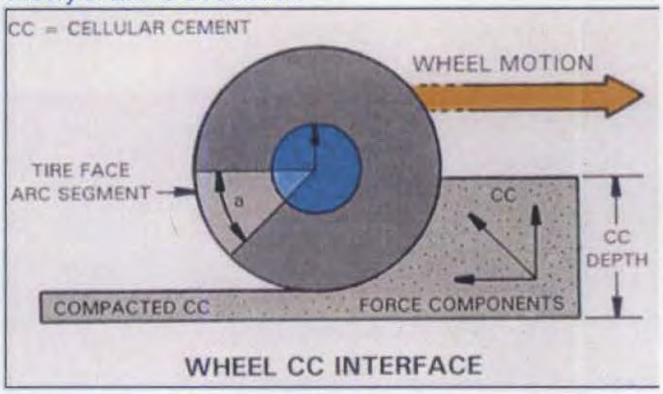
Source: Zodiac Aerospace

A.4.2. Basis of EMAS Design

In their Advisory Circular AC 150/5220-22A, the FAA quote data gathered for aircraft overruns over a 12 year period (1975 to 1887) which showed that 90% of overruns exited the runway end at speeds of 70 knots or less and that most come to rest between the extended runway edges within 1,000 ft (300 m) of the runway end.

This influences the runway exit speed selected and the length and width of the EMAS bed design proposed in most locations.

Theory of EMAS Bed Action



Source: Zodiac Aerospace

Result of EMAS Bed Action

Source: Zodiac Aerospace

The length of the EMAS bed is determined by the manufacturer based on the 70 knot runway exit speed, the distance between the end of the runway and the start of the EMAS bed, the slope of the site and the specific list aircraft types expected to be in operation and significant to the detail design of the bed. The design method has been developed mathematically and verified in tests under the supervision of the FAA. The manufacturer claims to use more than 100 variables in their computer program that calculates the design of the EMAS bed and the predicted performance for each aircraft type. The CAA has accepted that methodology.

The FAA's requirement for a conventional overrun area within their RSA extends 1,000 ft (300 m) beyond the runway end (equivalent to a 240 m long RESA). The FAA's standard design for an EMAS enhanced overrun RSA extends 180 m beyond the runway end (equivalent to a 120 m long RESA). In addition, the FAA recognises that even this shortened dimension may not be possible at some airports.

Having examined the spatial constraints at Northolt, we neither consider it impractical nor unaffordable to provide a RESA that is at least 120 m long (i.e. extending 180 m from the end of the runway).

The FAA standard design should therefore be used for any EMAS installation.

The remaining issues of concern are the width of the EMAS bed compared with the potential path of some overrunning aircraft and the fact that a shortened EMAS enhanced RESA offers no additional or equivalent undershoot protection.

In the specific case of the width issue, the statement by the FAA quoted at the start of this section clearly implies that an EMAS bed equal in width to the runway should be encountered by about 90% of overrunning aircraft. This is a higher percentage than implied by ACRP Report 3, but is the basis on which the FAA have given their approval.

Most past events are where there was no arrestor bed. In some instances the pilot in charge may have deliberately chosen to steer off of the runway centreline to try and avoid obstacles, but if an EMAS bed is provided, pilots would now endeavour to steer into the arrestor bed. Therefore, in order to maximise the use of an EMAS arrestor bed in an overrun event, pilots must be aware of its presence at the end(s) of the runway, a fact which should be promulgated in the airports entry in the CAA Aeronautical Information Publication (AIP) and commercial equivalents. They must also have directional control, which will apply in the vast majority of cases, but not all overrun events.

The RESA must be wider than the 46 m EMAS bed width to provide an overrun area for aircraft that undershoot, or veer off and overrun into the area outside of the extended runway edge lines.

The FAA standard design for an EMAS enhanced RSA, still assumes an overall RSA width of 150 m, which is the same as the ICAO/CAA recommended width for a Code 3 or Code 4 RESA. We support the concept with a 150 m RESA width. If that width cannot be provided due to site constraints, then the 90 m minimum should apply, but in our opinion, without any instant change from the 150 m wide CGA to the reduced RESA width.

A.4.3. Design Aircraft for EMAS Bed

The EMAS manufacturer calculates the dimensions they recommend for the EMAS bed based on the particular mix of aircraft that are expected to operate using a computer-based analysis that they have developed. This is required by the FAA to consider multiple aircraft parameters, including, but not limited to allowable aircraft undercarriage gear loads, undercarriage configuration, tyre pressure, aircraft centre of gravity, aircraft speed and allowable g-forces on the aircraft occupants.

While the largest or heaviest aircraft may be the critical aircraft for design purposes, that is not always the case. The undercarriage configuration varies between some aircraft types and that may result in different degrees of drag. Lighter aircraft may also prove a critical case, if there is a risk that they might not bed into the EMAS material.

A.4.4. Performance of an Overrun EMAS Bed

The performance of the latest design of EMAS does not materially change between dry and wet conditions or if overlain by snow. The manufacturers state that their latest design is also now less susceptible to jet blast erosion and they claim it requires less routine maintenance.

An overrun into an EMAS bed is a more predictable event than an aircraft overrunning onto a grassed RESA, even if that is built to the recommended dimensions. The extent of aircraft damage and injury to its occupants is also much lower than on a graded overrun area in all the actual incidents to date (although the number so far, 7, is small).

Because it is designed to limit the stress applied to the undercarriage, a low level of damage is to be expected and is a benefit of the concept.

A.4.5. Equivalent RESA Length

In A.2 above we state that the CAA's policy is to permit an increase in runway declared distances that can be achieved from the installation of EMAS only where installation of EMAS has provided the equivalent to a 240 m RESA and 60 m strip end (a full length EMAS for the design size aircraft).

The CAA's RESA requirements are based on, and the same as, the ICAO SARPs, even though the method of runway classification is different. To retain/maximise declared distances, the CAA's policy is also to require an EMAS installation to be equivalent to a 240 m long RESA (+ 60 m strip).

There are no stated performance standards for a conventional (grass) RESA and ICAO/CAA make no distinction between its overrun and undershoot roles. In addition, for a given runway Code Number, its dimensions are not varied in relation to the actual length of the runway, the size of the aircraft types it is intended to serve, or their respective numbers of movements.

There is therefore no simple relationship between the dimensions of conventional grass RESAs and an "equivalent" EMAS enhanced RESA.

In its Advisory Circular 150/5220-22A (dated 30/09/2005), the FAA does refer to **a standard EMAS design that provides a level of safety that is "generally equivalent" to a full RSA** built to the FAA's standard dimensions in dry conditions, which are 1,000 ft (300 m) long, measured from the end of the relevant runway declared distance, by 500 ft (150 m) wide.

This FAA "standard" EMAS installation provides an EMAS bed that finishes 600 ft (180 m) from the end of the relevant runway declared distance. However, the length of the EMAS bed (and hence the length of set back distance between the end of the runway distance and the start of the EMAS bed) is not prescribed, but varies according to the deceleration characteristics of the relevant design aircraft. Appendix 2 of Advisory Circular 150/5220-22A contains graphs relating speed and EMAS length for 7 specific aircraft types. These all assume no operating reverse thrust and poor aircraft braking performance.

We conclude that the FAA's standard EMAS installation is the closest that can be achieved to meeting the CAA's equivalency test.

A.4.6. EMAS RESA Dimensions

A.4.7. Undershoot Scenario

The FAA requirement is that an undershoot, in which an aircraft touches down on an EMAS bed, must not cause control problems for the aircraft. The Zodiac EMAS design meets this requirement.

An undershoot onto an EMAS bed is expected to cause shallow wheel ruts in surface once the undercarriage (which initially is at full extension) makes contact with the upper surface of the EMAS blocks.

A.4.8. Light Aircraft

Light general aviation aircraft tyres may not penetrate into the bed to a significant extent to provide the full drag effect. However, the overrun distance provided by a standard FAA EMAS installation is the same as that recommended by the CAA for a Code 1 or Code 2 runway RESA.

A.4.9. Impact of Vehicles on EMAS

The strength of the EMAS bed is sufficient to support vehicles with high-floatation tyres, although they may cause shallow wheel ruts. Vehicles should only run over the EMAS bed in an emergency.

A.4.10. Maintenance and Service Life

An EMAS bed does require occasional inspection and maintenance. Joints may need to be sealed. The strength of the aerated concrete blocks must also be checked regularly (probably every 5 years)

The FAA's financial rules require the calculation for the lifetime cost of an EMAS bed to be on the basis that it is replaced after 10 years. This is a cautious approach built into their financial cost/benefit model and does not necessarily mean that the beds will have to be replaced after 10 years. In fact, the FAA's requirement is that an EMAS installation should have a service life of twenty years. Existing installations are only just exceeding 10 years old and so this lifespan is yet to be proven, but the condition of the existing beds does not yet suggest that this lifespan will not be achieved.

The only EMAS replacements to date have been in connection with runway development options, although we understand that some of the early installations that were constructed close to the runway end suffered some jet blast and vibration damage.

A.4.11. EMAS Damage and Repair

The EMAS installation must be designed and constructed so that it will not be damaged by jet blast or propwash. We understand that the latest Zodiac EMAS design, which has a plastic top coating and the minimum set-back distance meets this requirement.

The damage to the EMAS bed caused by actual overruns is extensive in the aircraft's wheel tracks, but unless caused by emergency or recovery vehicles, is unaffected elsewhere. Concerns have been expressed as to the cost and time that will be taken to effect a repair. The costs should be reclaimable from the aircraft's operators and their insurers. Pilots will be notified by NOTAM of a damaged EMAS installation.

The EMAS bed is a means of mitigating the potential damage of an accident. Unless there is a contributory cause that would equally apply to other aircraft immediately using the runway, then the probability of a repeat event in the near future is very low. The bed also remains effective unless another overrunning aircraft follows the same wheel tracks (again very unlikely).

The FAA's specification requires that a damaged EMAS is repaired in a timely manner and must be designed to be repairable within 45 days. While the supply of replacement blocks would have to come from the USA, modern transport systems mean that this should be possible.

The CAA's policy is to follow the FAA's recommendations.

A.5. Conclusion

The use of an FAA standard EMAS installation on a restricted site is permitted by the CAA and could be used at Northolt

Its predictable and safe performance means that it is preferable to the existing lightweight aggregate arrestor bed – particularly where significant numbers of movements by civil airliners could benefit from its protection.

An EMAS enhanced overrun RESA, based on the FAA Standard solution, would be 120m long (180m from the end of LDA, TORA or ASDA) and equal to the runway width (46m). The bed of blocks would be placed at the rear of the RESA on a paved area that extends 10m outside the EMAS blocks. The blocks would be designed for the particular aircraft mix.

Operational advantages of an EMAS enhanced RESA:

- Provides a predictable and reliable method of bringing an overrunning aircraft to a halt;
- Can be designed to accommodate a wide range of aircraft size and types;
- Performance only relies on limited braking action by the aircraft and does not rely on the frictional characteristics of ground;
- Performance is not affected by rain or snow;
- For a given set of circumstances, EMAS will arrest an aircraft in a significantly shorter distance than a grass or surfaced RESA;
- AN overrun into EMAS does minimal damage to the aircraft and minimises potential injury to aircraft occupants; and
- Can be walked on and, if necessary, run on by emergency response vehicles (some damage to EMAS blocks will occur)

Operational disadvantages of an EMAS enhanced RESA:

- Relies on the aircraft entering the EMAS bed to stop the aircraft, which means pilot must have control of aircraft direction, understand the need to steer onto the bed and have confidence that it will stop his aircraft;
- Is limited in width (usually only installed to the same width as the runway), thus providing no overrun protection for an aircraft that has veered off the runway to either side;
- Provides no benefit in an undershoot scenario and if installed as part of a reduced length and/or width of RESA, will mean there is a reduced degree of undershoot protection;
- Is damaged by the overrunning aircraft and is more complex, time-consuming and costly to repair than a grass RESA;
- Requires occasional maintenance; and
- May have a limited life (presently assumed to be 20 years)

However, it has to be recognised that in many situations, EMAS is considered an expensive solution.

To be consistent, the undershoot RESA provision would be based in the minimum FAA dimensions (120m long by 150m wide) commencing 60m prior to the threshold.

Appendix B. Existing Runway Obstacle Analysis

The following drawings show the obstacles that infringe the stated Obstacle Limitation Surfaces for a Code 3 runway

Note: Drawings are Not to a Standard Scale

These are produced using computer software that only shows obstacles that penetrate the selected surfaces. However, these are based on objects surveyed by Masons Land Surveys (and supplied by the MoD) for the existing OLS. They therefore do not include potential obstacles located outside of those surfaces.

In addition, if one obstacle is close to another obstacle that is only slightly lower, then it will not be in the Masons Survey database. For example: A TV aerial on a chimney will be higher than the chimney or adjacent roof. There are also many examples where a tree is taller than an adjacent building. Removing the tree will remove that obstacle, but the height of the building is unknown and yet it is still likely to present a significant obstacle. The hedge alongside the site boundary fence is generally slightly higher than the fence. Therefore removing or lowering the hedge will only reduce an infringement by a small amount.

We have used visual inspection, photographs and even Google Streetview to help assess the nature, relative heights and positions of some obstacles.

The work we have undertaken on the obstacle infringements is therefore an estimate of the situation and cannot be relied upon to produce the same results as a design based on a specific site survey.

Items coloured green are trees or hedges

Items coloured red are indicative heights of vehicles (up to 4.8m high) on public roads. The road surface levels are not on survey drawings and have had to be estimated.

All other items are coloured blue.

The actual drawings reveal the elevation of each obstacle. The following drawings are reduced in size and so the individual obstacle elevations are not legible. The notes indicate the more significant obstacles.

B.1. Commentary on Runway 07/25 Infringements

The runway points from the survey have been used to construct the OLS, with the exception of the Runway 25 TORA End which has been shifted east so that this point is 60m before the TODA End, resulting in a Runway 25 TORA of 1640.56m. This is to place the TOCS in the expected position.

The Approach Surface for Runway 07 has been produced for a non-precision approach, whilst for Runway 25 the Approach Surface is relevant to a precision approach. An ARP is not given in the AIP, so the midpoint of the extreme ends of the runway has been taken for the purposes of this example, with a nominal level of 35m.

B.1.1. Runway 07 Infringements

B.1.1.1. Runway 07 Approach Surface

There are 105 infringements of this surface, these include;

- 31 lamp posts along the A40, which infringe by up to 4m.
- Two infringements are caused by vehicles on the A40, the worst of these also being an infringement of 4m.
- The perimeter fence and two CCTV masts on the fence line form seven further infringements of up to 4.5m.
- Two masts approximately 2km from the 07 Threshold infringe by 7m and 16m.
- The remaining 63 infringements are trees, the worst of which infringes by 11.5m.

B.1.1.2. Runway 07 Take-off Climb Surface

There are 198 infringements of this surface;

- 46 of these are Runway 25 approach lights, with the worst infringement being 5.5m.
- Eleven infringements are formed by aerials, of which the worst is 6m in Odyssey Business Park. Other aerials are on residential properties in Cavendish Road and Trenchard Avenue, the scale of the infringements caused by these suggests that the chimneys and roofs of these buildings are also infringements.

- Fourteen buildings the majority in Odyssey Business Park, the worst is an infringement of over 4.5m.
- Eleven floodlights, most in the Odyssey Business Park infringe by up to 2.5m.
- Perimeter features such as hedges, walls and fences form 45 infringements with the worst over 9m. Many of these are along the A4180 West End Road.
- Vehicles along the A4180 infringe by almost 8m at worst, which indicates that the ground itself is an infringement of some 3m.
- The spire of St Mary's Church at Harrow on the Hill infringes by over 25m, and it is therefore likely that numerous other buildings in the area infringe too, although these have not been recorded in the survey.
- Fifty-five trees are infringements, many of these inside or adjacent to the north eastern boundary of the airfield
- The remaining infringements are permanent structures including CCTV masts and a "Portakabin" within the site at up to 8m infringement. The canopy of a petrol filling station on the A4180 infringes by over 4.5m.

B.1.2. Runway 25 Infringements

B.1.2.1. Runway 25 Approach Surface

There are 267 infringements of this surface. The first 3000m of this surface beyond the Runway 25 Threshold shares the same slope as the 07 Take-off Surface, albeit that the origin of these two surfaces differs by approximately 20 meters. Most of the infringements of the 07 Take-off Climb Surface are therefore infringement of this surface too. This surface is however wider and more infringements are introduced as a result. Some of the notable additional infringements are described below:

- Infringements caused by vehicles on the A4180 increase to over 11m in magnitude.
- The number of infringing trees is 91 with the worst infringement reaching over 21m in Trenchard Avenue.
- The number of infringing buildings is 19 and the worst of these is the building 096, one of a pair of three storey block of flats in the north east corner of the site which infringes by over 14m.

B.1.2.2. Runway 25 Take-off Climb Surface

There are 174 infringements of this surface. Many of the infringements of this surface are shared with the 07 Approach, but others are added as the origin of this surface is lower and closer to the obstacles. Some of the notable additional infringements are described below;

- Thee two masts approximately 2km from the 07 Threshold infringe by 9m and 17.5m.
- 75 lamp posts on the A40 infringe the worst by 4m.
- There are 59 infringing trees, the worst by over 8m.

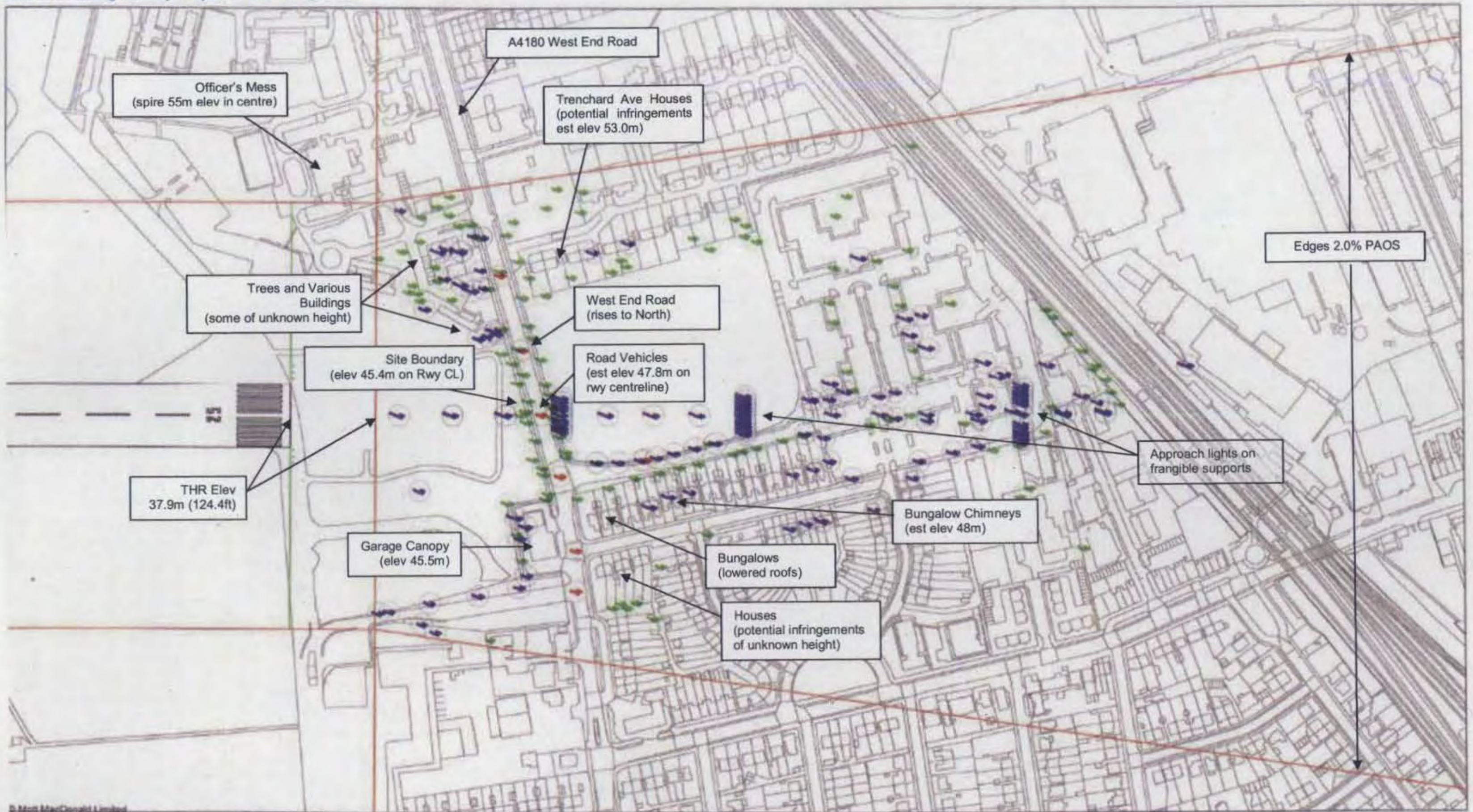
B.1.3. Other Runway 07/25 Obstacle Limitation Surfaces

We have examined the infringements of the transitional surface "on screen". Most of these are to the north between and including the Officer's mess and the houses in the area served by the northern loop of Trenchard Avenue. The infringements are mostly a mixture of trees and buildings.

A high level examination of the Rwy 25 missed approach surface indicates that there are unlikely to be an significant obstacles.

We have not examined any other surfaces in relation to the existing runway configuration.

East End Existing Runway: Rwy 25 PAOS Infringements



Mott MacDonald

Mott MacDonald House
8-10 Sydenham Road
Croydon
United Kingdom

T +44 (0)20 8774 2000
F +44 (0)20 8681 5706
W www.mottmac.com

Client

Rev	Date	Drawn	Description	Ch'k'd	App'd

Title: Runway 25 Approach Surface Code 3 Instrument Runway Infringements

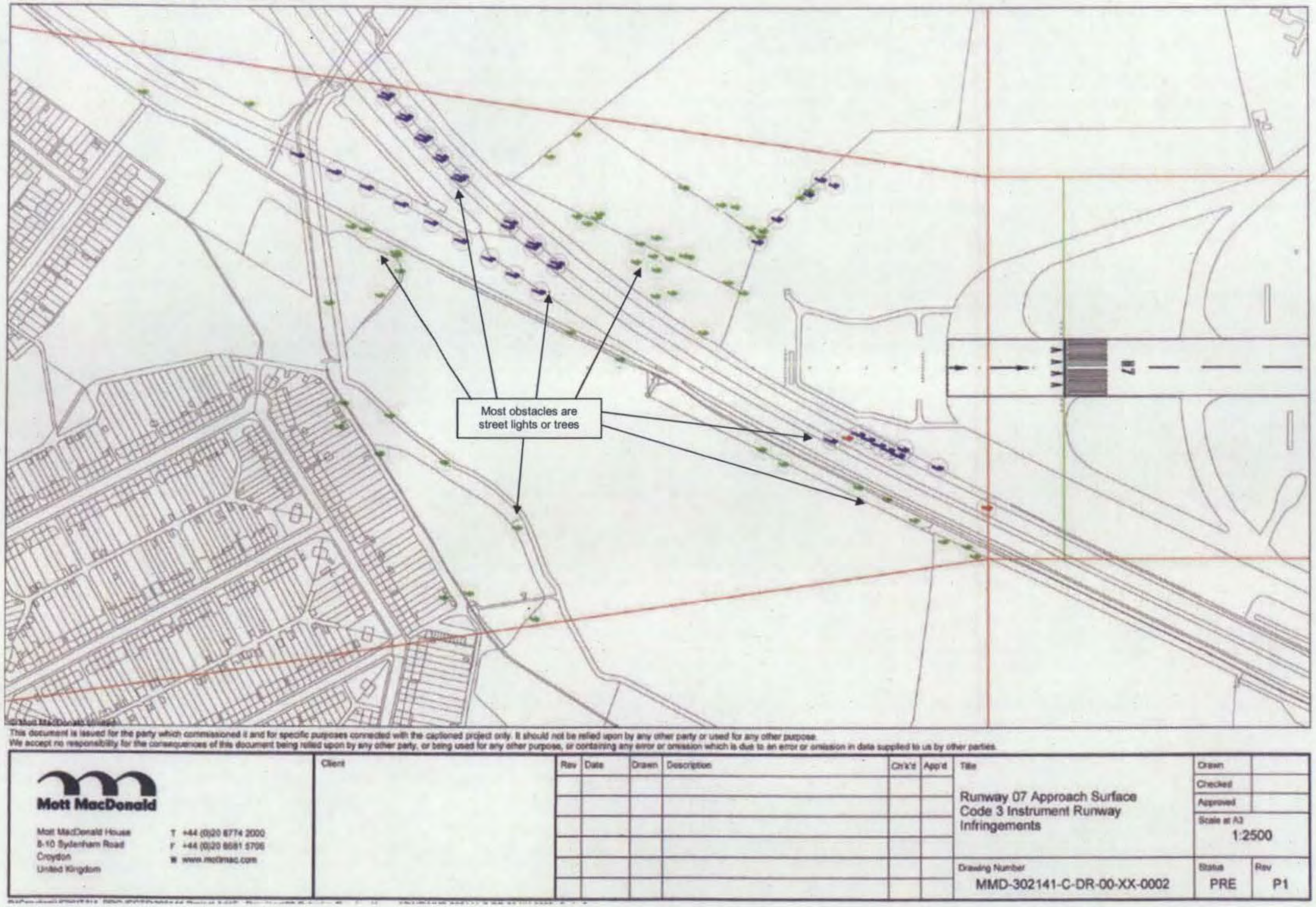
Drawn:
Checked:
Approved:
Scale at A3: 1:2500

Drawing Number: MMD-302141-C-DR-00-XX-0001
Status: PRE
Rev: P1

\\Croydon\VOY\TA\1 PROJECTS\302141 Project Ark\F - Drawings\02 Outgoing Drawings\Issued\DWG\MMD-302141-C-DR-00-XX-0001- Code 3

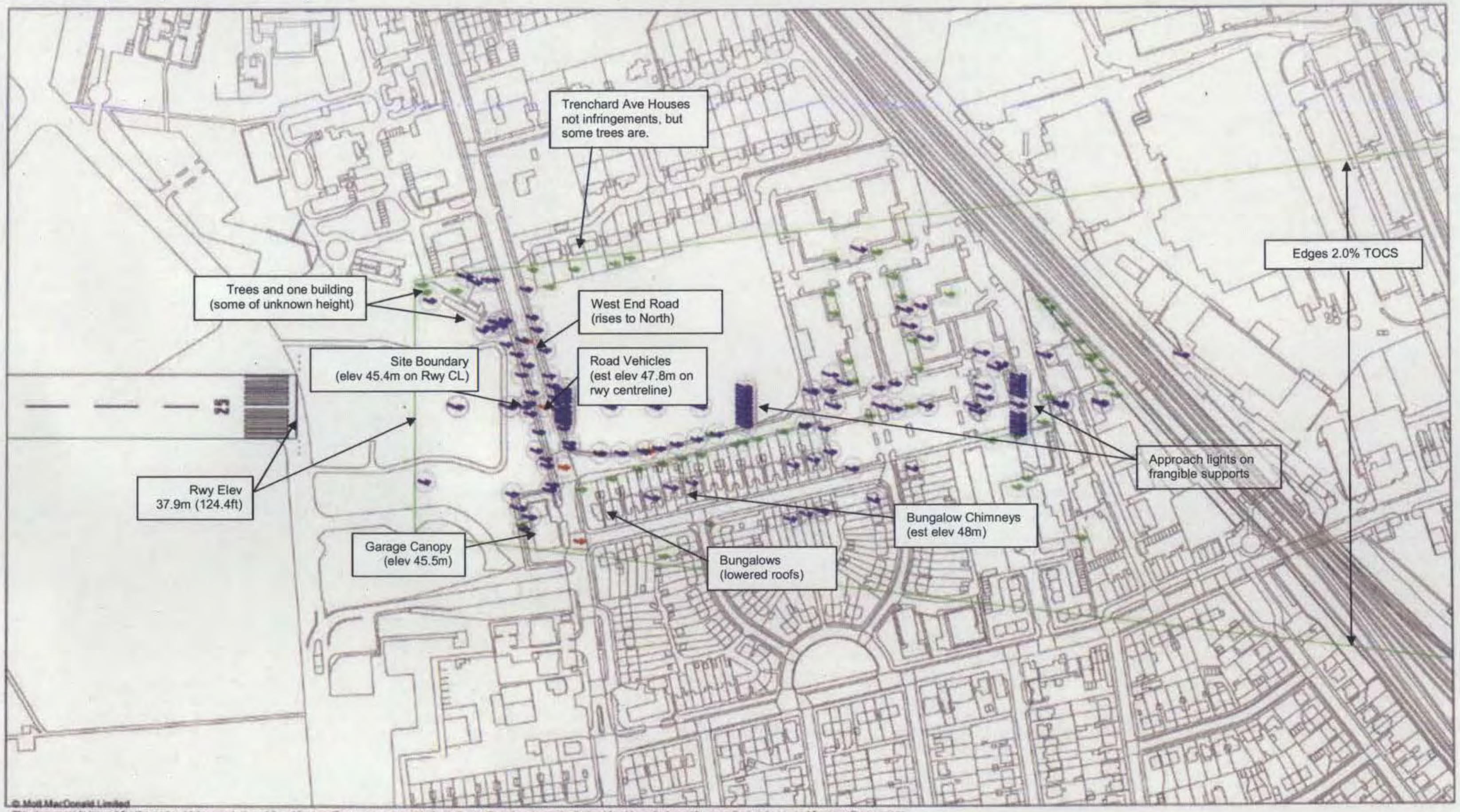
Source: MM

West End Existing Runway:Rwy 07 NPAOS Infringements



Source: MM

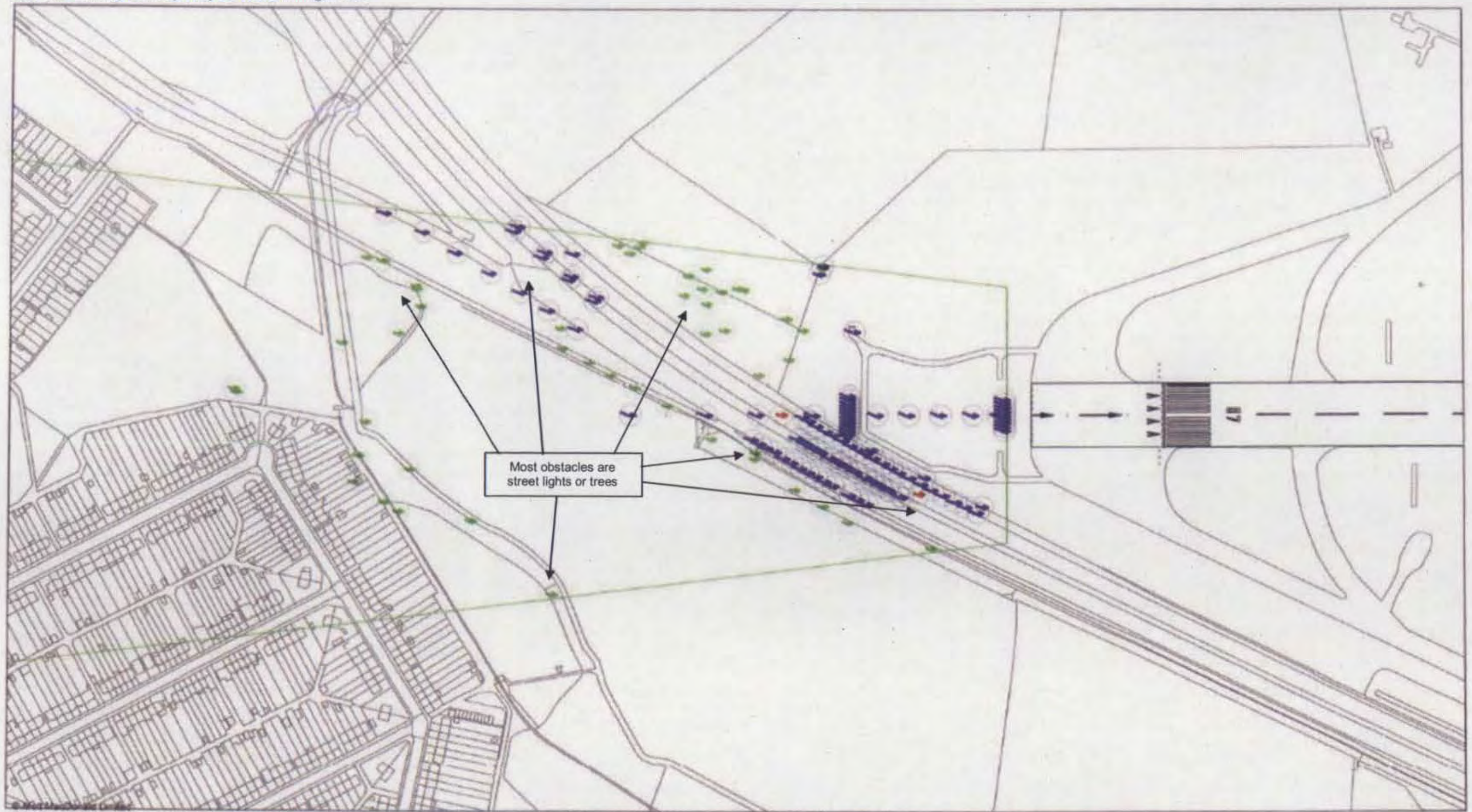
East End Existing Runway: Rwy 07 TOCS Infringements



Mott MacDonald Mott MacDonald House 8-10 Sydenham Road Croydon United Kingdom T +44 (0)20 8774 2000 F +44 (0)20 8681 5706 W www.mottmac.com	Client	Rev	Date	Drawn	Description	Ch'k'd	App'd	Title Runway 07 Take-off Climb Surface Code 3 Instrument Runway Infringements	Drawn Checked Approved Scale at A3: 1:2500
								Drawing Number: MMD-302141-C-DR-00-XX-0004	Status: PRE / Rev: P1

Source: MM

West End Existing Runway: Rwy 25 TOCS Infringements



Mott MacDonald
Mott MacDonald House
8-10 Sydenham Road
Croydon
United Kingdom
T +44 (0)20 8774 2000
F +44 (0)20 8681 5706
W www.mottmac.com

Client	Rev	Date	Drawn	Description	Ch'k'd	App'd

Title	Runway 25 Take-off Climb Surface Code 3 Instrument Runway Infringements
Drawn	
Checked	
Approved	
Scale at A3	1:2500
Drawing Number	MMD-302141-C-DR-00-XX-0003
Status	PRE
Rev	P1

P:\Croydon\VOYNTA\1 PROJECTS\302141 Project Ark\F - Drawings\02 Outgoing Drawings\Issued\DWG\MMD-302141-C-DR-00-XX-0003- Code 3

Appendix C. Shortened Runway Obstacle Analysis

The following drawings show the obstacles that infringe the stated Obstacle Limitation and Obstacle Assessment Surfaces for a Code 3 runway

Note: Drawings are Not to a Standard Scale

Except for drawing MMD-302141-C-DR-00-XX-0016, these are produced using computer software that only shows obstacles that penetrate the selected surfaces. However, these are based on objects surveyed by Masons Land Surveys (and supplied by the MoD) for the existing OLS. They therefore do not include potential obstacles located outside of those surfaces.

In addition, if one obstacle is close to another obstacle that is only slightly lower, then it will not be in the Masons Survey database. For example: A TV aerial on a chimney will be higher than the chimney or adjacent roof. There are also many examples where a tree is taller than an adjacent building. Removing the tree will remove that obstacle, but the height of the building is unknown and yet it is still likely to present a significant obstacle. The hedge alongside the site boundary fence is generally slightly higher than the fence. Therefore removing or lowering the hedge will only reduce an infringement by a small amount.

We have used visual inspection, photographs and even Google Streetview to help assess the nature, relative heights and positions of some obstacles.

The work we have undertaken on the obstacle infringements is therefore an estimate of the situation and cannot be relied upon to produce the same results as a design based on a specific site survey.

Items coloured green are trees or hedges

Items coloured red are indicative heights of vehicles (up to 4.8m high) on public roads. The road surface levels are not on survey drawings and have had to be estimated.

All other items are coloured blue.

The actual drawings reveal the elevation of each obstacle. The following drawings are reduced in size and individual obstacle elevations are not legible. The notes indicate the more significant obstacles.

Drawing MMD-302141-C-DR-00-XX-0016, shows the East End Shortened Runway (240m inset THR): Rwy 25 Cat 1 ILS Obstacle Assessment Surface (OAS). This is not computer generated and therefore does not automatically show penetrating obstacles. We have compared this OAS with obstacles on other drawings and comment as shown.

South Arm of Officers Mess

Source: MM

Garage Canopy on A4180 West End Road

Source: MM

C.1. Commentary on Shortened Runway 07/25

This Appendix shows the effect of insetting the thresholds and altering the declared distances in the manner proposed in Chapter 9. It also incorporates some relatively small adjustments to accommodate an EMAS enhanced overrun RESA to FAA standard dimensions. The minimum length of under-shoot RESA to the relevant FAA requirements is 120m long, although longer under-shoot RESAs can be accommodated at each runway end.

This option considers a Code 3 runway, featuring Code 3 OLS, with the exception of the 07 TOCS and 25 PAOS, which have a 2.8%, rather than 2% slope. This is in recognition of the 3.5° glideslope. This is not a standard or recognised slope, but is used to maintain the same vertical clearances that a 2.0% slope would provide under a 3.0° glideslope. It therefore indicates a similar level of obstacle assessment and an equivalent level of infringements.

The use of the PANS-OPS OAS and the Collision Risk Model are the appropriate methods to finally assess the collision risks associated with the resulting obstacle environment.

The location of the Runway 07 Threshold has been further displaced from 92m to 214m from the west end of the paved runway, with the LDA ending 60m before the 46m x 120m EMAS RESA.

The Runway 25 Threshold has been displaced by 240m from the east end of the paved runway, with the LDA ending 60m before the 46m x 120m EMAS RESA.

The origin of the 07 TOCS is the same as the 25 PAOS, whilst the 25 TOCS has been shifted 175m east to reduce the infringements by vehicles on the A40.

The new 07 Threshold falls between CAP 232 Survey Check Point 1 and the original 07 Threshold, interpolating between these levels gives a level of 34.72m; 34.68 +((36.77 - 34.68) x (78.57/200.89)).

The new 25 Threshold falls between CAP 232 Survey Check Points 6 and 7, interpolating between these levels gives a level of 36.22m; 34.96 +((36.44 - 34.96) x (176.4/208)).

The obstacles surveyed by Masons Land Surveys are largely limited to those which fall under the existing OLS. There are some omissions from this survey, notably the vehicles on the public roads immediately beyond the runway ends, specifically the A4180 West End Road to the east and the A40 Western Avenue to the west. Our analysis used the latest obstacle data from the CAP232 Survey, supplemented with road levels taken from Google Earth to which vehicle heights of 4.8m have been added in accordance with ODPM Safeguarding Circular 1/2003.

The Obstacle Assessment Surface (OAS) for the Runway 25 approach has been generated by hand from the formula contained in PANS-OPS. It therefore does not automatically show obstacle penetrations. We have determined this for a Cat 1 ILS precision approach with a 3.5° glideslope, RDH of 16.6m, 2.5% missed approach gradient, 36m wingspan aircraft with a 4m antenna to wheel height.

C.1.1. Runway 25 Infringements

C.1.1.1. Runway 25 Approach Surface

By moving the Runway 25 PAOS to the west, it is raised relative to the existing obstacles (it is further raised by showing it at 2.8%). However its width at any comparable point is now greater and so it captures more obstacles, some of which are of unknown height. This is a particular issue around the Officer's mess.

Most remaining infringements are much reduced in magnitude and many are trees.

When these obstacles are examined in relation to the PANS-OPS OAS, most obstacles, including the Officer's mess, buildings adjacent to the Officer's mess and houses in Cavendish Road and Trenchard Avenue are now beneath this narrower and more complex surface. In fact only road vehicles penetrate to a slight extent (circa 1.5m) at the northern edge of the "W" surface and there are a small number of infringements by trees.

From this we conclude that use of the CRM would probably show an acceptable level of risk and may allow a slight reduction in the inset distance. However other factors, such as the runway strip and RESA limit the potential extent of such a reduction.

C.1.1.2. Runway 25 Take-off Surface

The number of infringements is considerably reduced. They amount to some trees and a small number of street lights that could be lowered.

C.1.2. Runway 07 Infringements

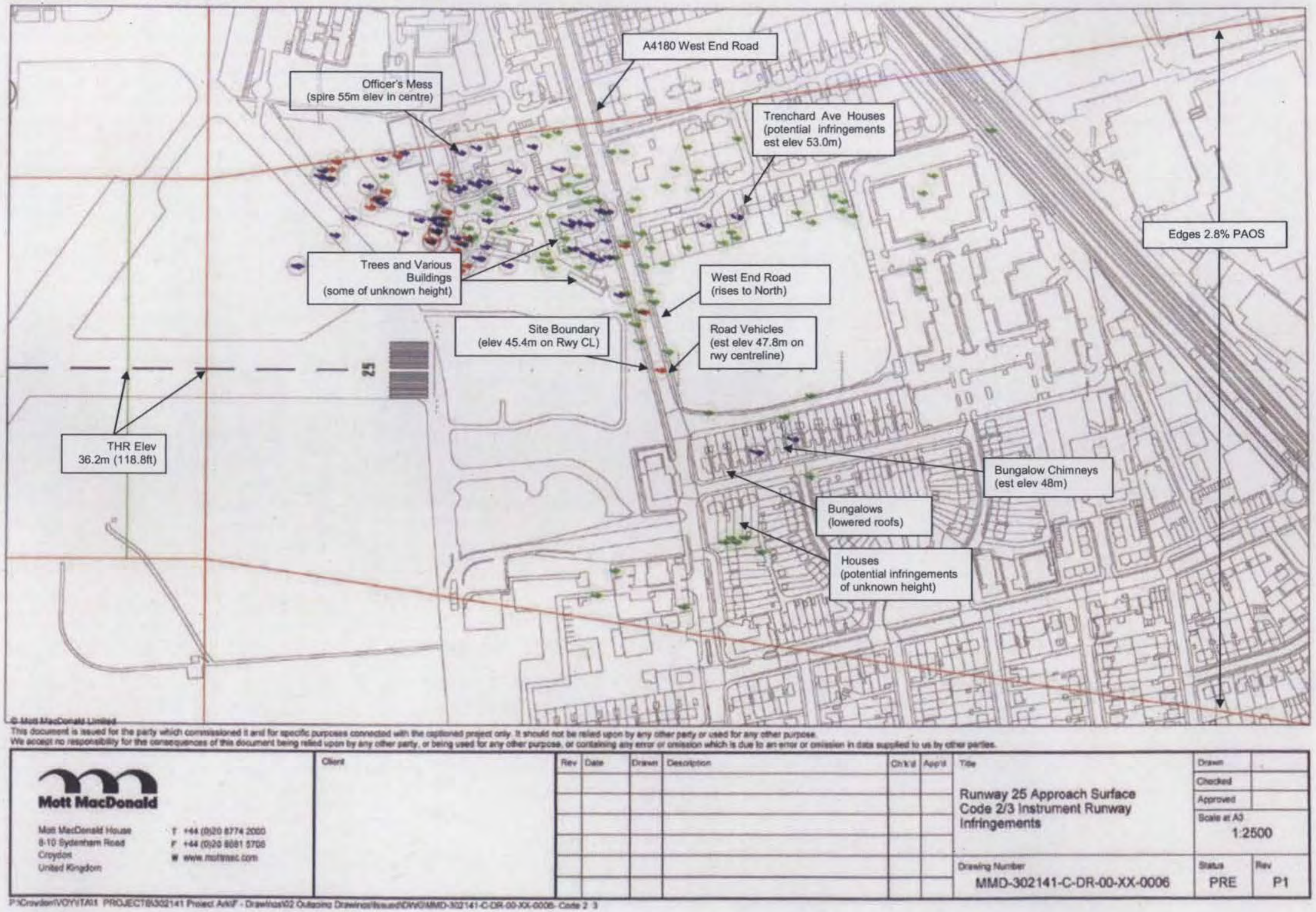
C.1.2.1. Runway 07 Approach Surface

This is infringed by the same infringements to the Rwy 25 TOCS, but with slight more trees and street lights to consider.

C.1.2.2. Runway 07 Take-off Surface

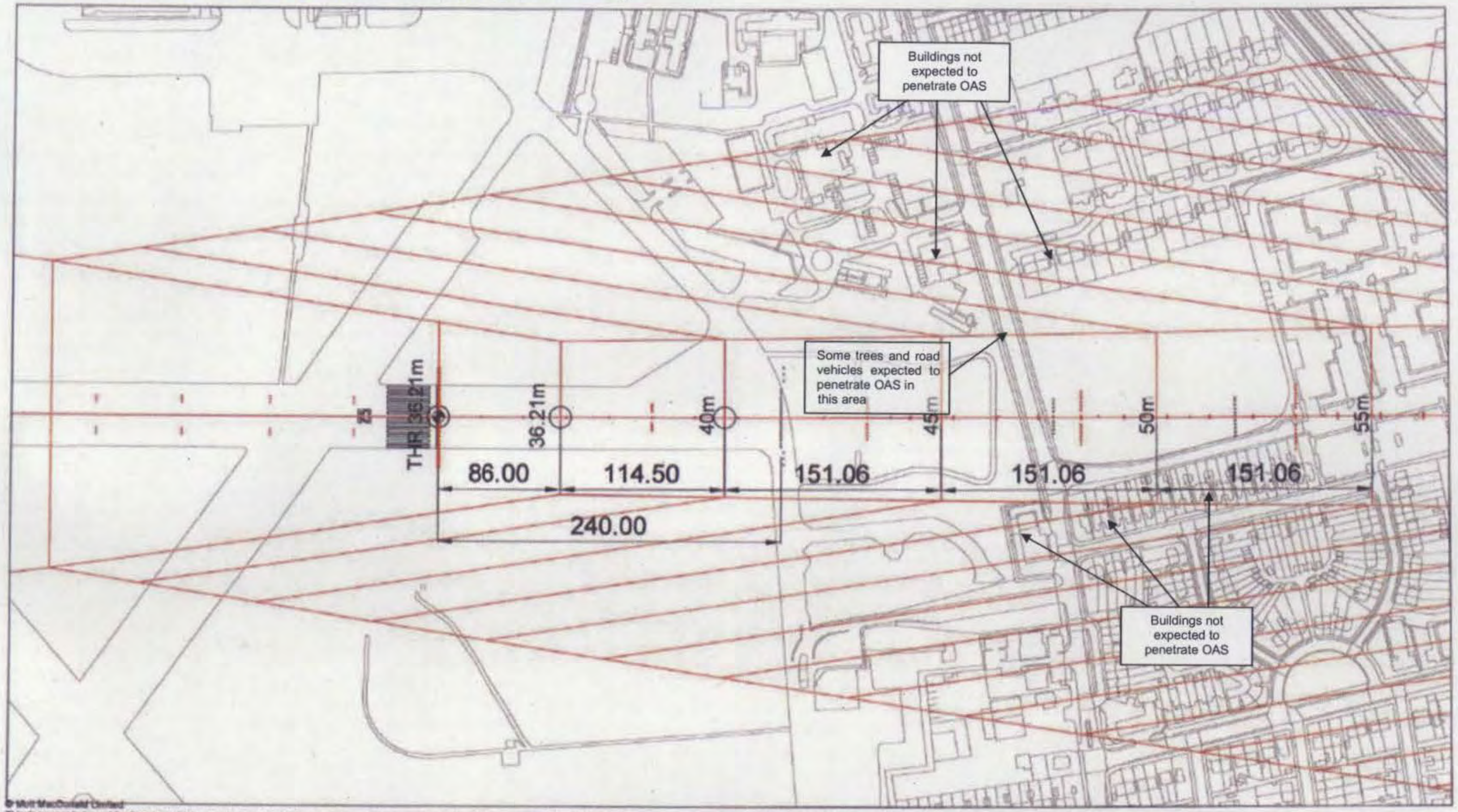
This is infringed by some of the same infringements as the Rwy 25 PAOS, but being narrower, with fewer to consider. Pilots will continue to have to calculate their take-off procedures in relation to these existing obstacles. As the start of the take-off run is in the same location as at present, this will not represent a more onerous situation.

East End Shortened Runway (240m inset THR): Rwy 25 PAOS Infringements



Source: MM

East End Shortened Runway (240m inset THR): Rwy 25 Cat 1 ILS OAS (Infringements not shown)



Mott MacDonald

Mott MacDonald House
8-10 Sydenham Road
Croydon
United Kingdom

T +44 (0)20 8774 2000
F +44 (0)20 8681 5706
W www.mottmac.com

Client	Rev	Date	Drawn	Description	Ch'k'd	App'd	Title	Drawn	
							Runway 25 Code 3 ILS Obstacle Assessment Surface	Checked	
								Approved	
								Scale at A3 1:2500	
							Drawing Number MMD-302141-C-DR-00-XX-0016	Status PRE	Rev P1

P:\Croydon\VGY\ITA\1_PROJECTS\302141 Project Ark\F - Drawings\02 Outgoing Drawings\Issued\DWG\MMD-302141-C-DR-00-XX-0016- Code 3 OAS.dwg Jan 19, 2012 - 3:51PM coo53624

Source: MM

East End Shortened Runway (240m inset THR): Rwy 25 Non-Instrument (Visual) AOS Infringements

[redacted] with the optional project only. It should not be relied upon by any other party or used for any other purpose.
We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

Mott MacDonald

Mott MacDonald House
8-10 Sydenham Road
Croydon
United Kingdom

T +44 (0)20 8774 2000
F +44 (0)20 8681 5706
W www.mottmac.com

Client

Rev	Date		Description	Ch'k'd	App'd

Title

Runway 25 Approach Surface
Code 2B Visual Runway
Infringements

Drawn
Checked
Approved
Scale at A3
12500

Drawing Number
MMD-302141-C-DR-00-XX-0011

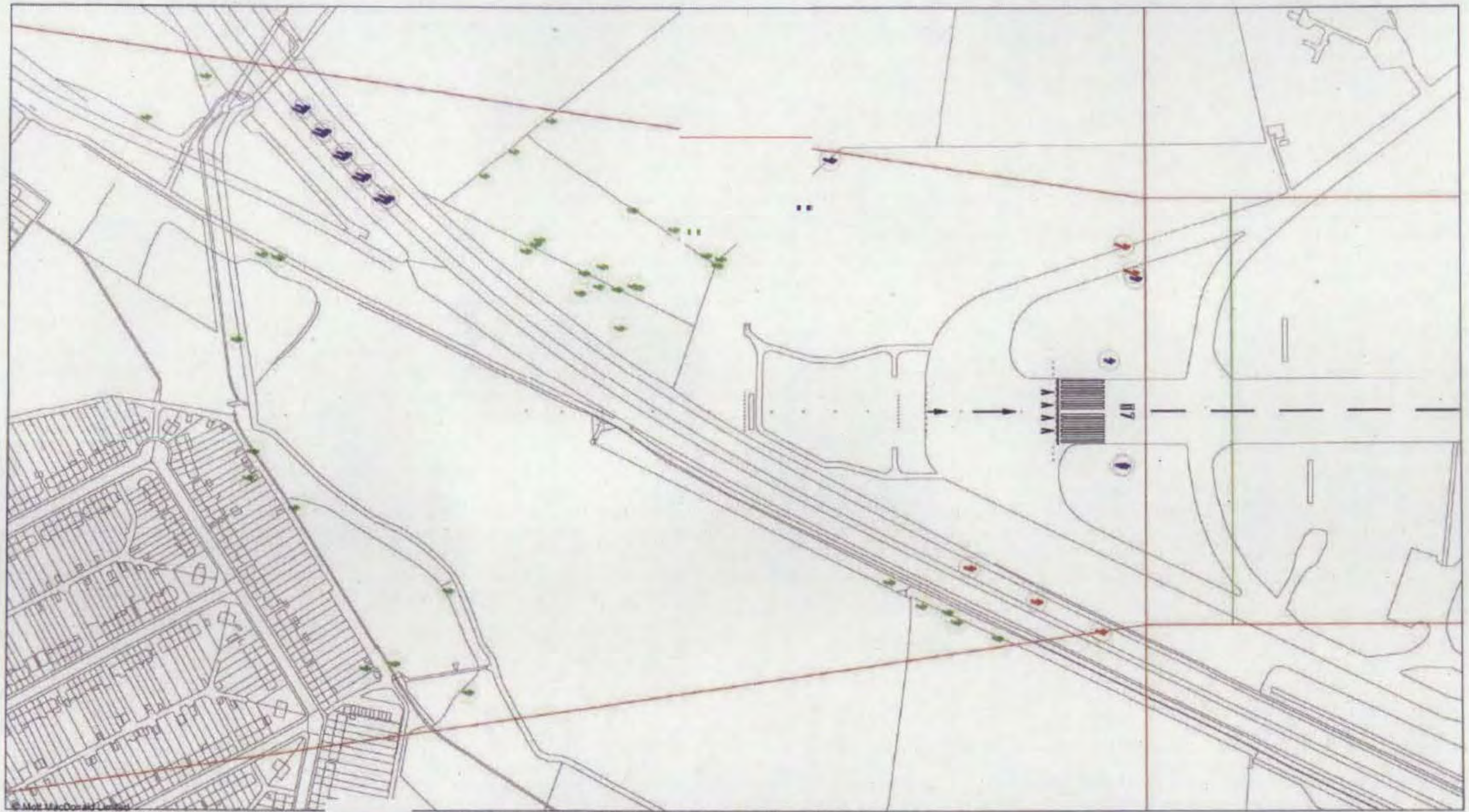
Status
PRE

Rev
P1

P:\Croydon\MVO\TA\1 PROJECTS\302141 Project Ark\F Drawings\02 Outline Drawings\Issued\DWG\MMD-302141-C-DR-00-XX-0011 Code 2 3

Source: MM

West End Sh:>rtened Runway (214m inset THR): Rwy 07 NPAOS Infringements



Mott MacDonald

Mon MacoonMcJ House
8-1() Sydetlham RoW
CfOydon
Urjted Kingdom

T +44 (0)20 877-*2000
F . 4 (0)20S8SI 6706
W WNN.

Clie-ll

Rev	Date	Drawn	Description	Chd	AW'd

Title: Runway 07 Approach Surface Code 213 Instrument Runway Infringements

Drawn	
Checked	
Approved	
Scale at A3	1:2500

Number: MMD-302141-C-DR-00-XX-0007

Status	Rev
PRE	P1

Source: MM

[redacted]

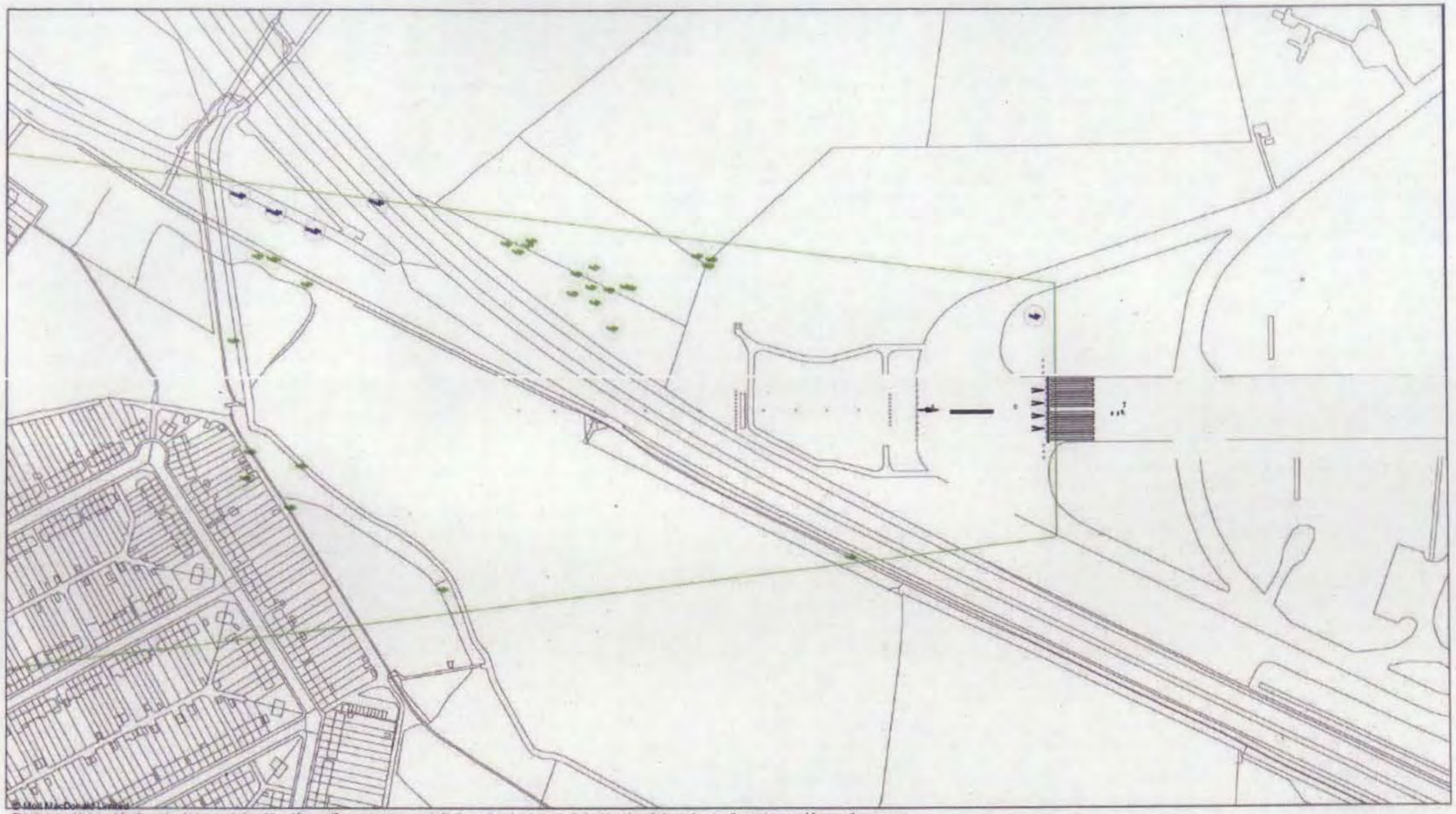
East End Sh:>rtened Runway: Rwy 07 TOCS Infringements

Mo4t MacDonald Moel M cOont Id HoiM · -(0)20 a77· 2000 CO.,... United Kingdom · www.mottmac.com	Client	Runway 07 Take-off Climb Surface Code 2/3 Instrument Runway Infringements Scale A:1 1:2500 Drawing Number MMD-302141-C-DR-00-XX-0009 · PRE · P1

P:\Croydon\VOY\TA\I PROJECTS\302111 PIOIte\ MR\F - 0ff,_ f\I0'02 01 K0/ e 0I&WhM'ISS\ld\DWGWM\ 302141c.DA.OO-XX.0009 COde 2 3

Soutee: MM

West End Shortened Runway: Rwy 25 TOCS Infringements



MCitt MacDonald
Mott MacDonald House
8-10 Sydenham Road
Croydon
United Kingdom
T +44 (0)20 8774 2000
F +44(0)20 8681 5706
W www.mottmac.com

Client

Rev	Date	Drawn	Description	Ch'k'd	App'd

Title: Runway 25 Take-off Climb Surface Code 2/3 Instrument Runway Infringements

Drawn [redacted]
Checked
Approved
Scale @A3 1:2500

Drawing Number: MMD-302141 C DR-QO.XX 0008

Status: PRE | Rev: P1

Project Ark

Source: MM