Department for Transport

Reflecting changes in the relationship between UK air travel and its key drivers in the National Passenger Demand Model

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Introduction

In producing unconstrained forecasts of UK passenger demand the National Air Passenger Demand Model (NAPDM) draws on econometric analysis of the relationship between air travel and its key drivers in the past. A series of 19 econometric models have been estimated for different segments of the UK air travel market using data covering the past thirty years. The analysis has found that models implying constant relationships between demand and its key drivers (so-called constant elasticity models) perform well in explaining past changes in air travel. However, whilst it is reasonable to start from the premise that the drivers of air travel in the past will continue to drive air travel in the future, this can only be the starting point; it is also necessary to consider how the relationships observed in the past might change in the future.

This paper summarises the work the Department has been doing to review how potential changes in the relationship between UK air travel and its key drivers are reflected in the Department's aviation forecasts. It is divided into the following sections:

- Section 1 – Why do we expect the relationship between UK air travel and its key drivers to change?
- Section 2 - How have the impacts of maturity and market liberalisation been reflected in the past?
- Section 3 - Evidence of impact of maturity and market liberalisation in the market for UK Air Travel
- Section 4 - Proposed approach to reflecting change in the National Air Passenger Demand Model (NAPDM) in future
- Section 5 - Implications of the proposed approach for unconstrained UK passenger forecasts
- Section 6 – Potential further work

Section 1 - Why do we expect the relationship between UK air travel and its key drivers to change?

1.2 Many factors will affect the number of passengers using UK airports in future decades that cannot be forecast from past data. For example, an exogenous increase in the rate of migration might lead to UK air travel growing faster than would be projected from past trends. Changes in communications and aviation technology can be imagined that might in future drive air travel up or down. The historical effects of some such changes, such as the massive development of electronic communications since the mid 1990s, are subsumed in the estimated elasticities. However there are some ways in which it can be foreseen that the future will differ from the past and about which quantitative judgements can be made. This applies in particular to market maturity and to the effects of market liberalisation. These are addressed in turn below.

Market Maturity

1.3 As with most markets, we might expect there to be some product cycle in aviation demand, with rapid early demand growth giving way to steadier growth in later years. Various possible explanations for this phenomenon are suggested in the literature. One explanation is that, when a good is introduced to the market, it experiences a rapid growth phase as consumers gradually become more aware of it. The growth of demand then gradually slows and becomes less responsive to changes in its key drivers as the product becomes more familiar and widely available. An alternative explanation, more specific to the market for leisure air travel, is that as the number of flights people take increases they have less remaining time available for additional trips. This increases the value they place on their remaining leisure time and reduces the likelihood that they will respond to increases in their incomes by increasing their demand for leisure travel. The term 'market maturity' is often used to refer to the process by which the demand for a product becomes less responsive to its key drivers over time. In the literature, income elasticity of demand (YED) is often used as an indicator of the

maturity of a market. The YED is a measure of the responsiveness of the demand for a good or service to changes in the incomes of potential customers, expressed as the percentage change in demand associated with a 1% change in incomes, and will tend to decrease as markets become more mature.

1.4 Dr Anne Graham, currently at University of Westminster, has produced a significant amount of work in this area. She argues that product markets are often characterised as having a life cycle, which can be broadly decomposed into five stages. Table 1 below shows Graham's model of income elasticities for different markets, comparing the results against a five-stage model of the market maturation process.

Table 1: Product Life Cycle

Income elasticity value	Maturity/saturation stage
Constant and substantially greater than 1	Stage 1 (Full Immaturity)
Decreasing but still greater than 1	Stage 2
Approaching 1	Stage 3
1	Stage 4 (Full Maturity)
0	Stage 5 (Full Saturation)

1.5 As markets mature, and as demand becomes less responsive to changes in income levels, they move gradually from stage 1 through stages 2, 3 and 4 to stage 5. Early stages of market maturity are considered to exist when elasticity values are falling but are still larger than one. Graham defines 'Full' maturity as occurring when the income elasticity is unity, though this is not a universally accepted definition of maturity. Correspondingly 'full' saturation is defined to occur when the elasticity value is zero and an increase in income has no effect on demand.

1.6 This five stage model is highly stylised. It is not clear what Graham intended to happen between stage 4, maturity, and stage 5, saturation. We think it more helpful to think of maturity as being a process that continues to full market saturation.

1.7 In principle, market maturity affects the way demand responds to all of its key drivers (e.g. fares), not just income. In fact, it is standard practice in transport models to assume that travellers' response to fare changes

also decreases through time as their incomes increase and they place higher value on the time costs associated with travel.

Market liberalisation

1.8 One factor that has attracted particular attention in the literature as a potential source of bias in aviation forecasting is market liberalisation. Some commentators[1] have argued that estimates of the income elasticity of air travel derived from econometric analysis of historic data are often biased because they do not take account of the degree of market liberalisation over the estimation period. The argument is that YEDs estimated for markets that have experienced significant liberalisation, (e.g. the US domestic market) overstate the relationship between GDP and air travel growth, because the positive effect of liberalisation in the past on air travel demand has wrongly been attributed to income growth. On the other hand, these commentators argue, the elasticities estimated for the markets that are still heavily regulated (e.g. markets to/from the Asia-Pacific region) may be biased downwards, because demand growth has been suppressed by artificial restrictions on the availability of air travel options.

1.9 The potential for bias from this source in a given piece of econometric analysis is dependent on the extent to which the econometric models are specified to control for the effects of market liberalisation. Liberalisation manifests itself in a number of ways including, for example, lower fares, changes in service quality and an increase in the number of routes served. Fares are included as an explanatory variable in a number of the models underpinning the Department's aviation forecasts. Dummy variables are also used in some markets to account for the short term boost in demand that occurs when markets are further liberalised. The inclusion of fares and dummy variables in the models should largely prevent any bias in the elasticities we have estimated.

1.10 Liberalisation is a process that tends to happen gradually through time. In so far as market liberalisation has led us to estimate income elasticities that are biased upwards, the extent to which those elasticities will lead us to produce forecasts of air travel growth that are too high will depend on how closely income growth and liberalisation continue to be in future. Where the rate of liberalisation is expected to slow relative to income growth in future, we might choose to represent this as a gradual reduction in YEDs in future (i.e. in the same way as market maturity).

[1] See, for example Swan, W. (2008), "Forecasting Air Travel with Open Skies", presented at the joint EWCKOTI Conference, August 13-15, 2008 in East West Center, Honolulu

Section 2 - How have the impacts of maturity and market liberalisation been reflected in the past?

2.1 In the absence of quantified evidence on how maturity is likely to affect the way demand responds to its key drivers in future, market maturity has been reflected in the NAPDM via judgement-based adjustments to the passenger forecasts produced by the econometric models. For each of the sectors of the air travel market separately modelled, assumptions are made about the date from which market maturity will take affect and the scale of the impact on demand.

2.2 The formula for adjusting the forecast number of passengers in each segment to reflect maturity is given by the following formula:

$$Pax_t^* = \left(\frac{Pax_t}{Pax_{y0}} \right)^x \times Pax_t$$

- Where:
- Pax_t^* is the number of passengers in the segment after taking account of maturity,
- Pax_t is the unconstrained passenger forecast in year t obtained by applying the econometric model for the segment (i.e. before adjusting for maturity)
- y0 is the year from which maturity is applied.

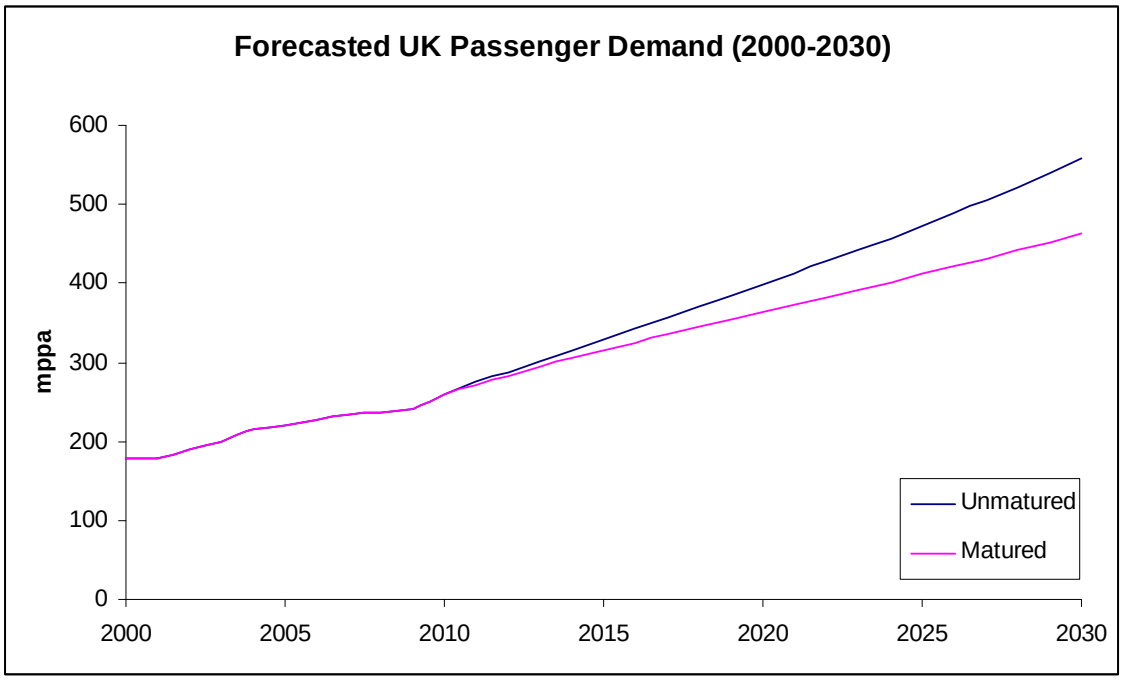
2.3 The values of ‘x’ and of ‘y0’ vary across the market segments and are shown in table 2.

Table 2: Previous Maturity Factors

Sector	x	Year applied from (y0)	
Short Haul Business	-0.1	2020	
Domestic Business	-0.2	2010	
Long Haul Business	-0.1	2020	
Short Haul Leisure	-0.3	2015	
Domestic Leisure	-0.5	2010	
Short Haul Charter	-0.7	2010	
Long Haul Leisure	-0.2	2020	
Long Haul Charter	-0.2	2020	

Figure 1 shows how the impact of the maturity adjustment on the unconstrained passenger forecasts became more significant through time. The maturity adjustments reduced the unconstrained forecasts at a national level by 4% in 2015 and 17% in 2030.

Figure 1: Effect of previous maturity factors on forecasting demand



2.4 The Domestic Leisure market was the most affected by the correction for maturity, with its traffic reduced by 48% in 2030. At the other end of the scale, international to international interliners were not affected at all by the maturity assumptions.

2.5 In previous forecasts no attempt was made to explicitly differentiate between the impacts of market maturity and market liberalisation.

Section 3 - Evidence of impact of maturity and market liberalisation in the market for UK Air Travel

DfT attempts to find evidence in historical data

3.1 As noted in the introduction to this paper, the econometric models underpinning the Department's national unconstrained passenger forecasts are estimated from data covering the past thirty years, and so reflect the most recent form of the relationship between demand and its key drivers. As part of the work to re-estimate these econometric models, we attempted to fit models with a variety of functional forms including some implying falling income elasticities of demand. We found that, consistently across the market segments, models which imply constant relationships between demand and its key drivers (i.e. constant elasticity models) perform better in explaining past changes in demand than models that imply that the responsiveness of demand to income and price changes is falling through time.

Advice from University of Westminster

3.2 Having been unsuccessful in our attempts to identify evidence of market maturity in historic data, we commissioned a team from the University of Westminster (UoW) to review the evidence on the maturity of air travel, both in the UK and elsewhere. The team were also asked to:

3.3 investigate how, if at all, other organisations producing aviation forecasts seek to reflect market maturity in their forecasts; and

3.4 provide recommendations on how the Department could modify the assumptions and/or forecasting tools to better reflect market maturity

3.5 The UoW team were not specifically asked also to consider market liberalisation as a factor that might justify our adjusting the elasticities estimated from historic data in producing forecasts. However it appears from their report that the project team considered the potential impact of

market liberalisation in developing recommendations on how the Department should reflect market maturity in its forecasts.

Evidence of maturity

3.6 The project team reached the following conclusions as to the empirical evidence on the impact of maturity on the market for air travel:

- Over the last few decades the air transport industry has experienced almost ceaseless growth, yet growth is forecast to remain strong for the foreseeable future, driven in large part by emerging market economies. Air passenger travel is increasing at a slowing rate but there is little in the empirical evidence at a global level suggesting the market for air travel is mature.
- Different segments of the UK market for air travel are exhibiting very different dynamics, such that while the UK short haul market (including domestic) appears to be exhibiting early signs of maturing, the long haul market does not.
- More generally, any conclusions that can be drawn from recent changes in the air travel market as to the existence of market maturity are subject to very high levels of uncertainty, and thus professional judgement is required in reflecting such evidence in aviation forecasting.

Recommendations

3.7 On the basis of their review of the empirical evidence UoW made the following recommendations:

- The current 'x-factor' approach to incorporating maturity effects should be abandoned. The complexity of the approach implies a spurious level of accuracy and the implicit effects on the way the forecasts respond to changes in key variables is also difficult to interpret.
- The existing approach should be replaced by an approach that involves direct adjustments to the income elasticities estimated for each market segment.
- Given the uncertainties, sensitivity tests should be used to illustrate the sensitivity of the forecasts to alternative assumptions about market maturity.

3.8 The project team went further by suggesting, for each of the market segments used by the Department in its latest published forecasts, assumptions about the year in which market maturity might take effect

and alternative income elasticities of demand to replace those estimated from historical data. These are summarised in table 3 below.

Table 3: Recommended income elasticities for use in sensitivity tests

Sector	YED Recommended	Year applied from
Short Haul Business	1.0 - ML 0.5 - LL	2015
Domestic Business	1.0 - ML 0.5 - LL	2010
Long Haul Business	1.0	2025
Short Haul Leisure	1.0 - ML 0.5 – LL	2015
Domestic Leisure	1.0 - ML 0.5 - LL	2010
Long Haul Leisure	1.0	2025

ML - More Likely Scenario LL - Less Likely Scenario

3.9 The report however left open questions such as whether the recommended YEDs should be imposed immediately in the year maturity is assumed to take effect or achieved by gradual reduction through time from the values estimated in the econometric analysis.

Section 4 - Proposed approach to reflecting impact of maturity and market liberalisation in the NAPDM

4.1 The advice from UoW confirmed that there is a lack of evidence on how market maturity and changes in the rate of market liberalisation are affecting air travel in the UK. In light of this lack of evidence we are following their advice and use sensitivity tests to reflect the significant uncertainty and to illustrate the sensitivity of our forecasts to a range of assumptions about how these factors will affect the UK air travel market in future.

4.2 We are also following UoW's advice to use income elasticities as an indicator of the changing relationship between UK air travel and its key drivers in different market segments. However, given our expectation that market maturity will cause demand to become less responsive to all of its key drivers through time, not just to income, we propose to reduce the elasticities of demand to its other drivers (e.g. fare) at the same proportionate rate as we reduce the income elasticity. Given the ambiguity surrounding how UoW believe income elasticities should be assumed to vary through time, it has also been necessary to go beyond the UoW's advice in developing our proposed approach.

4.3 Finally, we agree with the UoW that the old approach to reflecting maturity in our forecasts was complex to understand and very difficult to interpret from a behavioural perspective. We therefore propose an alternative approach to reflecting market maturity in our models which is significantly more transparent and easier to interpret behaviourally.

Sensitivity Tests

4.4 We have developed a range of assumptions to illustrate the uncertainty around the impact of maturity and market liberalisation on the market for UK air travel. In total we have 3 projections; high, central and low growth. We regard the upper and lower bounds of the range as either end of a range of reasonably likely outcomes with the central case falling in the middle of that range.

4.5 There are a number of factors which could be varied in defining the maturity scenarios. These include:

- the year maturity is assumed to affect each market;
- how the income elasticities in each market change once maturity is assumed to take affect
- how the responsiveness of passenger demand to other key drivers (e.g. fare) varies through time

4.6 In defining the range of assumptions, we have split the 19 market segments for which econometric models have been estimated in the National Air Passenger Demand Model into 3 groups. Broadly, the groups bring together markets according to how soon we expect them to show signs of market maturity.

Table 4: Maturity of different markets

Maturity of markets	Markets included2
1. Most mature	DMB, DML
2. Fairly mature	UBW, UBO, ULW, ULO, FBW, FBO, FLW, FLO, ULN, ULL
3. Least mature	UBN, UBL, FBN, FBL, FLN, FLL

4.7 Group 1 is the domestic markets. Whilst we have been unable to find definitive evidence of maturity in these segments, these markets have already experienced rapid growth, and have seen their growth slow recently, even before the recent recession. We expect the effects of maturity to show more clearly on these markets in the near future.

4.8 Group 2 contains the fairly mature business and leisure markets to/from Western Europe and the OECD. These markets are relatively large markets that have already experienced rapid growth in the period that the econometric models were estimated and are considered to have less potential for rapid growth in the future than in the past.

4.9 This group also includes the UK leisure markets to NICs and LDCs. These markets experienced very rapid growth between 1984 and 2008, the period over which the econometric models used in the forecasting

2 **Domestic journeys within the UK:** DMB: Domestic business; DML: Domestic leisure.
Journeys between the UK and other countries: First letter denotes UK resident (U), or Foreign resident (F). Second letter denotes Business (B), or Leisure (L). Third letter denotes foreign origin or destination:
W: Western Europe; O: OECD excluding Western Europe; N: Newly Industrialised Countries (NICs); L: Less Developed Countries (LDCs).

model were estimated. The YEDs estimated for these markets are amongst the highest of any of our models. We believe the high YEDs are a reflection of these markets having experienced the rapid growth phase of their life cycle. Therefore whilst they appear to be the least mature (according to the estimated YEDs) we believe they are likely to be affected by maturity in the nearer future than group 3. Therefore we are including these markets in the 'fairly mature' group such that they will have maturity applied from early in the forecasting period.

4.10 Group 3 includes the less mature business markets in NICs and LDCs as well as foreign leisure to NICs and LDCs. The countries in these markets generally are low income, and are forecast to have the highest GDP growth rates over the forecasting period, such that we expect these markets to have significant scope for further growth. We therefore expect these markets to mature later than those in groups 1 and 2. This is in line with UoW's advice that long haul markets are some of the least mature. These markets also have the scope to benefit more than the other segments from further market liberalisation.

4.11 We have assumed that the econometric models estimated for each segment are applicable until the year at which maturity adjustment takes effect (except in the high growth scenario, where we have imposed higher YEDs in some markets to reflect the possibility that growth in air travel will increase as more markets benefit from liberalisation). For simplicity, we also assume that the year in which the maturity adjustment starts to affect the responsiveness of demand in each group of markets is constant across the three projections. Table 5 present the year in which we propose to assume that the maturity adjustment starts to affect each group.

Table 5: Year Maturity Adjustment Takes Effect

Maturity of markets	Maturity starts
1. Most mature	2010
2. Fairly mature	2015
3. Least mature	2025

4.12 In the absence of any empirical evidence to guide us in our choice of sensitivity tests we tested a range of assumptions about:

a. the value of YED to which each market segment will converge through time
b. the year in which the final YED is reached in each market segment; and
c. the speed at which maturity affects the YED in each market.

4.13

4.14 We have settled on three tests which are defined in terms of the YED reached in the most mature markets at the end of the forecasting period (i.e. 2080). All markets are assumed to converge on the same YED value within 70 years of the year from which the maturity adjustment is assumed to take effect. Finally, for simplicity, and to reflect advice from the technical working group who felt market maturity would be most likely to have a gradual effect on YEDs, we assume a constant annual absolute decline in elasticities through time.

4.15 Ultimately the sensitivity tests were chosen not because they were clearly more defensible than all the potential alternatives, but because the high and low growth scenarios reflect what the technical group set up to oversee this work regarded as broadly representing the upper and lower bounds of the range of reasonably likely outcomes.

High Growth Assumptions

4.16 In the high growth (low maturity) sensitivity test we assume that the most mature market segments reach a YED of 1 (full maturity in Dr Graham's terminology) by the end of the forecasting period. All other markets are assumed to converge to a YED of 1 within 70 years of market maturity adjustment starting to take effect. The YEDs in markets for which a YED of less than 1 was estimated in the econometric analysis are assumed to remain constant over the forecasting period.

4.17 To reflect the possibility that the YEDs estimated for the markets to/from Newly Industrialised Countries (NICs), and Less Developed Countries (LDCs), are biased downwards we have also assumed that the YEDs for these markets increase from their estimated value to 1.3 before 2025. This is again in line with the YEDs suggested for these markets in an influential paper delivered to the International Transport Forum in 2009.[3]

[3] T.H.Oum et al. (2009) *Air Transport Liberalisation and its Impacts on Airline Competition and air passenger traffic,* OECD

4.18 Table 6 shows what this means for the YED in each segment in 2030 and 2080.

Table 6: High Growth YEDs

Market	YED in 2008	YED in 2030	YED in 2080	Year maturity factor is applied from	Year saturation reached
UBW	1.28	1.22	1.02	2015	2085
UBO	0.97	0.97	0.97	2015	2085
UBN	1.01	1.28	1.06	2025	2095
UBL	1.01	1.28	1.06	2025	2095
ULW	1.33	1.26	1.02	2015	2085
ULO	1.35	1.27	1.02	2015	2085
ULN	1.59	1.46	1.04	2015	2085
ULL	1.85	1.67	1.06	2015	2085
FBW	1.11	1.09	1.01	2015	2085
FBO	0.55	0.55	0.55	2015	2085
FBN	0.76	1.28	0.76	2025	2095
FBL	0.69	1.28	0.69	2025	2095
FLW	1.21	1.16	1.01	2015	2085
FLO	0.55	0.55	0.55	2015	2085
FLN	0.51	1.28	0.51	2025	2095
FLL	0.46	1.28	0.46	2025	2095
DMB	0.99	0.99	0.99	2010	2080
DML	2.26	1.71	1	2010	2080

	1) Most mature
	2) Fairly mature
	3) Least mature

Low Growth Assumptions

4.19 For the low growth (high maturity) test we propose to assume that each market segment reaches saturation 70 years after maturity is assumed to start. Saturation is defined as being reached when demand is growing in line with population growth only. If our income variables were expressed per capita this would be achieved when the YED was equal to 0. However, as the income variables used in the model are expressed as national aggregates, saturation is reached when the YED is equal to the

proportion of income growth that is expected to be related to population growth. On the basis of the latest projections of population and income growth in the UK, we estimate that saturation occurs at a YED of about 0.2 (i.e. 20% of the projected growth in income is expected to be due to population growth).

4.20 To reflect the possibility that the YEDs estimated for the domestic markets, and the markets to/from Europe and OECD, are biased upwards we have also imposed YEDs of 1 on these markets at the start of the forecasting period. This is broadly in line with the YEDs suggested for these markets in an influential paper delivered to the International Transport Forum in 2009.[4]

Table 7: Low Growth YEDs

Market	YED in 2008	YED in 2030	YED in 2080	Year maturity factor is applied from	Year saturation reached
UBW	1.28	0.83	0.26	2015	2085
UBO	0.97	0.81	0.26	2015	2085
UBN	1.01	0.95	0.37	2025	2095
UBL	1.01	0.95	0.37	2025	2095
ULW	1.33	0.83	0.26	2015	2085
ULO	1.35	0.83	0.26	2015	2085
ULN	1.59	1.06	0.28	2015	2085
ULL	1.85	1.06	0.28	2015	2085
FBW	1.11	0.83	0.26	2015	2085
FBO	0.55	0.48	0.23	2015	2085
FBN	0.76	0.72	0.32	2025	2095
FBL	0.69	0.65	0.3	2025	2095
FLW	1.21	0.83	0.26	2015	2085
FLO	0.55	0.47	0.22	2015	2085
FLN	0.51	0.49	0.27	2025	2095
FLL	0.46	0.45	0.26	2025	2095
DMB	0.99	0.78	0.2	2010	2080
DML	2.26	0.77	0.2	2010	2080

	1) Most mature
	2) Fairly mature
	3) Least mature

[4] T.H.Oum et al. (2009) *Air Transport Liberalisation and its Impacts on Airline Competition and air passenger traffic,* OECD

Central Assumptions

4.21 For the central growth test we assume that each market segment reaches a YED of 0.6 (i.e. half way between the high growth and low growth scenarios) 70 years after maturity is assumed to start. We make no further adjustments to reflect the possibility that the YEDs estimated in the econometric analysis are biased. This reflects our believe that most of the effects of market liberalisation will be captured separately in our models by the inclusion of fares and dummy variables

4.22 It should be noted that under this scenario the YEDs in 2030 for the Business markets are broadly in line with those recommended by the UoW team – short haul business markets have a YED of slightly over 1, while domestic business and long haul business markets have YEDs of just under 0.9 and 0.8 respectively. The YEDs in 2030 in the leisure markets are slightly higher than recommended by UoW – short haul leisure has a YED of just over 1.1, domestic leisure a YED of just over 1.2 and long haul leisure markets an average YED of just over 1.4. However, in contrast to the UoW recommendations, we assume that the YEDs in all markets continue to decrease after 2030, significantly reducing the level of demand in the latter part of the forecasting period. The technical working group overseeing this work agreed that this scenario better reflects the way they expect market maturity to affect the UK air travel market in future.

4.23

Table 8: Central Growth YEDs

Market	YED in 2008	YED in 2030	YED in 2080	Year maturity factor is applied from	Year saturation reached
UBW	1.28	1.13	0.65	2015	2085
UBO	0.97	0.89	0.63	2015	2085
UBN	1.01	0.98	0.69	2025	2095
UBL	1.01	0.98	0.69	2025	2095
ULW	1.33	1.18	0.65	2015	2085
ULO	1.35	1.19	0.65	2015	2085
ULN	1.59	1.38	0.67	2015	2085
ULL	1.85	1.58	0.69	2015	2085
FBW	1.11	1.00	0.64	2015	2085
FBO	0.55	0.55	0.55	2015	2085
FBN	0.76	0.75	0.63	2025	2095
FBL	0.69	0.68	0.62	2025	2095
FLW	1.21	1.08	0.64	2015	2085
FLO	0.55	0.55	0.55	2015	2085
FLN	0.51	0.51	0.51	2025	2095
FLL	0.46	0.46	0.46	2025	2095
DMB	0.99	0.88	0.6	2010	2080
DML	2.26	1.24	0.6	2010	2080

	1) Most mature
	2) Fairly mature
	3) Least mature

Implementing maturity adjustments in NAPDM

4.24 Implementing the proposed maturity assumptions in the NAPDM has proved challenging. In the NAPDM, forecasts for all market segments are derived by applying econometric models that have been estimated to best explain historic changes in passenger numbers in each market. For all market segments, the econometric models take the Unrestricted Error Correction Model (UECM) form such that:

$$\Delta Y_t = \alpha_0 + \sum_{i=0}^{\infty} \beta_i \Delta X_{i,t-1} + \sum_{i=1}^{\infty} \eta_i \Delta Y_{i,t-1} + \gamma_1 Y_{t-1} + \sum_{i=2}^{\infty} \gamma_i X_{i,t-1} + u_t$$

- Where:
- Y_t is passenger demand in the market segment at time t
- $X_{i,t}$ is the value of explanatory variable i at time t
- α , β_i, η_i and γ_i are parameters to be estimated

4.25 The long run elasticity of demand with respect to explanatory variable Xi is equal to

5.1

$$\boxed{-\frac{\gamma_i}{\gamma_1}}$$

4.26 Despite significant effort, we have been unable to find a way to vary the elasticities through time, whilst retaining the UECM form. Instead we propose to focus on the long run relationship between passenger demand and its key drivers implied by the UECM estimated for each market segment. For example, the UECM estimated for the ULN market (UK residents travelling for leisure to/from the NICs) is:

$$\boxed{\Delta \ln Tra_t = 1.88\Delta \ln Con_t - 0.16\Delta \ln IPS_t - 0.84 \ln Tra_{t-1} + 1.33 \ln Con_{t-1} - 0.46 \ln IPS_{t-1} + u_t}$$

- Where:
- $LnTra_t$ is the natural logarithm of the number of passengers in ULN at time t
- $LnCon_t$ is the natural logarithm of UK Consumer Spending at time t
- $LnIPS_t$ is the natural logarithm of fares at time t

- This implies a long run relationship of the form:

$$\boxed{\ln Tra_t = -\frac{1.33}{-0.84} \ln Con_{t-1} - \frac{-0.46}{-0.84} \ln IPS_{t-1} + u_t}$$

- or,

$$\boxed{\ln Tra_t = 1.58 \ln Con_t - 0.55 \ln IPS_t + u_t}$$

4.27 The coefficients on lnCont and lnIPSt can be interpreted as the (constant) income (in this case consumer spending) and fare elasticities of demand respectively. This follows because the model is in log-log form].

4.28 By subtracting $lnTra_{t-1}$ from $lnTra_t$ we can express the long run relationship in differences, such that:

$$\boxed{\Delta \ln Tra_t = 1.58\Delta \ln Con_t - 0.55\Delta \ln IPS_t + u_t}$$

4.29 This model form is attractive as it allows us to vary the income and price elasticities of demand (1.58 and -0.55 above) through time, without affecting the relationship between demand and income and fare in previous periods.

4.30 We have successfully implemented the above approach across all markets. The key advantage of this approach over the previous approach is its transparency. By changing the elasticities of demand directly we can explain any changes in passenger numbers in future with reference to the values of the key explanatory variables. This was not the case with the previous x-factor approach, where we found that in some circumstances the approach led to reductions in passenger numbers that could not be explained by reference to changes in the key explanatory variables.

4.31 Whilst we are confident that the proposed approach represents a significant improvement on the previous approach it is not without its limitations. Key amongst them is that it involves abandoning the UECM form. This is unfortunate, as this form has been found to provide the best fit to historic data, especially given how early in the forecasting period maturity is assumed to take effect in most markets.

Section 5 - Implications of proposed approach for unconstrained passenger forecasts

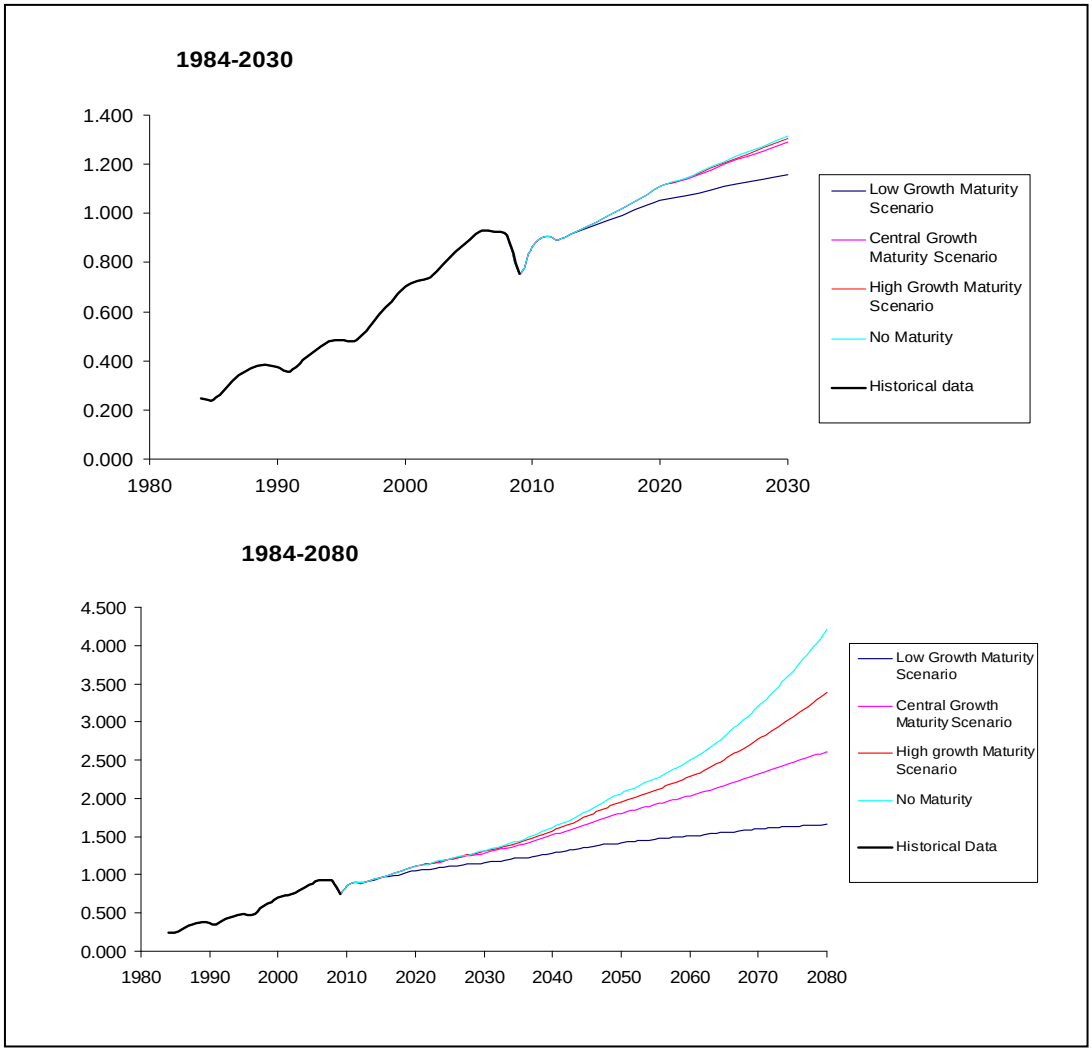
Postscript, August 2011 - Please note that the forecasts contained in this section do not represent official DfT forecasts. They were provided to illustrate the impacts of the proposed approach to reflecting market maturity in the forecasts only. They have now been superseded by the forecasts published by the DfT in UK Aviation Forecasts, published in August 2011.

5.2 Table 9 and figure 2 show the unconstrained forecasts that are consistent with the low, central and high growth scenarios, and compares these with i) the forecasts we would obtain if we made no adjustment to reflect market maturity or market liberalisation and ii) the forecasts we would obtain if we applied the 'x-factor' approach used in previous forecasts.

Table 9: Passenger forecasts (mppa) under alternative maturity scenarios

	Low Growth	**Central Growth**	**High Growth**	**No maturity adjustment**	**Old 'x-factor' approach**
2010	233	233	233	233	233
2030	343	375	389	383	341
2080	570	862	1,206	1,328	821

Figure 2: Passenger forecasts (mppa) under maturity growth scenarios



5.3 When the old 'x-factor' approach is applied to our current unconstrained demand forecasts, the forecasts in 2030 lie just below the proposed low growth scenario (2 mppa below), but by 2080 the 'x-factor' forecasts lie much closer to the proposed central growth scenario (41 mppa below). The previous 'x-factor' approach implies a much greater impact of maturity up to 2030 than the proposed approach but a significantly weaker effect towards 2080, relative to the proposed low and central growth maturity scenarios.

5.4 Under the proposed approach, the adjustments for maturity have the greatest effect on the UK leisure markets, as can be seen by the large decreases in YED in those markets in table 8. The UK leisure market has the largest level of modelled forecasted traffic so maturity in this market reduces the national forecasts significantly. Table 10 compares the

forecasts in the UK leisure market under the proposed central growth scenario with those derived by applying no maturity adjustments. It shows that under this central scenario, the maturity adjustments do not have much of an effect in 2030 but have a large effect on the forecasts in 2080. In terms of passenger numbers, the maturity adjustments have the greatest effect on the forecasts in the UK leisure to Western Europe (ULW) market - under the central scenario the passenger forecasts are 35% lower in 2080 than they would be if no maturity adjustment was applied to the forecasts.

Table 9: Passenger forecasts (mppa) under alternative maturity scenarios

	Low Growth	Central Growth	High Growth	No maturity adjustment	Old 'x-factor' approach
2010	233	233	233	233	233
2030	343	375	389	383	341
2080	570	862	1,206	1,328	821

Sense checking

5.5 In order to sense check the proposed maturity assumptions we have calculated what our forecasts imply about the number of annual international trips made per UK resident in the future with the number of annual international trips per UK resident observed in recent years. Annex A explains the method employed and data sources used.

5.6 Table A1 in Annex A shows the number of annual international trips per UK resident for each year for the 25 year period 1984 to 2009. Tables B1 to B4 in Annex B show what the forecasts derived under the proposed low, central and high growth scenarios, and a no maturity scenario imply about the number of such trips per UK resident in the period from 2010 to 2080. The number of annual international trips by UK residents has increased from 0.246 in 1984 to 0.755 in 2009, an increase of over 200% or just under 5% per annum. In comparison, the proposed central growth scenario implies that the number of annual international trips per UK resident will increase by 60% in the next 25 years (or just under 2% per annum). It might be tempting to conclude that the proposed adjustments are rather severe. However, the growth in average trips has not been constant over the past 25 years. Average annual growth in the number of international trips was over 6% per annum for the 14 years from 1984 to 1998, fell to around 4.5% in the period 1998 to 2008, and then there was the unprecedented 17% fall in the number of trips per person in 2009.

5.7 Figure 3 charts the number of annual international trips per UK resident in the past and what the model forecasts imply about the number of annual international trips per UK resident in the future.

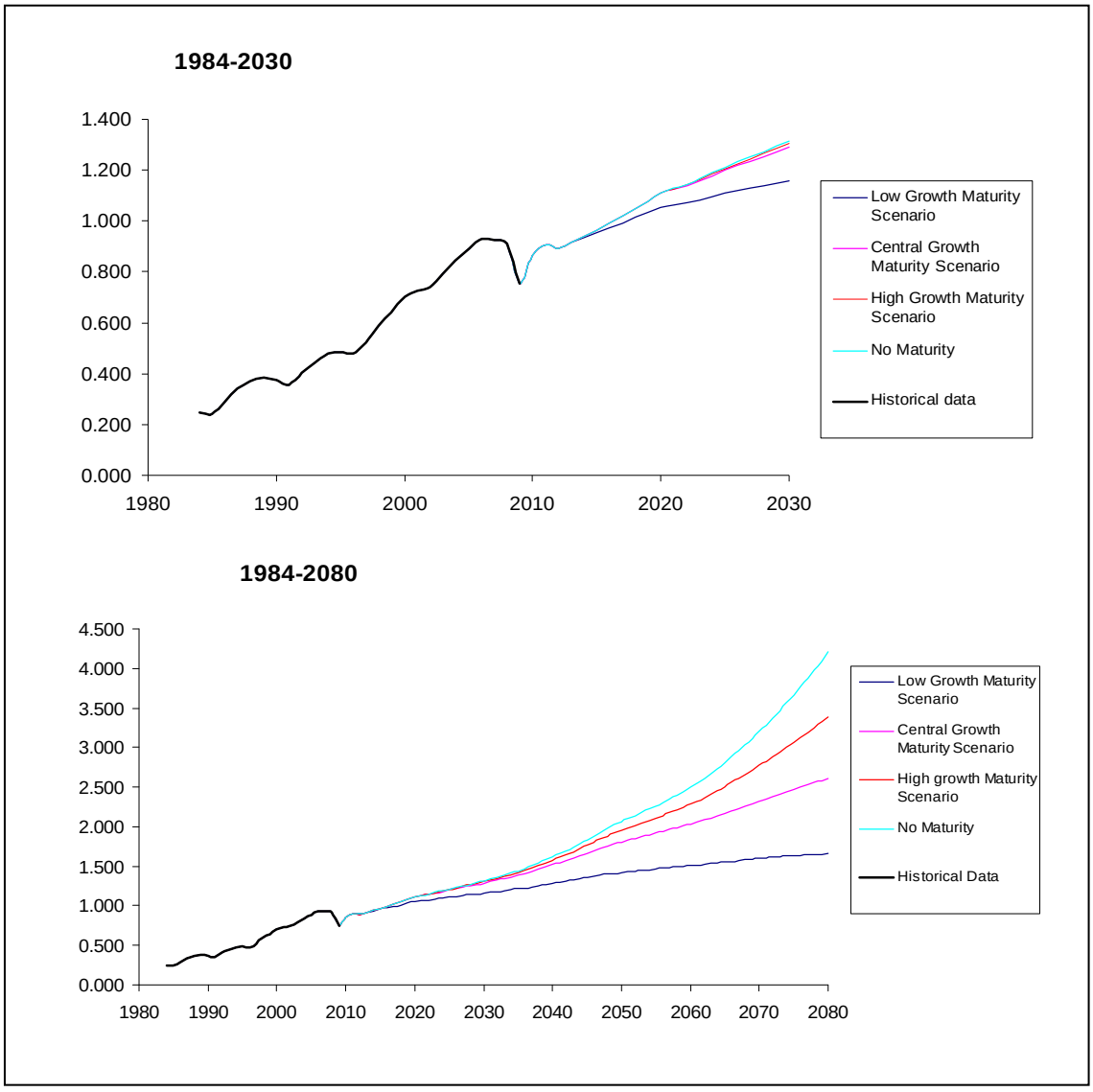
5.8 Broadly, the forecasts under the central growth scenario imply that the number of annual international trips per UK resident will increase at the same absolute rate per annum as was averaged over the past 25 years (i.e. about an additional 0.5 trips every 25 years) .

5.9 The high growth scenario implies very similar growth rates to the central growth scenario in the period to 2030 but with a slower reduction in the speed of growth (in percentage terms) beyond 2030. The forecasts under the high growth scenario in the 25 year period 2035-2060 imply a 61% increase in trips (additional 0.87 trips) or a compound growth rate of 1.9%, while the last 20 years of the forecast period imply a 48% increase in trips (additional 1.1 trips), or a compound growth rate of 2%.

5.10 In contrast, the low growth scenario implies that the growth rate in international trips per person will reduce much more rapidly, such that not only will the percentage average growth rate be significantly lower than has been experienced in the past, but so to will the absolute increase. The forecasts under the low growth scenario imply an additional 0.35 trips in the period 2010-2035, an additional 0.3 trips in the period 2035-2060, and an additional 0.16 trips in the remaining 20 year forecast period.

5.11

Figure 3: Annual international trips per UK resident



Section 6 - Potential further work

6.1 The continued absence of quantified evidence on how maturity is affecting the market for air travel has made the task of estimating how it will affect air travel in future a particularly challenging task. Given our expectation that the impact of maturity will become clearer, particularly in the domestic markets, over the next few years, we recommend that the evidence on this is reviewed within the next three years. That review should take on board advice from the UoW and attempt to fit a broad range of functional forms to the data. Ideally, the review will be successful in fitting a regression to historic data that implies falling elasticities through time, such that a single model form could be used to produce forecasts over the full forecast period.

Annex A: Data sources for sense check

A.1 Historical data was gathered for the total number of annual trips abroad by UK residents[5], annual population of the UK[6], and annual UK GDP[7]. The time series data for these 3 variables extends back to 1984. The number of terminal passengers from 2000-2009 was also extracted from the Unconstrained Passenger Demand Model.

A.2 Table A.1 shows the number of annual trips abroad per UK resident, calculated by dividing the total number of annual trips abroad by UK residents by the UK annual population. Before 1993 the only population growth data points available in the ONS dataset were 1984 and 1991. In between these years the population was increased in proportion each year. The population in 1992 is assumed to be half way between the population levels in 1991 and 1993.

A.3 In order to be able to compare our forecasts to the historical number of trips abroad per UK resident, we converted our forecasted terminal passenger numbers into trips abroad. This was done by dividing the number of terminal passengers from the UK Business and UK Leisure markets (2000-2009) by the total number of annual flights abroad by UK residents. This created an index figure for each year which could be used to convert terminal passengers into trips abroad. An average of 0.438 was taken over the 10 year time period and used to convert our forecasted terminal passengers into trips abroad.

[5] International Passenger Survey (2009) http://www.statistics.gov.uk/downloads/theme_transport/travel-trends09.pdf

[6] ONS (2009) http://www.statistics.gov.uk/statbase/ssdataset.asp?vlnk=9542&More=Y

[7] HMTreasury (2009) 'Long Term Public Finance Report'

Table A.1 : Annual international trips per UK resident

	Total number of annual trips abroad by UK residents	UK Population	Number of annual trips abroad per UK resident	% Change on previous year
1984	13,934,000	56,553,200	0.246	-
1985	13,732,000	56,618,600	0.243	-1.56%
1986	16,380,000	56,684,000	0.289	19.15%
1987	19,369,000	56,835,000	0.341	17.93%
1988	21,026,000	56,986,000	0.369	8.27%
1989	21,925,000	57,137,000	0.384	4.00%
1990	21,368,000	57,288,000	0.373	-2.80%
1991	20,408,000	57,439,000	0.355	-4.74%
1992	23,357,000	57,576,500	0.406	14.18%
1993	25,354,000	57,714,000	0.439	8.29%
1994	27,624,000	57,862,000	0.477	8.67%
1995	28,097,000	58,025,000	0.484	1.43%
1996	27,907,000	58,164,000	0.480	-0.91%
1997	30,341,000	58,314,000	0.520	8.44%
1998	34,510,000	58,475,000	0.590	13.43%
1999	37,510,000	58,684,000	0.639	8.31%
2000	41,392,000	58,886,000	0.703	9.97%
2001	43,011,000	59,113,000	0.728	3.51%
2002	43,990,000	59,323,000	0.742	1.91%
2003	47,101,000	59,557,000	0.791	6.65%
2004	50,435,000	59,846,000	0.843	6.56%
2005	53,626,000	60,238,000	0.890	5.64%
2006	56,460,000	60,587,000	0.932	4.68%
2007	56,329,000	60,975,000	0.924	-0.87%
2008	56,041,000	61,383,000	0.913	-1.17%
2009	46,657,000	61,792,000	0.755	-17.30%

Source: International Passenger Survey (2009)
http://www.statistics.gov.uk/downloads/theme_transport/travel-trends09.pdf
ONS (2009) http://www.statistics.gov.uk/statbase/ssdataset.asp?vlnk=9542&More=Y

Annex B: Annual international trips per UK resident implied by unconstrained forecasts

B.1 Annual international trips per UK resident implied by unconstrained forecasts (Low Growth)

Low Growth Scenario				
	Total terminal passengers in international UK business and leisure sectors	Total number of annual flights abroad by UK residents	Number of annual flights abroad per UK resident	Average % change on previous year
2010	122.3	53.6	0.862	-0.53%[8]
2015	140.3	61.5	0.954	2.09%
2020	160.1	70.2	1.053	1.99%
2025	173.6	76.1	1.109	1.07%
2030	186.9	81.9	1.160	0.91%
2040	216.4	94.9	1.285	1.03%
2050	249.3	109.3	1.421	1.02%
2060	273.6	119.9	1.508	0.59%
2070	299.3	131.2	1.596	0.57%
2080	321.5	140.9	1.659	0.39%

[8] The average percentage change on the previous year in the 5 year period 2005-2010 in annex B1-B4, uses modelled demand for 2009 rather than actual demand figure in table A.1. This is so that the annual percentage change on previous year 2005-2010 is more comparable to forecasts in all other time periods in tables B1-B4.

B.2 Annual international trips per UK resident implied by unconstrained forecasts (Central Projection)

Central Scenario				
	Total terminal passengers in international UK business and leisure sectors	Total number of annual flights abroad by UK residents	Number of annual flights abroad per UK resident	Average % change on previous year
2010	122.3	53.6	0.862	-0.53%
2015	141.3	62.0	0.961	2.23%
2020	168.5	73.9	1.108	2.89%
2025	187.8	82.3	1.199	1.59%
2030	207.7	91.0	1.289	1.45%
2040	255.7	112.1	1.519	1.66%
2050	317.1	139.0	1.808	1.76%
2060	368.4	161.5	2.030	1.17%
2070	434.2	190.4	2.316	1.32%
2080	506.8	222.2	2.616	1.22%

B.3 Annual international trips per UK resident implied by unconstrained forecasts (High Growth)

High Growth Scenario				
	Total terminal passengers in international UK business and leisure sectors	Total number of annual flights abroad by UK residents	Number of annual flights abroad per UK resident	Average % change on previous year
2010	122.3	53.6	0.862	-0.53%
2015	141.3	62.0	0.961	2.23%
2020	168.9	74.0	1.111	2.93%
2025	188.9	82.8	1.206	1.66%
2030	210.4	92.3	1.306	1.64%
2040	265.6	116.5	1.578	1.91%
2050	342.4	150.1	1.952	2.15%
2060	414.6	181.8	2.285	1.59%
2070	519.8	227.9	2.772	1.95%
2080	656.4	287.8	3.387	2.02%

B.3 Annual international trips per UK resident implied by unconstrained forecasts (No Maturity adjustment)

No Maturity adjustment Scenario				
	Total terminal passengers in international UK business and leisure sectors	Total number of annual flights abroad by UK residents	Number of annual flights abroad per UK resident	Average % change on previous year
2010	122.3	53.6	0.862	-0.53%
2015	141.4	62.0	0.961	2.24%
2020	169.0	74.1	1.111	2.94%
2025	189.8	83.2	1.212	1.75%
2030	212.1	93.0	1.317	1.67%
2040	272.3	119.4	1.617	2.08%
2050	362.2	158.8	2.065	2.47%
2060	452.7	198.5	2.495	1.91%
2070	599.8	263.0	3.199	2.52%
2080	816.3	357.9	4.213	2.79%