JACOBS

Leigh | Fisher

14. Operational Efficiency:

Phasing and Facilities Review

Airports Commission

18 June 2015

JACOBS

Document Control Sheet

BPP 04 F8
Version 16; October 2013

Project:	Airport Operations, Logistics and Engineering Support		
Client:	Airports Commission	Project No:	B1988000
Document title:	14. Operational Efficiency: Phasing and Facilities Review Update		
Ref. No:	AC/14/01		

JACOBS

Contents

1 Introduction

This report addresses comments related to Appraisal Framework Module 14: Operational Efficiency raised by respondents to consultation. The report should be read in conjunction with the consultation materials and especially the following *Appraisal Framework Module 14. Operational Efficiency* reports:

- *Ground Infrastructure: Gatwick Airport Second Runway*
- *Ground Infrastructure: Heathrow Airport Extended Northern Runway*
- *Ground Infrastructure: Heathrow Airport Northwest Runway*

A summary of consultation comments and observations are provided in Appendix B, with Sections 2, 3 and 4 presenting detailed discussions on specific areas of comment.

Section 2 considers the air transport movement (ATM) capacity of each of the three schemes and includes observations against the consultation comments that addressed this aspect of the schemes.

Section 3 considers the revised phasing proposed by Gatwick Airport Limited (GAL) for the construction of its Second Runway (2R) scheme.

Section 4 relates to each of the three proposals and assesses whether the scope of each scheme could be reduced and the operational consequences of such a reduction. This report discusses the potential for a reduction in scope of each proposal's ground infrastructure. The consequential effect on capital expenditure, operational expenditure and non-aeronautical revenue are described in the *13. Cost and Commercial Viability: Reduced Scope Scenarios Costs* and *13. Cost and Commercial Viability: Cost and Revenue Identification Update* reports. Each of the three schemes is discussed: Gatwick Airport 2R, Heathrow Airport Extended Northern Runway (ENR) and Heathrow Airport Northwest Runway (NWR).

Supporting information is provided in Appendix C.

2 Capacity

This section considers the capacity of each scheme in the light of comments made during consultation. It sets out the background and context of airport capacity in Section 2.1 and subsequently considers the comments made in relation to capacity in Section 2.2. Conclusions with respect to the capacities stated by the promoters are presented in Section 2.3.

Airport capacity is not an absolute value, but depends upon a number of factors. In particular, capacity depends upon the airlines' tolerance of congestion and delay, and the airport operator's aspirations for resilience and reliability.

The capacity of an airport system is governed by the lowest rate at any stage of the processing of passengers, bags or aircraft through the system. For the purpose of this assessment it is assumed that all passenger and bag processes are optimised such that the constraining capacity is the movement of aircraft around the airfield. It is also assumed that the movement of aircraft through airspace does not present a constraint. Therefore, the processes considered are:

- *Landing and take-off, i.e. use of the runways.*
- *Taxiing between runway and apron, i.e. use of the taxiway network.*
- *Turning around on stand, i.e. use of the aprons.*

To achieve maximum capacity, an element of aircraft queuing is necessary as this means that the next available slot is used immediately with no capacity wasted between aircraft movements[1]. However, this queuing causes delay. Therefore, the airfield system represents a balance between capacity and delay, with capacity declared at a throughput that can be accommodated with a tolerable delay within acceptable resilience and reliability parameters.

The capacities of each of the three process elements are governed by a number of different parameters, which, amongst others, include:

- *Runway: mix of aircraft types (i.e. light, medium or heavy).*
- *Taxiway network: geometric layout including taxiway widths (which govern the size of aircraft able to use individual taxiways) as well as the configuration and availability of alternative taxi paths permitting flexibility of use and ability to manage congestion.*
- *Aprons: number and distribution of sizes relative to the mix of demand; time of occupation (i.e. turn-around time).*

Process element capacity is measured on an hourly basis, but airport "capacity" is conventionally stated as an annual value. Whilst hourly movements could be either empirically observed or simulated, both to good degrees of repeatability, the extrapolation into annual throughput rates depends upon a number of external factors such that no definitive relationship exists. Throughout this report "capacity" is used to relate to the maximum hourly rate reasonably achievable from efficient

[1] For example a queue of aircraft at a runway entry hold-point ensures that the next aircraft can line-up immediately on departure of the preceding aircraft. In theory aircraft could be delivered to the runway "just-in-time", but that would necessitate aircraft being spaced further apart on the taxiway, which would likely increase land-take and may not guarantee that the next aircraft was immediately ready for departure.

use of the ground infrastructure and “throughput” is used to relate to the reasonably achievable daily or annual movement rates.

2.1 Airport Capacity

This section considers firstly runway capacity, subsequently apron capacity, and finally the taxiway network initially on an hourly basis and then projected to an achievable throughput over a year. All ATM values stated are rounded and are indicative of the scale of capacity: a full dynamic simulation would be required to define capacity more accurately.

2.1.1 Runway System

The maximum capacity of a single runway operated in mixed mode is around 60 movements per hour. This rate is at the high end of achievement and requires all other processes to be optimised. Practically it cannot be sustained (as the accumulated delays would likely become unacceptable and “fire breaks”[2] are provided at periods through the day to permit the release of delays). Consequently, the practical average capacity over an operational day for such a single runway is likely to be around 50 ATMs/hour[3]. Assuming 17 operational hours per day for 365 days per year, the theoretical annual capacity would be around 300,000 ATM. In practice, such a high use of theoretical capacity is not achieved and would not be expected to deliver an operation that exhibited acceptable levels of resilience and reliability. Therefore, taking into account external factors such as weather and air traffic control, and resilience and reliability aspirations, the achievable annual throughput is between circa 250,000 and 300,000 ATMs.

The two independent, mixed mode runways proposed at Gatwick Airport could therefore accommodate an annual throughput of between 500,000 and 600,000 ATMs[4]. The capacity stated by GAL of 560,000 ATM per annum (pa) lies towards the higher end of this range, but is considered reasonable given GAL’s demonstrated ability to operate the existing single runway at a high level of utilisation and the nature of the operation, dominated by short-haul low cost movements, facilitating a high utilisation of available capacity.

Similarly, the three independent, mixed mode runways proposed at Heathrow Airport by Heathrow Airport Ltd (HAL), could accommodate an annual throughput of between 750,000 and 900,000 ATMs[5]. The capacity stated by HAL, of 740,000 ATM pa, lies at the low end of this range. This reflects the greater proportion of larger/heavier aircraft and the long-haul/hub operation which makes maximal use of available capacity more difficult to achieve and HAL’s aspiration to enhance resilience and reliability.

Heathrow Hub’s (HH) proposed extended northern runway (ENR) at Heathrow Airport does not provide two northern runways that could be operated independently in mixed mode. Rather they would be operated independently in segregated mode. A single runway used in segregated mode typically delivers a lower capacity than a mixed mode runway. Used exclusively for either arrivals or departures the gap between successive movements cannot be used efficiently. Therefore the capacity

[2] Periods during which available capacity is declared below theoretical capacity.
[3] Over time, the reliably achievable hourly rate has increased as technology has improved and airport operations have become more efficient. It is reasonable to assume that this trend will continue, although with reducing scope for further efficiencies.
[4] Being two times 250,000 and 300,000 respectively.
[5] Being three times 250,000 and 300,000 respectively.

is reduced to around 45 ATMs/hour from the above 50 ATMs/hour[6]. Therefore, as above, taking into account external factors, the achievable annual capacity is between circa 220,000 and 280,000 ATMs.

Therefore, HH's proposal, operating two independent segregated mode runways and one independent mixed mode runway over the same annual periods, could provide around 850,000 ATMs per annum (pa) [7] as a theoretical maximum, but between 700,000[8] and 850,000 ATMs pa as a practical range. As for HAL above, the capacity stated by HH, of 700,000, lies at the low end of this range reflecting the long-haul/hub operation which makes maximal use of available capacity more difficult to achieve, the same aspiration to enhance resilience and reliability, and HH's additional proposal to alternate movements between runways to provide enhanced noise respite.

All three options could accommodate a greater annual throughput if the number of operational hours per day were increased. The above assumes a typical 17 hour operational day (06:00 to 23:00), with no allowance for "night time" movements. Any such allowance would apply equally to all options and be dependent upon other factors, notably permitted night time noise impacts.

In passing it is worth noting that Gatwick Airport, with 255,000 ATMs in 2014, and Heathrow Airport, capped at 480,000 ATMs pa, deliver world leading runway utilisation rates being respectively the busiest one and two runway airports in the world as shown in Figure 2-1[9].

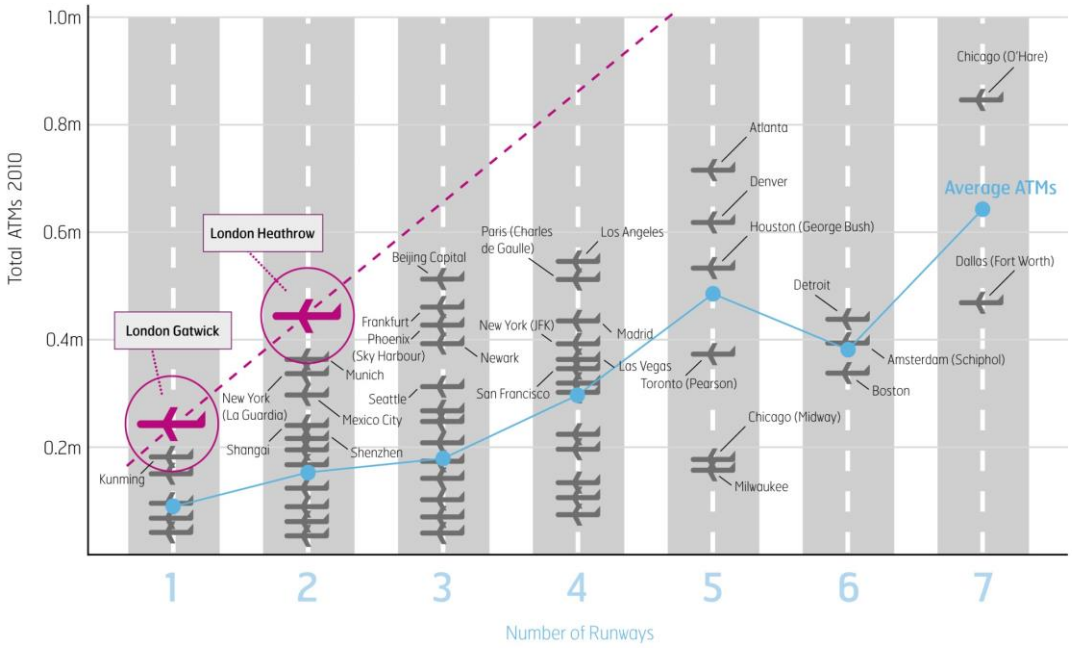

Figure 2-1: Air Transport Movements at Significant Airports, 2010 (Source: NATS)

[6] For example, arriving aircraft are required to be separated by defined distances to permit the wake vortex from the leading aircraft to have dissipated sufficiently for following aircraft not to be adversely affected. A runway used in mixed mode can sequence a departing aircraft between two such arrivals making effective use of the mandated separation. In contrast, a runway used solely for arrivals experiences the full capacity loss of this separation.
[7] Being roughly 2 x 280,000 (the two northern runways) plus 300,000 for the southern runway.
[8] Being roughly 2 x 220,000 plus 250,000.
[9] Note: Gatwick and Heathrow's latest traffic data for 2014 exceed the throughputs previously shown by NATS in 2010.

2.1.2 Apron System

Assuming an appropriate distribution of sizes reflecting demand, capacity of the apron system depends upon stand occupancy times which in turn depend upon turn-around times. Short-haul low-cost movements are scheduled to turn-around within circa 30 minutes and therefore each stand could, theoretically, be used twice within an hour. Conversely, long haul movements may occupy a stand for two or more hours. In simple terms therefore stand capacity can be related to hourly runway capacity with factors ranging from, typically, around one to over two times. Airports operating with fast turns require a number of stands around one times hourly runway capacity; slow turns require at least two times hourly runway capacity and often more. Spare capacity to increase resilience and reliability increases the number of stands required from these simple factors.

The 2R scheme, with a theoretical hourly capacity of around 100 ATM[10], would therefore require between 100 and 200 stands given the nature of the proposed Gatwick Airport operation. The ENR scheme, with an hourly capacity of around 140 ATM[11], would require around 280 stands, and NWR, with an hourly capacity of around 150 ATM[12], would require around 300 stands.

Each proposal delivers stand numbers of these scales and therefore the apron systems are not considered to be constraints to runway capacity.

2.1.3 Taxiway System

Taxiway system capacity is more complex to estimate and does not lend itself to the simple, high level approaches used above. Capacity is a factor of the ability of the network to provide sufficient lengths to queue aircraft whilst minimising taxi-path lengths, providing alternative routes to effectively manage congestion and to provide the minimum hindrance to manoeuvring aircraft. For the two Heathrow schemes in particular, but to a lesser degree for the Gatwick scheme also, capacity of the taxiway network is further influenced by the airline/terminal strategy driving the requirement for aircraft to taxi longer distances than minimum to/from the runway to the required terminal.

With reference to Sections 5.1 of the respective *Appraisal Framework Module 14 Operational Efficiency: Ground Infrastructure* reports, it is possible to make the following general observations of the proposed taxiway networks:

2R:

- *Runway entry points and associated taxiway queuing areas north and south of the proposed midfield terminal (including the current "Alpha Box") may cause congestion and delay during peak periods.*
- *The dual taxiway between the midfield terminal and its satellite may be congested at busy times.*

ENR:

- *The taxiways south of T5/T6 are likely to be congested given the close proximity of aircraft exiting (westerlies)/entering (easterlies) the southern runway and aircraft taxiing through the area.*

[10] Being two times 50 ATMs/hour.
[11] Being two times 45 ATMs/hour (the two northern runways) plus 50 for the southern runway.
[12] Being three times 50 ATMs/hour.

- *As an extension of this first constraint, the area north of T5/T6 presents a unique challenge given the proximity of aircraft (on westerlies for example) exiting the north-east runway to those queuing to enter the north-west runway and those taxiing through the area to access other terminals or the southern runway.*
- *The heaviest aircraft will be required to taxi to the southern runway which has longer declared distances than the two northern runways.*[13]
- *Aircraft taxiing to T4 will need to cross the Southern runway, as today.*

NWR:

- *The taxiways between the new northern runway (R3) and its associated T6 satellite could represent a capacity constraint. This could be reduced were the satellite and R3 largely operated as a single unit with limited taxiing to/from the remainder of the airfield.*
- *Similarly, the taxiway linking the T6 satellite to T6 could constrain capacity unless, again, R3 and its satellite were operated largely as a stand-alone unit.*
- *The taxiways north and south of T5/T6 are likely to be congested given the close proximity of aircraft exiting (westerlies)/entering (easterlies) the northern/southern runway and aircraft taxiing through the areas.*
- *Aircraft taxiing to T4 will need to cross the Southern runway, as today.*

On balance, it is reasonable to assume that the Gatwick 2R proposed taxiway network has sufficient capacity to accommodate the proposed throughput. For Heathrow it is reasonable to note that both proposals present similar capacity constraints, but that the degree of constraint is likely to be higher for the ENR scheme than NWR, given:

- *The concentration of movements in the area north of T5/T6.*
- *The lack of the option (available to the NWR scheme) to operate the additional runway and its satellite as a single unit minimising impact on the remainder of the airfield.*
- *The requirement for the heaviest aircraft from all terminals to use the southern runway rather than the nearest, most conveniently located runway*

2.2 Consultation Capacity Comments

Certain responses to consultation addressed aspects of the capacities of the three schemes. The following tables, ordered by commenting organisation, provide our observations on these comments.

Text in italics in the following tables has been directly quoted from the referenced sources.

[13] With reference to the *Appraisal Framework Module 14 Operational Efficiency: Ground Infrastructure: Heathrow Airport Extended Northern Runway* report, the proportion of departing aircraft that might use the southern runway due to restrictions on the northern runways could be between 3 and 10%.

Table 2-1: Gatwick Area Conservation Campaign

Scheme	Reference	Comment	Observation
2R	Paragraph 20, page (pg) 4	*20. A major operational problem at Gatwick is that the two existing terminals are on the north side of the existing runway while the new runway would be to the south. It is therefore proposed that the runways would operate in 'independent mixed mode' with each runway handling both arriving and departing aircraft. Aircraft using the new southern runway would use the new terminal between the runways, and would mainly use flight paths to the south. Aircraft using the existing runway would use the two existing terminals and would mainly follow flight paths to the north. [reference to 'A Second Runway for Gatwick GAL April 2014 page 27']*	The observation of allocation of movement to runway and terminal is correct. During busy times, the preferred allocation of movement to runway may have to be amended, with conflicts managed in airspace. However, this is not considered to materially affect the potentially achievable annual throughput rate.
2R	Paragraph 21, pg 4	*21. The Commission needs to note that with both runways handling arrivals and departures, there could be no scheme to provide daytime respite by alternating the use of the runways, as at Heathrow. [reference to 'A Second Runway for Gatwick GAL April 2014 page 27']*	The 2R scheme could be operated with alternation as currently observed at Heathrow. Were this to be the case, Gatwick would operate with two segregated mode runways with, with reference to Section 2.1 above, annual throughput rates of between 220,000 and 280,000 ATMs, i.e. between 440,000 and 560,000 in total.
2R	Paragraph 22, pg 5	*The proposed runway separation of 1,045m is only just greater than the minimum of 1,035m allowed for mixed mode operations by international safety regulations. [ref. to 'ICAO Annex 14 Vol 1'] Thus there would be frequent occasions when two aircraft approaching Gatwick would be side-by-side only one kilometre apart for the final ten or fifteen miles: this separation would require accurate navigation and might not be practicable in strong winds. This would reduce the resilience of Gatwick to bad weather delays.*	With reference to the consulation *Appraisal Framework Module 14. Operational Efficiency: Ground Infrastructure Gatwick Airport Second Runway* report, the proposed second runway does not present any significant issues in terms of safety and security and appears capable of being delivered against relevant safety and security standards. Compliant with the appropriate standards, the scheme should be able to deliver the assumed throughput rate within acceptable resilience parameters.

Scheme	Reference	Comment	Observation
2R	Paragraph 28, pg 5	*Aircraft having to cross an in-use runway is a well-known safety hazard. It also takes time, using up the equivalent to a take-off or landing slot. Yet this problem is created by the design of Gatwick with the two existing terminals on the 'wrong side' of the runway. The proposed procedure whereby flights headed north would be allocated to the existing terminals and flights to the south would be based on the new terminal would cause an operational problem for airlines such as easyJet which operate services both to the north and to the south: they would need to duplicate their facilities in both terminals.*	The proposed scheme includes end around taxiways (EATs) to facilitate north-south movement of aircraft avoiding the need to cross the active northern runway. The EATs should be provided in the first phase of development for this reason.

Table 2-2: Gatwick Airport Ltd

Scheme	Reference	Comment	Observation
NWR	Executive Summary, paragraph 6l, pg 9. Paragraphs 2.7-2.8, pg 22. Paragraph 2.65, pg 35. Paragraph 3.14, pg 39. Paragraphs 4.47-49, pg 56-57. Paragraph 4.55, pg 58. Paragraphs 4.709-472, pg 184-186.	*…in relation to capacity assessment:* • *correcting implausible assumptions on Heathrow issues such as ATM capacity, passengers per ATM, technical and operational limitations, and the assumed absence of planning and environmental constraints at that airport.* • *correcting claims by Heathrow that it could deliver 740,000 movements per year and 132-149 million passengers per year. Work undertaken by independent experts suggests that the incremental capacity generated by a third runway at Heathrow is likely to be some 60% of that generated by a second runway at*	With reference to the consultation *Appraisal Framework Module 14. Operational Efficiency: Ground Infrastructure Heathrow Airport North West Runway* report and the discussion in Section 2.1 above, the proposed infrastructure is considered reasonable to accommodate the assumed annual throughput rate.

Scheme	Reference	Comment	Observation
		Gatwick – and of the capacity claimed by Heathrow. The complex dependencies of integrating a three runway Heathrow into the London airspace system mean that a more realistic estimate would be only 645,000 movements and 118 million passengers.	
2R	Paragraph 2.40, pg 31	*We will continue to explore new operational practices and procedures that would reduce further the impact on the local community. We have already proposed that it would be appropriate to alternate the use of the runways for early morning arrivals and we see no need to increase night flying when the new runway first opens. This will limit the night time impact of the airport.*	As above, extended use of alternation would lower the achievable annual throughput to between 440,000 and 560,000 ATMs. However, during periods of the day when the runways are used below capacity, alternation could be adopted without loss of annual throughput.

Table 2-3: Heathrow Airport Ltd

Scheme	Reference	Comment	Observation
ENR	Section 5.16, pg 122 Paragraph 5.23.1, pg 128-131	*Our own work (see section 5.22.1* [5.23] *below) reveals that 700,000 ATMs per year from the ENR scheme can only be achieved with 2 hours of respite each day, which we consider to be unrealistic. Assuming a more realistic 8 hours of respite will reduce the number of ATMs achievable to 625,000 per year. This would broadly scale down the economic benefits of an extended northern runway by more than 10%.*	Within the respite modes of operation proposed by HH for the ENR scheme, the assumed annual throughput rate of 700,000 is at the high end of the likely achievable range. However, as noted in Section 2.1 above, the runway configuration alone could accommodate a greater annual throughput. In general we note that the ENR proposal presents unique constraints not reflected in the NWR option and therefore, it is reasonable to conclude that the NWR throughput rate is likely to be greater than that of the ENR scheme with all other parameters being held constant.

Table 2-4: Heathrow Hub Ltd/Runway Innovations Ltd

Scheme	Reference	Comment	Observation
ENR	Pages 12, 22 and 25	*However as the consultation assesses LHR---NWR on the basis of 740,000 ATM's, we have carried out further analysis and confirm that LHR---ENR can similarly provide this higher capacity in terms of runway flow rates, ground operations and stand capacity. [ref. to 'Ground Modelling Report in Appendix A-2']* *We observe that both LHR---ENR and LHR---NWR are expected to have broadly the same capacity since both operate the airport at maximum throughput with one runway for arrivals, one for departure and one for both.*	With reference to Section 2.1 and Table 2-3 we agree that the ENR scheme could achieve an annual throughput rate greater than the assumed 700,000 ATMs, however, such an increase would be achieved at the expense of the proposed pattern of noise respite. We also observe that were the ENR throughput rate increased, it is reasonable to also assume that the NWR scheme could be similarly increased. Therefore, as above, it is reasonable to conclude that the NWR throughput rate is likely to be greater than that of the ENR scheme with all other parameters being held constant.

Table 2-5: Transport for London (TfL)

Scheme	Reference	Comment	Observation
All	Operational Efficiency Supplementary Note 14 Section 5	*An assessment has been made but it fails to consider that any initial improvement in resilience disappears as the airport fills up; with the situation returning to today's position within the medium term. No assessment of resilience for the period 2040 to 2050 when utilisation will be back in the 90 – 100%. It should be noted that IATA recommend utilisation of 70% for hub airports.*	We note that the 2R scheme is likely to be operating at around 90% of its theoretical annual capacity and ENR/NWR at around 80%. We note TfL's comment with respect to 70%; however we do not find these utilisation rates to be unreasonable. The nature of Gatwick's operation should permit a greater use of available theoretical capacity than Heathrow's, and the lower utilisation of theoretical capacity at Heathrow is reasonable in the context of its operation. For each scheme, it is reasonable to assume that the resilience and efficiency of operations will increase over time, such that these utilisations rates are appropriate as planning parameters at this stage.

Scheme	Reference	Comment	Observation
Heathrow	Operational Risk Supplementary Note 15 Paragraph 1.3	*The provision of an additional runway will initially increase the resilience of the airport as the available spare runway capacity will increase. However at Heathrow particularly, it is forecast that the additional runway capacity will be used up in the short to medium term and the level of runway resilience will return to the position Heathrow faces today; with one important change – an extra 280,000 flights. Hence runway resilience is one risk that is not mitigated for the long term. However Heathrow's current operational resilience is already lower than European competitors as can be seen in the level of delay and disruption which is frequently experienced.*	Observation as above.

2.3 Conclusion

The achievable annual throughput rates at Heathrow Airport are likely to be the circa 700,000 ATMs (ENR) and 740,000 ATMs (NWR) as stated by the promoters, within comparable and reasonable resilience and reliability parameters. For the same comparable and reasonable resilience and reliability parameters Gatwick Airport should achieve a higher throughput rate, circa 560,000 ATMs pa as stated by its promoter, given the different nature of the operation at Gatwick to that at Heathrow. The utilisation of theoretical capacity at Gatwick (circa 90%) is high, but is not considered unreasonable given the nature of the operation at Gatwick. It would not be reasonable to operate Heathrow at this level of utilisation of theoretical capacity, and the proposed usage, around 80%, is also considered reasonable.

A comparison of the annual throughput rates achievable by the ENR and NWR schemes is more nuanced than the comparison between Gatwick and Heathrow airports. The promoter's stated annual rate for the ENR scheme is in part constrained by the proposed alternation to increase noise respite. However, the ENR scheme presents airfield constraints not reflected in the NWR scheme. It is, therefore, reasonable to conclude that the NWR throughput rate is likely to be greater than that of the ENR scheme with all other parameters held constant. At the assessed throughput rates both Heathrow schemes would be expected to operate with a similar level of resilience. However, the lesser degree of flexibility available within the ENR taxiway and runway layout means that it would be more likely that it would be required to impinge upon its planned noise respite periods in order to maintain that level of resilience when operating at 700,000 ATMs, compared to an NWR scheme operating at 740,000 ATMs.

3 Gatwick 2R Phasing

3.1 Gatwick Airport Limited Proposed Amended Phasing

In response to consultation GAL proposed revised phasing of construction of its additional infrastructure compared to its original scheme. The proposed phasing also varies from that considered by the Airports Commission in its Consultation. The revised phasing brings forward elements of midfield terminal and its processing facilities. The revised phasing is as follows:

- *Phase 1: Part of the terminal and its pier*
  - *Midfield capacity: 15 million passengers per annum (mppa)*
  - *Airport capacity: 63 mppa*
- *Phase 2: Terminal is extended, pier completed and part of the satellite*
  - *Midfield capacity: 28 mppa*
  - *Airport capacity: 73 mppa*
- *Phase 3: Terminal and satellite further extended*
  - *Midfield capacity: 37 mppa*
  - *Airport capacity: 82 mppa*
- *Phase 4: Terminal and satellite completed*
  - *Midfield capacity: 50 mppa*
  - *Airport capacity: 95 mppa*

These phases of the new infrastructure are preceded by improvements to the existing North and South Terminals to make maximum use of the existing infrastructure. These works are predominantly internal improvements to increase today's terminal capacity, 21 mppa, to 22.5 mppa per terminal.

Table 3-1 shows the capacity and gross floor area (GFA) of each phase. These are compared with GAL's original submission and the phases as assessed by the Airports Commission.

	GAL Original		GAL Amended		Airports Commission	
Phase	**Capacity** (mppa)	**GFA** (m^2)	**Capacity** (mppa)	**GFA** (m^2)	**Capacity** (mppa)	**GFA** (m^2)
Existing	42	345,000	42	345,000	42	345,000
Improvements	45	386,000	45	371,000	45	371,000
Phase 1	63	408,000	63	461,000	60	487,000
Phase 2	73	525,000	73	598,000	75	598,000
Phase 3	82	636,000	82	686,000	95	768,000
Phase 4	95	791,000	95	768,000	-	-

Table 3-1: Overview of Phasing

The most notable change between GAL's original submission and the amended version relates to the first phase of development. Originally, GAL proposed to build part of the remote satellite, which would function as a remote departure lounge. With the amended phasing, GAL proposes to provide part of the midfield terminal building with a GFA of 60,000 m^2 and its pier with a GFA of 30,000 m^2, as shown in Figure 3-1.

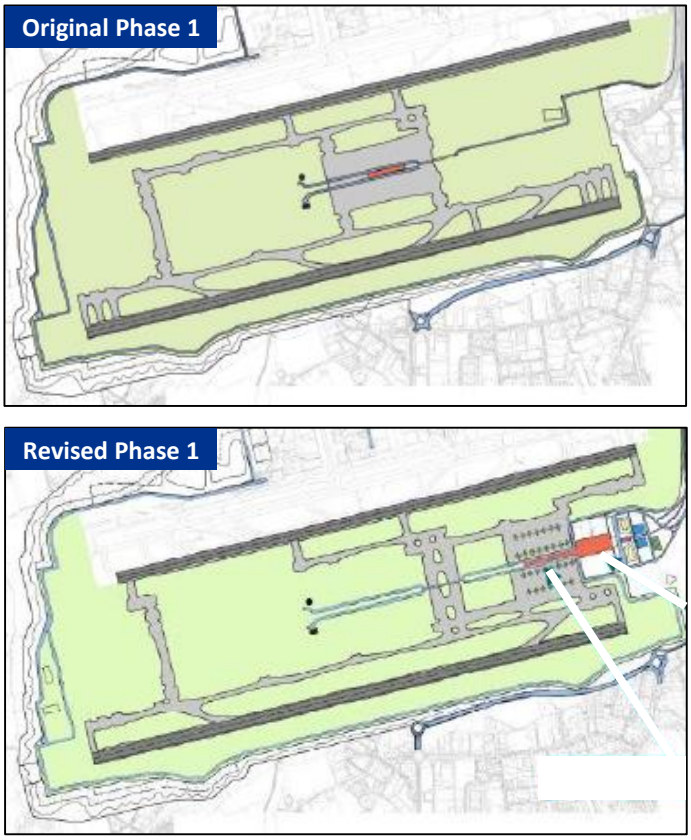

Figure 3-1: Comparison of GAL's Phase 1 in its Original Submission and in Response to Consultation

The amended phasing increases the size of the midfield building in the first phase compared to the original submission, and therefore the throughput placed upon the existing infrastructure would be expected to reduce. Nonetheless, during this phase, the existing North and South Terminals would be required to handle more passengers than their planned capacity (both terminals will have a capacity of around 22.5 mppa following the improvement works, but the South terminal would be required to handle up to 25 mppa, and the North up to 23 mppa). Both terminals could accommodate these levels of demand, and the revised phasing offers an improvement from the original proposal, however, operation at such levels implies either a reduction in passenger service standard or displacement of demand into off peak periods. Resilience and reliability may be negatively impacted during periods of operation above planned capacity.

To assess the potential impact on passenger service levels, with reference to the *Appraisal Framework Module 14. Operational Efficiency: Ground Infrastructure Gatwick Airport Second Runway* report, we considered a space planning factor that relates the gross floor area and design hour of an airport terminal. GAL's revised phasing reduces the space planning factor from today's circa 30 m^2 per design hour passenger (DHP) to around 27 m^2/DHP in this phase as shown against the same benchmark data used in Consultation in Figure 3-2 and Table 3-2 on the following page.

Across the airport, this represents an 11% reduction in service standard compared to today's passenger experience. In the new midfield terminal in isolation, the space planning factor would be around 22 m^2/DHP.

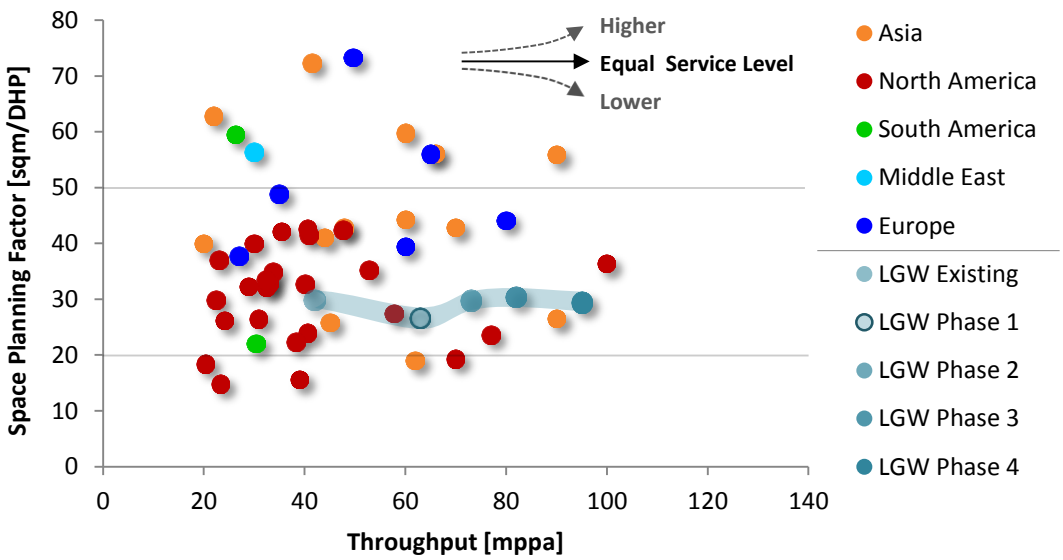

Figure 3-2: Space Planning Factor for Airports with more than 20 mppa, Showing All Phases of the Amended Scheme

Phase	Capacity (mppa)	GFA (m^2)	DHP	Space Planning Factor (m^2/DHP)
Existing	42	345,000	11,550	30
Improvements	45	371,000	13,200	28
Phase 1	63	461,000	17,325	27
Phase 2	73	598,000	20,075	30
Phase 3	82	686,000	22,550	30
Phase 4	95	768,000	26,125	29

Table 3-2: Amended Terminal Sizing and Space Allocation

GAL proposes to mitigate this apparent reduction in service standard through suggested process improvements and changes in customer behaviour, which compensate for this loss of space to enable continuing performance against the Airports Commission's objective of improving the passenger experience. As discussed in the *Appraisal Framework Module 14. Operational Efficiency: Ground Infrastructure Gatwick Airport Second Runway* report, the Airports Commission adopted a risk based approach to assess a phasing that broadly maintains the same space available per passenger throughout the lifetime of the scheme ensuring that the passenger experience is less reliant on the realisation of these proposed process improvements and would enhance the passenger experience, relative to today, should these benefits come to pass in future years. We also note that the size and phasing of the terminal and passenger processing infrastructure would ultimately be a commercial decision for the airport operator following constructive engagement with its airlines and the CAA.

4 Reduced Provision of Facilities

The following sections consider whether the scope of each proposal could be reduced and the operational consequences of such a reduction.

This assessment did not consider any potential impact on the Airports Commission's demand forecasts, only whether the infrastructure could be reduced from the schemes presented at consultation and provide adequate capacity for the forecast passenger and aircraft demand.

Sections 4.1 to 4.3 consider, by exception, the potential for elements of the schemes to be reduced. Subsequently Section 4.4 presents a summary of the identified scope reductions and notes those elements of the scope for which no material reduction was considered achievable whilst maintaining capacity.

Analyses setting out the potential cost efficiencies associated with the reductions in the provision of facilities for each scheme described in this report are set out in the *13. Cost and Commercial Viability: Reduced Scope Scenarios Costs* report.

4.1 Gatwick 2R

The 2R scheme is considered to be efficient in its design with only limited potential for reduction in scope. Particularly with reference to the discussion in Section 3, the major infrastructure elements are considered to operate at an efficient size for the type and nature of the anticipated operation.

The only identified potential reduction in infrastructure is to replace the proposed air traffic control (ATC) tower with a remote facility fulfilling the same role. Through careful design and collaboration with the stakeholders, it should be possible to provide effective air traffic control without a decrease in efficiency or safety.

4.2 Heathrow ENR

The ENR scheme is considered to be efficient in its design with only limited potential for reduction in scope. The only identified potential reduction in infrastructure is to reduce the size of T6.

The proposed T6 and its two satellites are currently designed at a space planning factor of 45 m^2/DHP, comparable to today's T5, delivering a good standard of passenger experience appropriate for a long-haul, hub operation. With reference to Figure 3-2 and the consultation *Appraisal Framework Module 14. Operational Efficiency: Ground Infrastructure Heathrow Airport Extended Northern Runway* report, T6 could be defined with a lower space planning factor. Although this would reduce passenger experience for those passengers using T6, reduce its flexibility, reliability and resilience, and may not facilitate the forecast traffic in all demand scenarios, it is possible to consider such a reduction. The main processing building could be redesigned with careful consideration of the number of floors, the footprint of the building and the requirements for key passenger processing and back-office areas. With reference to Section 3, we would consider a terminal designed to operate at a space planning factor of 30 m^2/DHP, comparable to today's terminals at Gatwick Airport, as the lower end of space provision for a major international airport terminal, but appropriate for and potentially more aligned with the business case requirements of a low cost carrier, short-haul, point-to-point operation. To illustrate

the reduction in passenger experience, Appendix B presents a comparison of a stylised passenger terminal operated at 30 and 45 m^2/DHP.

4.3 Heathrow NWR

The NWR scheme offers some potential sources of scope reduction. These relate to the size of T6, as for the ENR scheme, the removal of the ATC tower, as for the 2R scheme, and opportunities with respect to land acquisition.

As for the ENR scheme above, the proposed T6 and its satellite are designed at a space planning factor of 45 m^2/DHP, but could be considered at a space planning factor of 30 m^2/DHP.

Similarly, as for the 2R scheme above, the proposed ATC tower could be replaced with a remote facility fulfilling the same role.

The final scope reduction identified would consider acquiring only the minimum land necessary for the operation of the scheme - the layout and land acquisition requirement of the NWR scheme would be comparable with the layout and acquisition requirement of the ENR scheme. Following a similar approach to the ENR scheme, this scope reduction would implicitly assume that other parties would develop ancillary operations (for example, maintenance hangars, cargo facilities), but that the acquisition of the land necessary for these developments would not be an element of the NWR scheme.

4.4 Summary of Scope Reductions

Scope Element	Reduction in Project Scope		
	Gatwick 2R	ENR	NWR
Enabling works and demolitions	No material opportunity for reduction as required for the scheme.	No material opportunity for reduction as required for the scheme.	No material opportunity for reduction as required for the scheme.
Runway, taxiway and aprons	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme and airfield.	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme and airfield.	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme and airfield.
Stands	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme and airfield.	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme and airfield.	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme and airfield.
Airfield instrumentation	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme and airfield.	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme and airfield.	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme and airfield.
Air traffic control tower	Could be removed and replaced by a remote control room.	Not included within the scheme.	Could be removed and replaced by a remote control room.
Other airfield ancillary works	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme and airfield.	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme and airfield.	With respect to a reduced potential land acquisition, the extent of land prepared for third-party users would be reduced. No other material opportunities for reduction considered appropriate as scope provided is necessary for the functionality of the scheme and airfield.
Terminal and satellite	No material opportunity for reduction beyond existing size without significant detrimental impact on passenger service standards and operations.	Scope for reduction in size to provide a level of passenger service, as measured by the space planning factor, equivalent to the Gatwick Airport Second Runway scheme. Although the satellites are defined to a higher service standard than the 2R scheme, the greater width and functionality is considered to be required within this Heathrow scheme, therefore no scope for reduction in size of the satellites.	Scope for reduction in size to provide a level of passenger service, as measured by the space planning factor, equivalent to the Gatwick Airport Second Runway scheme. Although the satellite is defined to a higher service standard than the 2R scheme, the greater width and functionality is considered to be required within this Heathrow scheme, therefore no scope for reduction in size of the satellite.

Scope Element	Reduction in Project Scope		
	Gatwick 2R	ENR	NWR
Fixed links, nodes and boarding bridges	Even in the absence of boarding bridges, fixed links and nodes are required to enable passengers to access the apron level from the terminal. Although the number of contact stands served by boarding bridges could be reduced – in extremis to zero – such a reduction is considered to have a significant detrimental impact on passenger service. No reduction has therefore been considered.	Even in the absence of boarding bridges, fixed links and nodes are required to enable passengers to access the apron level from the terminal. Although the number of contact stands served by boarding bridges could be reduced such a reduction is considered to have a significant detrimental impact on passenger service. No reduction has therefore been considered.	Even in the absence of boarding bridges, fixed links and nodes are required to enable passengers to access the apron level from the terminal. Although the number of contact stands served by boarding bridges could be reduced such a reduction is considered to have a significant detrimental impact on passenger service. No reduction has therefore been considered.
Airside and landside APM	The removal of the APM would require replacement with a significant bussing operation which does not appear to be operationally practical and may have a negative air quality impact. No reduction has therefore been considered.	The removal of the APM would require replacement with a significant bussing operation which does not appear to be operationally practical and may have a negative air quality impact. No reduction has therefore been considered.	The removal of the APM would require replacement with a significant bussing operation which does not appear to be operationally practical and may have a negative air quality impact. No reduction has therefore been considered.
Car parks	No material opportunity for reduction as required for the surface access strategy.	No material opportunity for reduction as required for the surface access strategy.	No material opportunity for reduction as required for the surface access strategy.
Power and utilities	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme.	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme.	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme.
Baggage handling system	No material opportunity for reduction as scope provided is necessary for the functionality of the scheme.	A substantial reduction in provision of the proposed baggage handling system is not considered to be feasible given the distance between T6 and its satellites and that its reduction would necessitate a vehicle solution with potentially significant negative air quality impact. No reduction has therefore been considered.	A substantial reduction in provision of the proposed baggage handling system is not considered to be feasible given the distance between T6 and its satellite and that its reduction would necessitate a vehicle solution with potentially significant negative air quality impact. No reduction has therefore been considered.

Scope Element	Reduction in Project Scope		
	Gatwick 2R	ENR	NWR
Land	No material opportunity for reduction without affecting the surface car parks. As these would have to be provided as multi-storey car parks, which are significantly more expensive, there is no business case for a reduction in land acquisition.	No scope for reduction as land take is already minimised.	Land take could be reduced to a potential minimum. This may potentially represent between 15 and 20% of the total land acquisition required.
Environment and community	No material opportunity for reduction as essential to the scheme.	No material opportunity for reduction as essential to the scheme.	No material opportunity for reduction as essential to the scheme.

Table 4-1 Summary Scope Reductions

Appendix A Glossary

2R	Gatwick Airport Second Runway
APM	Automatic people mover
ATC	Air traffic control
ATM	Air transport movement
BoS	Back of shop
DHP	Design hour passenger(s)
EAT	End around taxiway
ENR	Heathrow Airport Extended Northern Runway
GAL	Gatwick Airport Ltd
GFA	Gross floor area
HAL	Heathrow Airport Ltd
HH	Heathrow Hub
MCT	Minimum connection time
mppa	million passengers per annum
NWR	Heathrow Airport Northwest Runway
pa	Per annum
pg	Page
TfL	Transport for London

Appendix B Consultation Comments

The following tables sets out consultation comments, by scheme, with corresponding observation. In most cases the tables presents a summary of the individual comment, which may have been discussed in more detail in the individual consultation response. The tables do not include consultation comments addressed in the main body of this report.

Table B-1: Gatwick 2R

Source	Comment	Observation
EasyJet	EasyJet supports the revised phasing plan at Gatwick but is concerned whether there remains adequate contact (pier served) stands to cater for peak periods.	The 2R proposal comprises a significant number of contact stands, and in particular almost all wide-body stands are contact (notably to the new satellite). However, the narrow body stands are significantly non-contact, with around half of the new stands (around the new midfield terminal) remote. This is not a dissimilar proportion to Gatwick's current configuration. It is not possible to be exact as a number of stands can be used in multi aircraft configurations, however, it can be observed that Gatwick currently provides a significant number of remote stands. For the scheme as proposed, it is inevitable that operations during peak periods will depend upon use of the remote stands. This would reduce service standards for those passengers and increase operational cost for the airline. However, the proposed layout, and in particular the separation between the two runway centrelines, limits the scope for infrastructure between the runways. With reference to the *Appraisal Framework Module 14. Operational Efficiency Ground Infrastructure: Gatwick Airport Second Runway* report, the proposed infrastructure is considered to be reasonable and sufficient, however it is not overly flexible, and could not readily provide additional contact stands. Therefore, we would tend to agree with easyJet's concern, but note that there is not a simple solution given the spatial constraints.
Gatwick Airport Ltd	Gatwick disagrees with the Commission comment that Gatwick's ability to accommodate more Code F aircraft is more limited. It is not necessary for all taxiways to be Code F compliant to meet forecast demand. Gatwick can accommodate similar	The observation at consultation was that the 2R proposal offers reduced flexibility to accommodate Code F aircraft. There are two aspects to this: the number of stands and the layout of the taxiway network. We note that the 2R proposal includes layout variants that deliver a greater number of Code F stands with a taxiway network that facilitates freer movement by such aircraft, however we also note that the pier to the satellite is relatively narrow and therefore, even if the airfield could accommodate more Code F movement, it is uncertain whether the greater number could be accommodated whilst maintaining an

Source	Comment	Observation
	share of Code F aircraft as Heathrow without significant congestion.	acceptable passenger service standard.
Gatwick Airport Ltd	There are inconsistencies in the Commission's assessment of minimum connection times and the Commission has misunderstood proposals for self-connecting passengers.	It is difficult to determine a connection time with precision. However we note a key difference in assessment between ours and each of the promoters. The promoters have considered minimum connection times (MCTs) which could potentially be achieved without queues or delay to passage. Our estimates are perhaps more pragmatic and take into account the less than perfect conditions of normal operations. An airline selling through tickets would wish to base its inter-flight minimum time on a practically achievable MCT to reduce the risk of a passenger missing his/her onward flight. Therefore, whilst accepting the potential for the fine detail of the calculation to vary, we find our assessment to be reasonably reflective of a practical MCT.
Heathrow Airport Ltd	The jet blast area of 100m is insufficient and unsafe. 300m is more appropriate, which would necessitate either shortening the runway (and create additional congestion issues) or increasing land take.	Jet blast from take-off thrust is around 300m, however, breakaway thrust jet blast extends for around 100m against which the assessment of the proposed end around taxiways was undertaken. Operation of the EATS will require careful management, however the proposed layout is considered reasonable at this stage of design development.
Heathrow Airport Ltd	There is an inconsistency in Gatwick's declared terminal areas which is based on unrealistic check-in improvements. We recommend that either the space planning factor either reduces or the area of the midfield terminal needs to increase.	The proposed terminals were not assessed in detail at the level of individual process element. The terminals were assessed on the basis of the space planning factor across the total gross floor area. Although this approach has its limitations, it is a convenient method for assessing the overall acceptability of a terminal. The methodology establishes whether the total gross floor area provides the potential for an operation of the scale and nature represented by the spatial planning factor and implicitly assumes that the provided floor area can be configured into efficient process elements. With reference to the *Appraisal Framework Module 14. Operational Efficiency Ground Infrastructure: Gatwick Airport Second Runway* report, and Section 3 and Appendix C of this report, the proposed terminal at Gatwick, and indeed at Heathrow, reflects the nature and requirements of the operation. This will be subject to detailed design and at that time individual elements would likely evolve from the current proposed layouts. The terminal will be subject to detailed design definition and development, but there is no reason to assume that it could not be configured within the proposed floor area to deliver an acceptable process capacity.
Heathrow Airport Ltd	There are much greater risks across the scenarios that Gatwick will not make full use of its runways. This will	The pattern of demand over a day and indeed over a year inevitably means that capacity is provided to accommodate the peak which is under-utilised during off peak periods. This is the case with all airports. The analysis assessed delivery of additional infrastructure as

Source	Comment	Observation
	mean peak periods will still be very busy but the operational efficiency reports do not allow for construction of the terminal being driven by the peak periods.	required to meet demand. The consequence of this supply against demand dynamic is reflected through the financial analysis which balances the cost of provision of that infrastructure against lower utilisation.
Heathrow Airport Ltd	We recommend that the Commission take account of the need to relocate the existing car parking in the analysis of the duration of this phase of the proposed works	This requirement, along with all construction sequencing requirements for each of the schemes, would be addressed during detailed design and construction planning. Each of the schemes presents their own challenges none of which should be underestimated. However, we did not identify any unique challenge, to any scheme, which could not be realistically expected to be addressed during detailed design.
Heathrow Airport Ltd	GAL's phasing plan makes no reference to when the new control tower will be operational. This may affect the runway opening date.	This requirement, along with all construction sequencing requirements for each of the schemes, would be addressed during detailed design and construction planning. Each of the schemes presents their own challenges none of which should be underestimated. However, we did not identify any unique challenge, to any scheme, which could not be realistically expected to be addressed during detailed design.

Table B-2: Heathrow ENR and NWR

Source	Comment	Observation
Gatwick Airport Ltd	The Commission should use computer simulation modelling of the taxiway networks at all three schemes as the Heathrow schemes will give rise to much greater congestion and taxi time variability.	All schemes would benefit from computer simulation to determine in greater detail the operational behaviour of the proposals. However we would note that it would be time consuming for the Commission to independently undertake such simulations for a number of reasons. Furthermore, for a model to be valid, it should be validated against current operations to ensure that the simulation appropriately models the current layout, operational rules and patterns of airline behaviours. This requires detailed information to be provided by the airport operator and its ATC provider. This simulation would be extended to include the new infrastructure. Both these processes are substantial undertakings requiring the close cooperation of airport management. We would note however, that such detailed simulation is unlikely to change the key headline conclusions reached from the high level analysis undertaken. We accept the limitations of the head line analysis, but we also note the limitations of computer simulation, particularly models that have been constructed without the detailed cooperation of airport management.
Gatwick Airport	Gatwick does not agree with the Commission's view that Heathrow can	It is a reasonable observation that Heathrow could not easily facilitate a low cost carrier operation model if such movements were included within the general operation of the

Source	Comment	Observation
Ltd	accommodate low cost carrier operations on any significant scale.	airport, i.e. operating from T2, T5 and probably also T4. However, it would appear that T6 could be operated as a standalone low cost facility with swift turn-arounds achieved from the adjacent runway. This scenario could be seen to be aligned with the reduced infrastructure scope discussed in Sections 4.2 and 4.3 of this report.

Table B-3: Heathrow NWR

Source	Comment	Observation
Gatwick Airport Ltd	HAL's new runways must adhere to separation minima and would therefore not be capable of fully independent operations. Modelling by DFS and ICF suggests this figure should be revised down to 580-680,000 ATMs.	HAL's proposed runway and its associated safety case are subject to CAA approval. With reference to the CAA's preliminary safety review (CAP 1215), the CAA notes that a number of design and operational parameters remain to be fully developed before a definitive statement can be reached. However, it is not unreasonable to consider that those elements could be developed to the satisfaction of the CAA permitting the runways to be used at the proposed annual throughput rates.
Heathrow Airport Ltd	The Commission has overstated Heathrow's minimum connection times by using overly cautious disembarkation assumptions, inconsistent walking speeds compared to Gatwick and overlooking Heathrow's efficiencies in transferring bags.	See comment above regarding MCT.
Heathrow Airport Ltd	We recommend that the Commission: acknowledges that Heathrow's NWR scheme has been designed to meet the requirements of ICAO Document 9643 SOIR.	With reference to the CAA's preliminary safety review (CAP 1215), the CAA notes that a number of design and operational parameters remain to be fully developed before a definitive statement can be reached. However, it is not unreasonable to consider that those elements could be developed to the satisfaction of the CAA.

Appendix C Illustration of Space Planning Factor

The space planning factor discussed in the *Appraisal Framework Module 14. Operational Efficiency: Ground Infrastructure* reports and used in this report varies between 30m^2/DHP and 45m^2/DHP for the three schemes. Both are appropriate standards for major international airports. 30m^2/DHP is representative of a terminal predominantly serving a low-cost, short-haul, point-to-point market, whereas 45m^2/DHP

There are two ways in which a lower space planning factor could be illustrated:

- *Showing an equal number of passengers in a smaller building; or*
- *Showing a higher number of passengers in the same building.*

To facilitate a side-by-side comparison, this illustration uses the latter of these two options.

Figures C-1 and C-2 on the following page illustrate a schematic departures level of a terminal building at these two levels of space provision at the design hour. Note that each dot represents 15 passengers. The check-in hall, passenger security and airside departures lounge are represented, with allowance for “back of shop” (BoS) facilities.

The BoS space is shown consistently between the two illustrations. In practice, the airport operator would balance the needs in each part of the terminal building to make best use of the available space within the building’s footprint. This might require BoS facilities to be displaced to reduce the impact on retail or food and beverages space. This would require that the displaced facilities be provided within other buildings on the airport site. However, by maintaining the same BoS space in both illustrations, the impact on passenger experience is more evident and does not inaccurately imply that the same area for BoS is not required.

With the increased number of design hour passenger in the 30 m^2/DHP illustration, the number of processors (check-in desks, security lanes) has increased, although the footprint of the building has not increased.

Within the same footprint, and with the increased number of processors required, it can be seen that the lower space planning factor increases the density of passengers. This reduces the space available for passengers and could reduce the overall passenger experience. In addition to passenger experience, reliability and resilience are also reduced as the terminal provides less space for use in unforeseen situations. Similarly, flexibility for varying future needs is also reduced. However, it is a matter of commercial judgement as to which level of density is appropriate for the nature and type of passenger handled by the terminal and the business cases of the airport operator and the airlines.

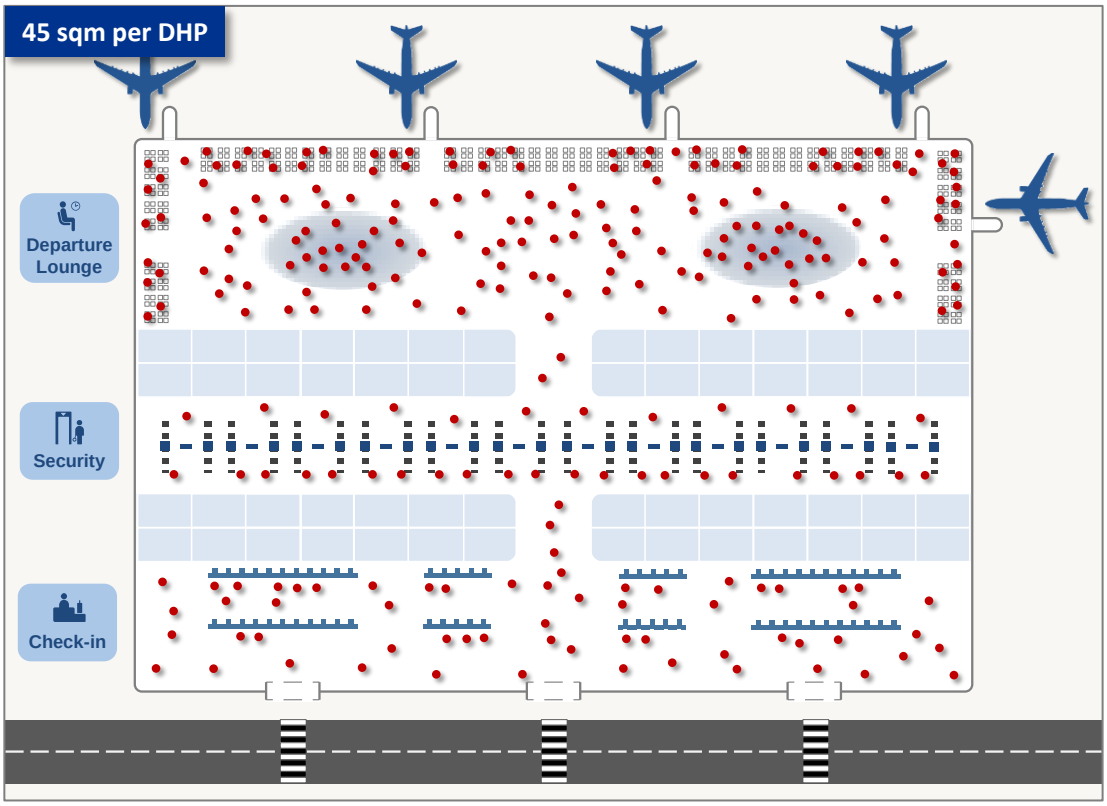

Figure C-1: Illustration of a terminal's departure level at 45m^2 per design hour passenger

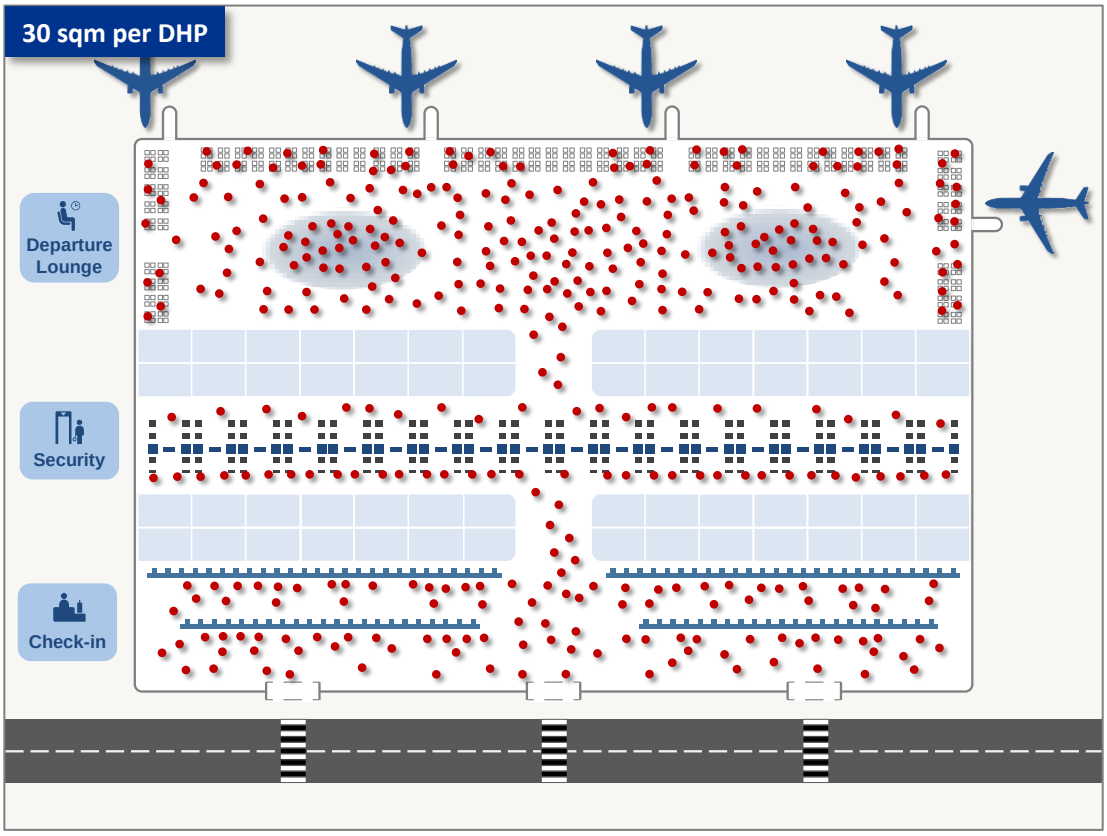

Figure C-2: Illustration of a terminal's departure level at 30m^2 per design hour passenger