

REMARKS

BOARDING

BOARDING

ON TIME

ON TIME

ON TIME

DELAYED

ON TIME

ON TIME

LAST CALL

ON TIME

ON TIME

ON TIME

DELAYED

# EUROPEAN AVIATION IN 2040 CHALLENGES OF GROWTH

## FLIGHTS IN 2040

HIGH  
19.5M  
+84%

**16.2M**  
**+53%**  
1.9%/year

## CAPACITY GAP 2040

**1.5M**  
**FLIGHTS**  
8% OF DEMAND  
160M PEOPLE

## CAPACITY PLANS

**+16%**  
**FLIGHTS**  
111 AIRPORTS

+28%  
TOP20

HIGH  
3.7M  
16%

# SUMMARY

The *Challenges of Growth* studies aim to deliver the best-achievable information to support long-term planning for aviation in Europe. EUROCONTROL has previously published four *Challenges* studies, in 2001, 2004, 2008 and 2013. This report summarises airport capacity challenges identified in the fifth study, *Challenges of Growth 2018* (CG18), which tackles the following question:

## What are the challenges of growth for commercial aviation in Europe between now and 2040?

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Recent variability in traffic has re-emphasised the need to consider a range of possible futures, in order to manage risks. After a stakeholder review, we have defined four scenarios, each describing a different future:

- **Global Growth:** Strong global growth with technology used to mitigate sustainability challenges;
- **Regulation and Growth (Most-Likely):** moderate growth regulated to reconcile demand with sustainability issues;
- **Fragmenting World:** a World of increasing tensions and reduced globalisation;
- **Happy Localism:** like *Regulation and Growth*, but with a fragile Europe increasingly, and contentedly, looking inwards.

The most-likely scenario is *Regulation and Growth*. However, we see a number of long-term risks that would lead to higher growth, and thus we also give particular attention to *Global Growth*.

By 2040, traffic in Europe is expected to grow to just over 16 million flights in *Regulation and Growth*, and close to 20 million in *Global Growth*. This is a total growth of 53% (*Regulation and Growth*) and 84% (*Global Growth*) compared to 2017.

This is rather slower growth than before 2008. Indeed, over the 20 years before the economic crisis, the number of flights in Europe doubled from 5 million IFR movements in 1988 to 10 million in 2008. Overall, the future deceleration in growth is explained by slower rates of economic growth, increasing fuel prices and increasing congestion at airports.

We now collect airport capacity data around the clock, for operations as well as long-term studies like this one. After cutting back between 2008 and 2013, airports are expanding their capacity plans again, with 111 airports planning a 16% increase in capacity between them, 4 million more runway movements. This growth is focused on the top 20 airports, who are planning growth of 28%, or 2.4 million runway movements.

These airport capacity expansion plans, even if they can be delivered, are not sufficient. Plans are better focused than they were in 2013, with more expansion where we predict more traffic growth. Even so, by 2040 there will be 1.5M flights more in demand than can be accommodated, 8% of demand in *Regulation and Growth*. That is 160 million passengers unable to fly. The gap is spread across 17 States. In *Global Growth*, the gap is 3.7M and 16% of demand.

## 2040 SUMMER DELAY

HIGH  
45  
+370%

20  
mins/flight  
+63%

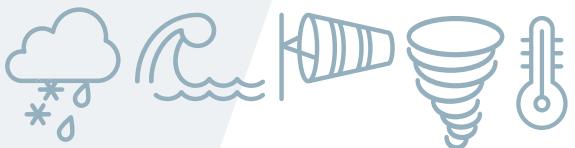
## CONGESTED AIRPORTS

16  
vs. 6 in  
Summer 2016

CLOSING  
THE GAP  
28%  
if deploy  
SESAR Wave 1

HIGH  
14%

## NEED TO ADAPT



HIGH  
28

Even with 1.5M flights unaccommodated and therefore lost, the network remains highly congested. The number of 'Heathrow-like' airports operating near capacity for much of the day climbs from 6 in Summer 2016 to 16 in 2040, or even 28 in *Global Growth*. We have modelled delays from all causes, and find that in the Summer, these would jump from 12 minutes to 20 minutes per flight in 2040. In particular, the number of flights delayed by 1-2 hours increases by a factor of 7, which means around 470,000 passengers each day delayed by 1-2 hours in 2040, compared to around 50,000 today.

Closing the capacity gap is a task for airports, providing more infrastructure, but also for airlines, regulators and others. Taking a cue from how Industry has responded in the past, we modelled six different mitigations, apart from new runways. Of these mitigations, the most promising are the developments under SESAR Wave 1, which target busy airports at peak hours. These developments could reduce the most-likely capacity gap by 28% in 2040, if they can be successfully deployed.

The climate is changing. Over the medium and long term, there will be changes to temperatures, to rain, snow, wind and storm patterns and in the sea level. This will affect aviation infrastructure, patterns of demand and daily operations. An updated and enlarged survey shows that the European aviation industry recognises that these challenges are coming. But there has been little change over the last five years in the proportion of organisations actually planning for adaptation to climate change impacts. This is a risk that needs further investigation.

There will be many more unmanned aircraft systems (UAS) or 'drones' by 2040. Most of these will operate outside current IFR airspace, but this will put pressure to cede parts of current controlled airspace. Within controlled airspace, 2017 saw about 6 flights/day. By 2040 the main effect will be to replace existing operations with 'optionally piloted' ones. On top of this transformation, we see further growth of about 100 flights/day.

In summary, we see three key challenges for 2040:

- Delivering current **airport capacity** plans is already a challenge, but they will fall 1.5M flights short of demand. More capacity is needed at airports in 17 different States.
- Even with 1.5M flights lost to the capacity gap, a typical Summer day in 2040 will have 16 airports as congested as Heathrow is now. That will push total **network delays** to an average of 20 minutes per flight. It will be a challenge to provide an adequate quality of service, day in, day out in these circumstances.
- Climate change will damage aviation infrastructure, alter patterns of passenger demand, and lead to more disruption of daily operations. Industry recognises the need for **adaptation**, but only half of organisations have begun to plan.





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# A FOUNDATION FOR PLANNING TO 2040

The *Challenges of Growth* studies aim to deliver the best-achievable information to support long-term planning for aviation in Europe. EUROCONTROL has completed four *Challenges* studies, in 2001, 2004, 2008 and 2013 (Ref. 1, 2 ,3 4). This report summarises the fifth study, *Challenges of Growth 2018* (CG18), which tackles the following question:

**What are the challenges of growth for commercial aviation in Europe<sup>1</sup> between now and 2040?**

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This summary report is complemented by more detailed, technical reports:

- The forecast of flights to 2040 and the effects of capacity constraints at airports are discussed in detail in Ref. 6.
- In Ref. 9 we report on the impact of this lack of capacity in terms of congestion and delays.
- In the mitigation report (Ref. 5), we look at ways to mitigate the lack of capacity, starting with building more airport capacity, but also how to use differently what capacity there is.

Later in 2018 we will publish a report on environmental issues (Ref. 12) providing: a forecast of CO<sub>2</sub> emissions and how aviation is reducing its impact; and how prepared European aviation is to adapt to climate change.

## ACKNOWLEDGEMENTS

The *Challenges of Growth* project team is grateful to the many in the industry who made the time to support the project with information and informed comments, directly or through questionnaires. In particular, DG MOVE and ACI EUROPE provided expert encouragement and advice, and members of the STATFOR User Group helped to review and refine the scenarios. Thank you.

The project was a collaboration between a number of teams in EUROCONTROL: the Airport unit provided the airport expertise and led the data collection, STATFOR led the forecasting and mitigation work, GIS provided the cartography, the environment experts of the Policy unit led the work on climate adaptation and emissions modelling, the Network unit developed and ran the methods to evaluate the impact of delays on the network, while the Master Plan unit helped with the SESAR benefits.

1- Unless otherwise specified, 'Europe' refers to the airspace of the European Civil Aviation Conference (ECAC) States. See Glossary for a map.

GATE	TIME	REMARKS
C	09	BOARDING
B	13	BOARDING
A	10	ON TIME
A	05	ON TIME
C	04	ON TIME
C	03	DELAYED
C	16	ON TIME
B	07	ON TIME
B	18	LAST CALL
A	07	ON TIME
A	03	ON TIME
B	08	ON TIME
A	15	DELAYED

# LOOKING AHEAD, BOUNDING THE RISKS

## RETURN TO GROWTH

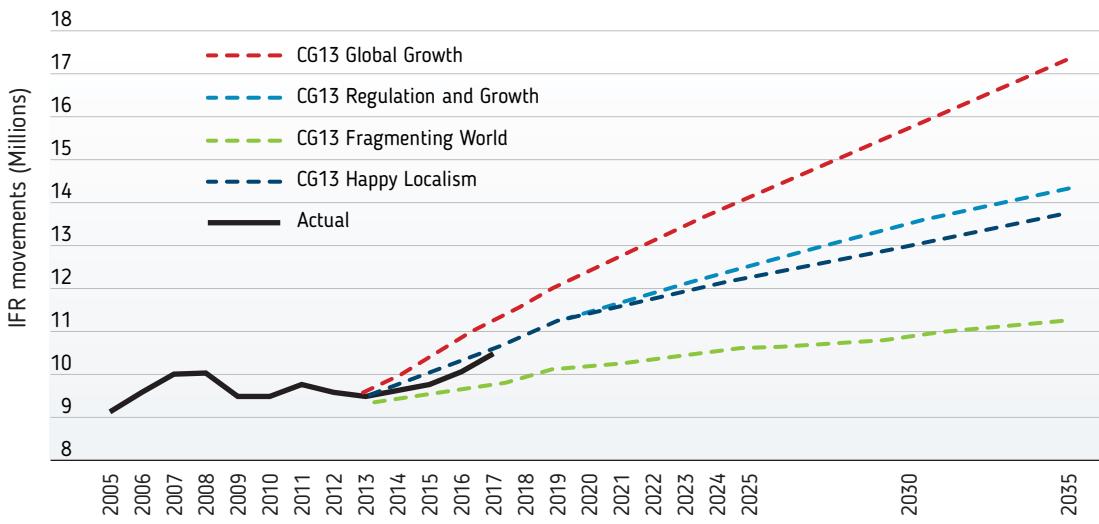
Flight growth is back: 2017 saw broad-based, strong growth that finally took European flight counts above the 2008 peak.

Five years ago, flights had just seen a double-dip decline and were still 5% below the 2008 peak. So there seemed a need to reassure readers of the Challenges of Growth 2013 (CG13) summary report (Ref. 4, p8) that, when economic growth returned, so would growth in air traffic.

It has taken a while to get here, but today the situation looks rather different; strong and broad-

based traffic growth in 2017 across all market segments finally took European flight totals over the 2008 peak, to 10.6 million. Indeed, even 4% growth in flights in 2017 looks modest compared to almost twice that reported for passengers or passenger-km. Current growth is certainly supported by strong demand. This growth has brought traffic back to the most-likely scenario from the 2013 forecast (Figure 1).

**Figure 1** / In 2017, strong growth saw traffic back on the most-likely scenario from the 2013 forecast



The supply side is also healthier than in recent years: globally IATA has reported airlines profitable for three years in a row, mostly in North America. Europe added to the total profit, even if there were some notable bankruptcies on this side of the Atlantic in late 2017. Significantly lower fuel prices have helped this profitability, as have record high load factors.

Geographically, there has been particularly strong growth in arrival and departing flights for Greece and Iberia, including the Canary Islands, as tourism preferences continued to change, moving at least temporarily away from Egypt, Tunisia and to some extent Turkey. Overflight patterns have also changed considerably in five years: Ukraine has around 70% fewer overflights than in 2012,

with neighbouring Moldova down 50%, after the attack on flight MH17; flights have re-routed to the South, with Bulgaria, Romania and Turkey up 40-50%.

Given this scale of change over just five years, when looking ahead 20 years we believe it is

essential for decision makers to take account of a range of different scenarios, that capture possible ways in which Europe and European air traffic might develop.

Figure 2 explores some of the main trends, and different directions that these trends could easily go.

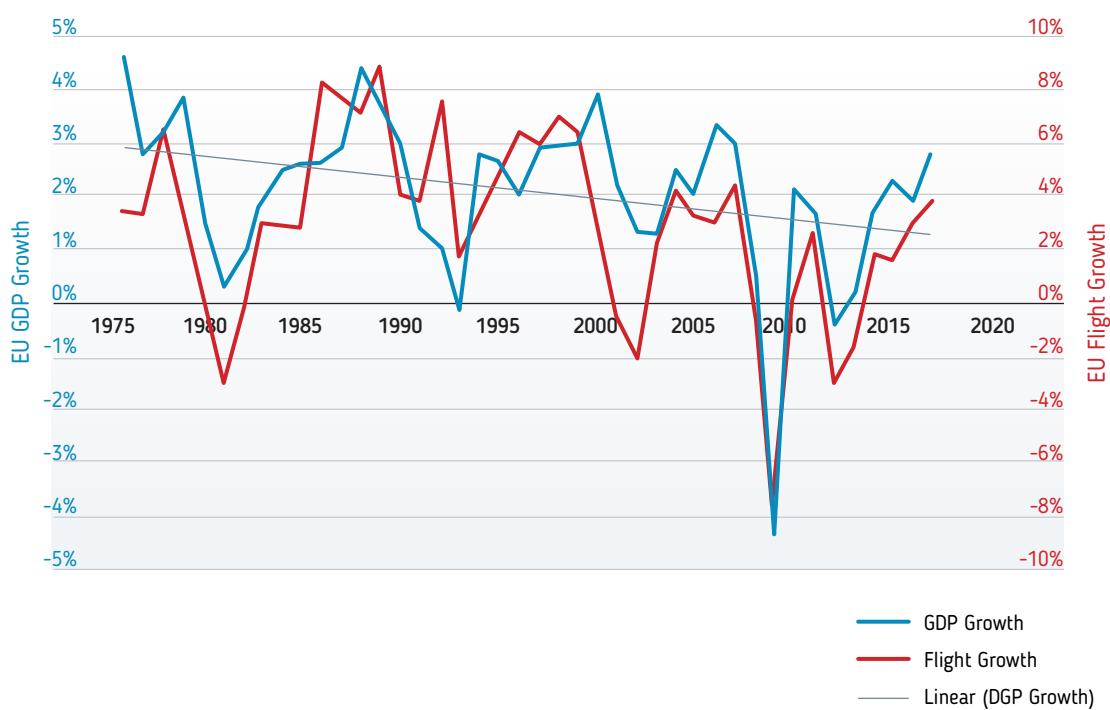
**Figure 2** / Long-term trends and possible futures

Trend	Upside: more flights	Downside: fewer flights
<b>Oil prices</b>	Rapid electrification of ground transport leads the way to peak oil use. Prices fall as producers compete in a contracting market.	Low investment in a declining oil market leads to dwindling yields. Scarcity drives up prices, though shale oil continues to provide a ceiling.
<b>Tourism</b>	Growing economies continue to drive both European and in-bound tourism.  A more mobile, millennial generation expects to travel more often, ie have a higher propensity to fly.	
<b>Low-cost long-haul</b>	New aircraft types, new carriers and 'de-constructed' fares increase the variety and reduce the cost of long-haul travel, boosting demand.	Higher oil prices, unattractively low frequencies on thin markets and much smaller price margins than possible in short-haul mean that low-cost long-haul remains a niche market.
<b>Hubbing</b>	Growing large hubs within and beyond Europe drive growth in feeder flights as well as long-haul flights and overflights.	-
<b>Electrification</b>	New, hybrid kerosene-electric aircraft change the economics of the 30-70 seat market, creating new possibilities for feeder and short-haul connectivity.	-
<b>Drones, UAS</b>	Even in current controlled airspace, new business models emerge, for example medium-haul, pilotless cargo.	-
<b>Middle-class growth</b>	Expanding economies in Europe, Asia and elsewhere create a larger population with more disposable income.	-
<b>Globalisation</b>	Long-term trends for global, interconnected industrial production and trade in services increase the need for face-to-face meetings.	Populist attacks on free trade lead to slower growth in trade, reducing the need for business travel and transportation of goods. Fragmentation, gloomier Brexit scenarios.

Five years ago, in addition to the baseline, business-as-usual growth scenario, the discussion was about maturity of the market, and the downside risks. Now it is clear that, even if scheduled aviation in Europe is reaching its centenary, there is 'life in the old dog yet'. Economic growth is not forecast to be as strong in the future as in the past, so this source of growth in demand will diminish, as Figure 3 shows. In 2018, with oil prices rising, threats to increase trade barriers and economic growth faltering there are clearly also economic down-side risks; some economists are suggesting we have reached the top of the latest economic cycle.

However, from Figure 2 it is clear that there are a number of potential societal and business transformations that have the potential to boost traffic over the long term, more so than there are long-term, down-side risks. Compared to the economic cycle, their potential effects are poorly understood. Even if only a subset of the list - low-cost long-haul, hybrid short-haul, drones, Chinese middle-class travel, new hubs, new long-haul aircraft – arrive in strength, the up-side risks are strong.

**Figure 3** / Economic and flight growth continue in tandem, but both are slowing.



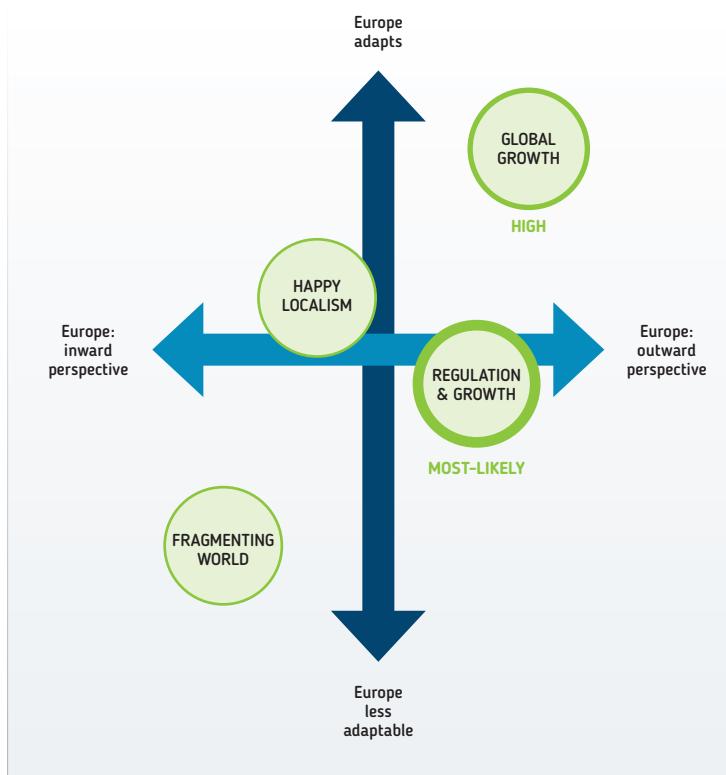
## FOUR SCENARIOS, FOUR POSSIBLE FUTURES

Recent variability in traffic has re-emphasised the need to consider a range of possible futures, in order to manage risks. After a stakeholder review, we have four scenarios, each describing a different future. The most-likely scenario is *Regulation and Growth*. However, we see a number of long-term risks that would lead to higher growth, and thus we also give particular attention to the high-growth scenario *Global Growth*.

We produce forecasts to help decision makers manage risks. Looking 20 years ahead, or even just looking to the swings of traffic over the last five years, makes it clear that no single forecast will capture the risks. So we have worked with stakeholders to develop four scenarios. That process started by identifying some principal axes of uncertainty, which we captured as:

- How adaptable Europe is, either economically, technologically or politically;
- Whether Europe is more or is less outward-looking.

**Figure 4** / Four scenarios to manage the risks.



This led to four possible futures (Figure 4), chosen so that they bracket a range of outcomes in order to make for robust planning.

- **Global Growth:** strong global economic growth with technology used to mitigate environmental challenges. This is a **high** growth scenario.
- **Regulation and Growth:** moderate growth regulated to reconcile demand with environmental sustainability issues. This is assessed to be the **most likely** of the four.
- **Happy Localism:** like *Regulation and Growth*, but with a fragile Europe increasingly and contentedly, looking inwards for trade and travel. In other words, "small is beautiful";
- **Fragmenting World:** a World of increasing tensions and reduced globalisation, as barriers to free trade multiply.

We see *Regulation and Growth* as the most likely scenario, but for CG18 we think that *Global Growth* also needs close attention. As discussed in the previous section, the recent return to traffic growth has been vigorous, and there are newer growth drivers - long-haul, low-cost; new aircraft types; middle-class growth in China; changes in propensity to fly; drones – all of which are under-represented in our forecast models because of their short histories. All four scenarios should be considered as part of a balanced risk assessment, but in this report we will discuss the higher-growth *Global Growth* scenario as a complement to the most-likely *Regulation and Growth* scenario.

The scenarios from CG13 were the starting point, and after consultation they were left structurally unchanged, although the detail of the assumptions which define them was adapted and updated. Figure 5 summarises and compares these updated input assumptions for the four scenarios. Supporting background material and differences between the scenarios are covered in more detail in the forecast report (Ref. 6).

**Figure 5** / Summary of the input assumptions per scenario

	<b>Global Growth</b>	<b>Regulation &amp; Growth</b>	<b>Happy Localism</b>	<b>Fragmenting World</b>
2023 starting point at end of 7-year forecast	High ↑	Base →	Base →	Low ↓
<b>Passengers</b>				
Demographics (Population)	Aging UN Medium-fertility variant	Aging UN Medium-fertility variant	Aging UN Medium-fertility variant	Aging UN Zero-migration variant
Routes and Destinations	Long-haul ↑	No Change →	Long-haul ↓	Long-haul ↓
Open Skies	EU enlargement later +Far & Middle-East	EU enlargement earliest	EU enlargement earliest	EU enlargement latest
High-speed rail (new & improved connections)	20 city-pairs faster implementation	20 city-pairs	20 city-pairs faster implementation	20 city-pairs later implementation
<b>Economic conditions</b>				
GDP growth	Stronger ↑	Moderate →	Weak ↓	Weaker ↓↓
EU Enlargement	+5 States, Later	+5 States, Earliest	+5 States, Earliest	+5 States, Latest
Free Trade	Global, faster	Limited, later	More limited, even later	None
<b>Price of travel</b>				
Operating cost	Decreasing ↓↓	Decreasing ↓	Decreasing ↓	No change →
Price of CO <sub>2</sub> in Emission Trading System	Moderate	Lowest	Lowest	Highest
Price of oil/barrel	Low	Lowest	Highest	High
Change in other charges	Noise: ↑ Security: ↓	Noise: ↑ Security: ↑	Noise: ↑ Security: →	Noise: → Security: ↑
<b>Structure</b>				
Network	Hubs: Middle-East ↑↑ Europe ↓ Turkey ↑ Point-to-Point: N. Atlantic ↑↑	Hubs: Middle-East ↑↑ Europe & Turkey ↑ Point-to-Point: N. Atlantic ↑	Hubs: Middle-East ↑↑ Europe & Turkey ↓ Point-to-Point: N. Atlantic ↑	No change →
Market Structure	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions

## AIRPORT CAPACITY: STABLE, AND BETTER FOCUSED

We now collect airport capacity data around the clock, for operations as well as long-term studies like this one. After cutting back between 2008 and 2013, airports are expanding their capacity plans again, with 111 airports planning a 16% increase in capacity between them, 4M more runway movements. This growth is focused on the top 20 airports, which are planning growth of 28%, which is 2.4M runway movements.

As Network Manager, EUROCONTROL is in constant contact with European airports. In particular, through an on-line tool called 'Airport Corner' (Ref. 7), we maintain a constant dialogue about current and future capacity plans at airports, from short-term reductions for taxiway repairs, say, to long-term master-planning of total passenger and flight capacity. Some of that information is public, but most future plans are shared in confidence, for commercial reasons.

For CG18, we have data on the future capacity plans of 111 airports in Europe. More are covered in the Airport Corner, but for current capacity only. 111 is slightly more than in 2013. Figure 6 illustrates the airports included. These airports include all but four of the top 50 in Europe. Some 9 million flights either arrived or departed one of these airports in 2017, which is 84% of total traffic. Our forecasting is based on all 2,000 or so airports for which we see instrument flight rules (IFR) flights, but with capacity issues analysed at these 111.

In fact, for analytic simplicity we treat Istanbul/Ataturk and the new Istanbul airport as one. So really this is 112 airports.

In the aftermath of the 2008 financial crisis, airports scaled back their expansion plans driven by a reduction in demand as well as increased difficulty in financing. Now the situation appears to be more stable. As Figure 7 shows, the growth of capacity over the 2017-2035 period is slightly stronger in CG18 than the plans seen in 2013: overall, the 111 airports are planning a 16% increase between 2017 and 2035, compared to 13% over the same period last time. In general, there seems to be a more agile approach to

capacity planning: having a current plan, but with a range of measures available for implementation at shorter notice that could enable increases or decreases relative to that plan, depending on how demand develops.

Figure 7 also illustrates that few plans look further ahead than that: there is little change between 2035 and 2040 now. The same was true in the last five years of the CG13 study.

An important change in the CG18 data, compared to CG13, is that the expansion is more concentrated in major airports, despite this being where it can be most difficult to make additional capacity, because many of the 'easier' initiatives have already been taken. We will see the impact of this change in a number of results. The top 20 airports, ranked in terms of flights in 2017, are highlighted in the map in Figure 6. These 20 airports saw 53% of all flights as arrivals or departures in 2017, although they account for only 35% of the available capacity.

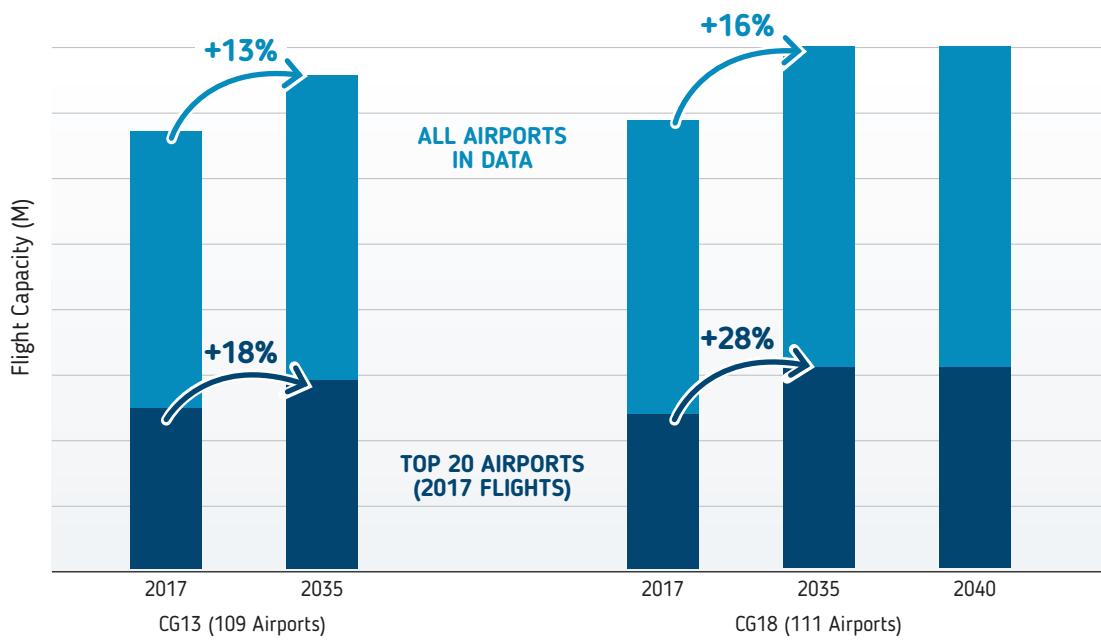
These top 20 are planning some 28% growth in capacity. For example, the additional runway at Heathrow is now included, and the opening of Berlin Brandenburg has moved into this window. In total, the top 20 are adding capacity for 2.4M new flights (arriving and departing runway movements), nearly two thirds of total capacity growth. In CG13, the equivalent was only a quarter of new capacity planned at these airports.



**Figure 6** / CG18 uses the capacity plans of 111 airports (top 20 highlighted in red)



**Figure 7** / In CG18, the additional capacity planned is more concentrated at the busiest airports





# MEASURING AND MITIGATING GROWTH

## SLOW FLIGHT GROWTH TO 2040

By 2040, traffic in Europe is expected to grow to just over 16 million flights in the most-likely scenario *Regulation and Growth*, or close to 20 million in *Global Growth*. This corresponds to a total growth of 53% (*Regulation and Growth*) and 84% (*Global Growth*). This is rather slower growth than before 2008. Indeed, over the 20 years before the economic crisis, the number of IFR movements in Europe doubled from 5 million IFR movements in 1988 to 10 million in 2008.

Overall, the future deceleration in growth is explained by slower rates of economic growth, increasing fuel prices and higher level of congestion at airports.

Each scenario paints a picture of a different future, with a different pattern of traffic growth (Figure 8). Focusing on the ECAC region which covers Europe, from Iceland to Azerbaijan (Figure 21), we observe the following.

In **Regulation and Growth**, there will be 16.2 million flights in Europe in 2040, 53% more flights than in 2017. That is an average growth of 1.9% per year. There will be a slow-down in growth from 2035 as markets become more mature, economic growth decelerates and as airport capacity limits across Europe become an increasing issue (see page 24).

**Global Growth** is the most challenging scenario, with high growth supported by economic growth at the high end of expectations, a high propensity to fly, a wide range of open skies agreements and relatively low fuel prices. This scenario records 19.5 million flights in 2040 in Europe, 84% more than in 2017. The average annual growth rate is 2.7%, but the earlier years see average annual growth rates of 3.1% per year (2017-2025) capitalising on the recent traffic recovery, while the later years show more moderate rates of 2% per year (2030-2040). This decelerating trend is explained by a mix of factors: market saturation, larger aircraft,

and capacity constraints at airports, which bite harder due to the higher traffic. As mentioned above, the recent return to traffic growth and new growth drivers mean that we recommend that, in addition to the most-likely *Regulation and Growth* scenario, particular attention be paid to the high-growth scenario *Global Growth*.

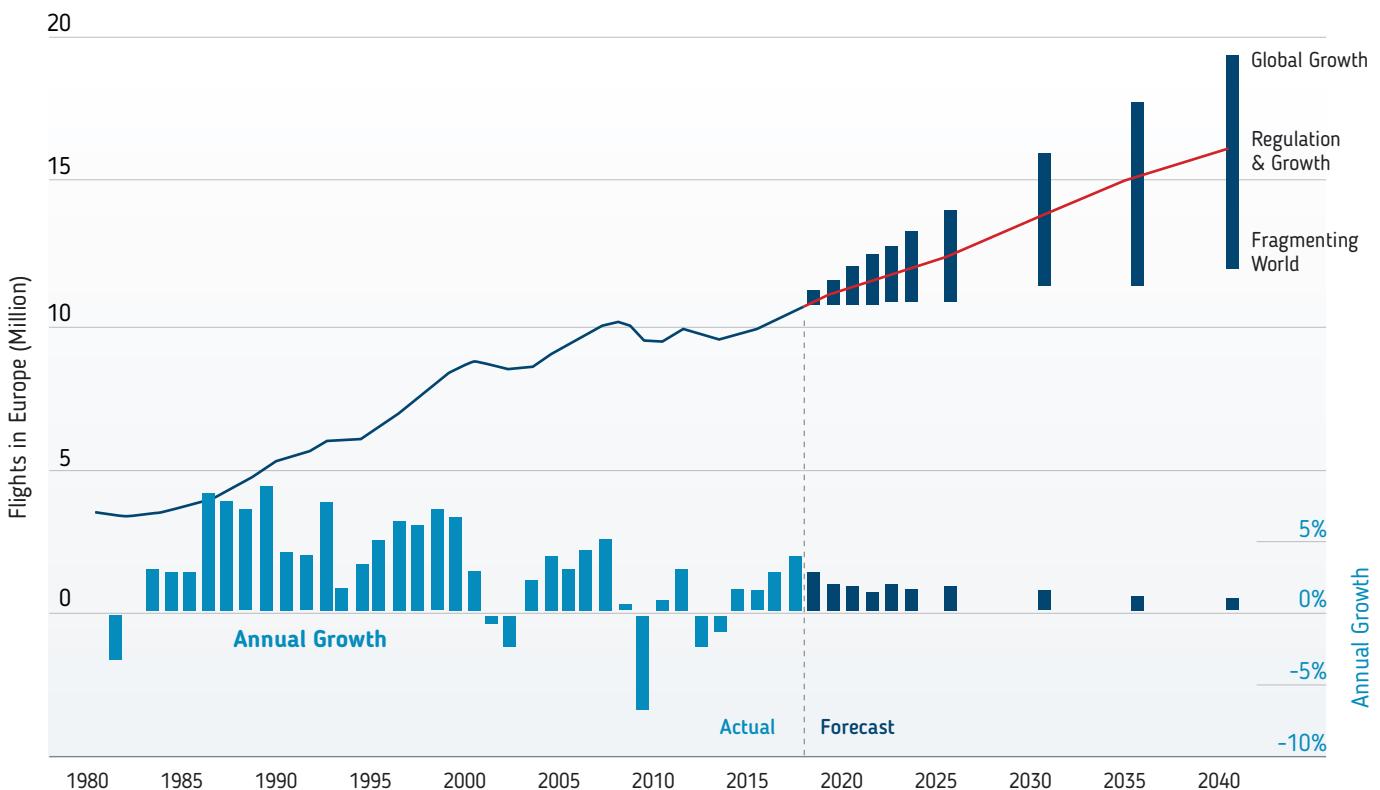
In **Happy Localism**, the effects of a more inward-looking Europe are slightly slower economic growth and higher fuel prices. Although starting from the same 2023 traffic levels as *Regulation and Growth*, growth is slower, resulting in 1.3 million fewer flights by 2040.

Lastly, in **Fragmenting World** many factors hinder the traffic growth: high oil prices, slow economic development, limited free trade agreements with partners outside Europe and a high price of travel. Flight growth stagnates, reaching only 11.9 million flights in 2040 in Europe, corresponding to 12% more flights than in 2017. In 2040, the final number of flights in Fragmenting World corresponds to the expected number of flights by 2022 in the most-likely scenario, *Regulation and Growth*.

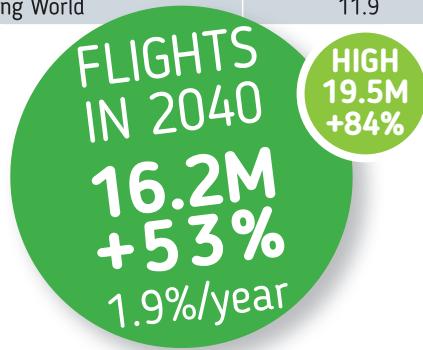
Overall, these are rather slower growth rates than before 2008. Indeed, over the 20 years before the economic crisis, the number of IFR flights in Europe doubled from 5 million IFR movements in 1988 to 10 million in 2008. This slower future

growth is due to slower economic growth (Figure 3), increasing fuel prices and higher levels of congestion at airports. There is more discussion of this in the 20-year forecast report (Ref. 6).

**Figure 8 / In Regulation & Growth flights increase by 53% between 2017 and 2040**



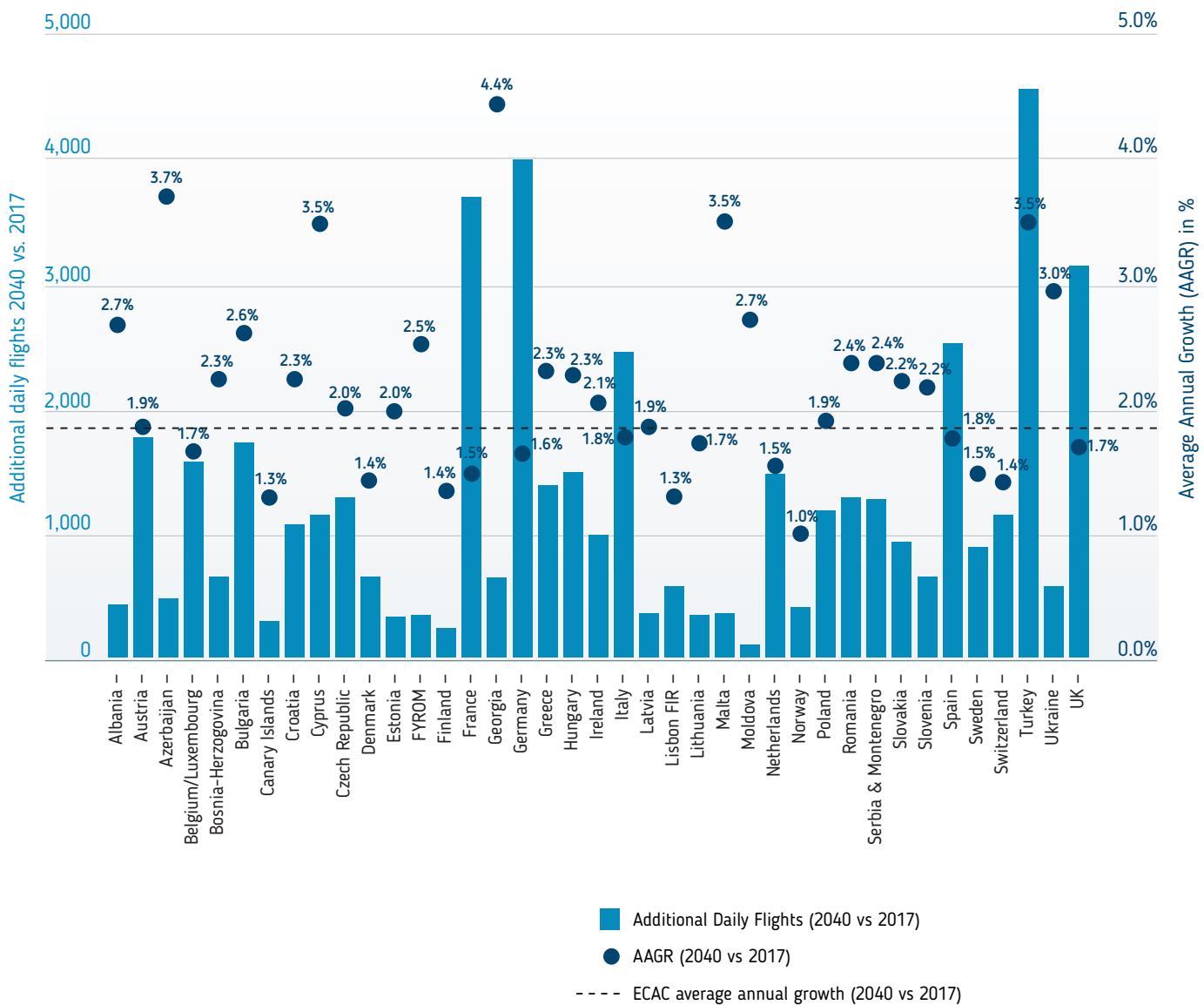
	IFR Flights (million) 2040	Total growth 2040/2017	Average Annual Growth 2040/2017	Extra flights/day (thousands)
Global Growth	19.5	84%	2.7%	24
<b>Regulation &amp; Growth</b>	<b>16.2</b>	<b>53%</b>	<b>1.9%</b>	<b>15</b>
Happy Localism	14.9	41%	1.5%	12
Fragmenting World	11.9	12%	0.5%	4



In percentage terms, the smaller markets to the East grow most quickly, due to the lower starting point, but also boosted by the new airport capacity at Istanbul. However, much of the most challenging airspace is in the West, and even small percentage increases here can mean a large

increase in flights per day on top of an already high total. In *Regulation and Growth*, four States add more than 3,000 flights per day (Figure 9). In *Global Growth* this climbs to six, with another half dozen not far behind. We return to this, with more detail, later (Figure 15).

**Figure 9 /** In *Regulation and Growth*, four states add more than 3,000 flights/day.





## DRONES: MORE OUTSIDE CONTROLLED AIRSPACE THAN INSIDE

There will be many more unmanned aircraft systems (UAS) or 'drones' by 2040. Most of these will operate outside current controlled airspace, but this will put pressure to cede parts of current controlled airspace. Within controlled airspace, 2017 saw about 6 flights/day. By 2040, the main effect will be to replace existing operations with 'optionally piloted' ones. On top of this transformation, we see growth of about 100 flights/day.

In 2017, there were 6 IFR flights/day by drones in controlled airspace, just 0.02% of total flights. We reviewed recent estimates for the growing use of unmanned aircraft systems (UAS), or 'drones', including sending out a questionnaire to industry. For Challenges of Growth, only flights in current IFR airspace are within scope. Towards the end of the 2040 horizon, there may be significant numbers of replacement 'optionally piloted' aircraft, which do not increase the overall demand, but present regulatory, safety and acceptance challenges if industry are to be able to deliver this new technology and thus continue to improve efficiency.

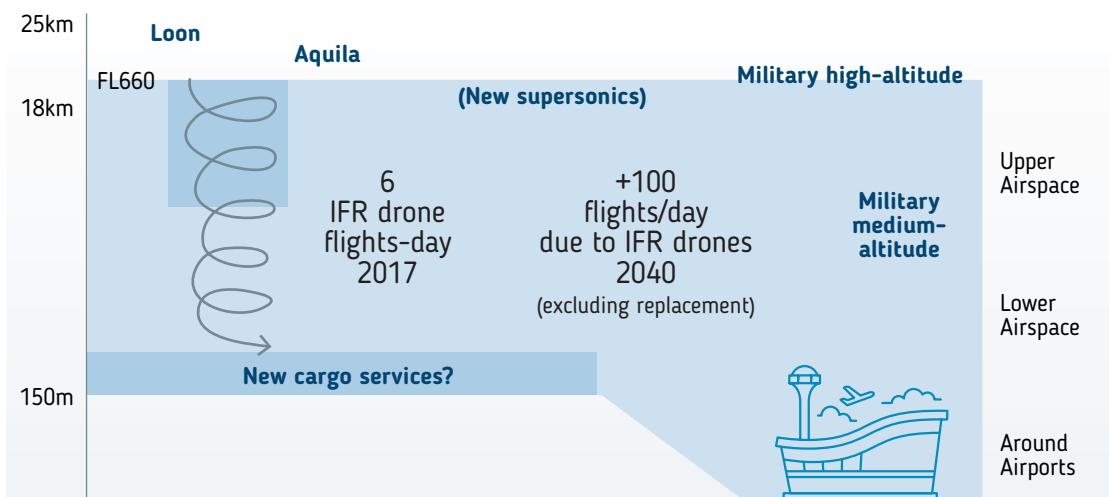
The number of applications that add to rather than replace existing flights, appears much smaller; mainly border and maritime patrol. We estimate around 100 additional flights/day net by 2040 for this, based on our analysis of SESAR Joint Undertaking (SJU) work (Ref. 8). However, there are up-side risks from new applications such as medium-haul cargo, currently being trialled

in China. By way of high-side estimate of the potential impact of this within Europe, we note that a doubling of the current all-cargo flights intra-Europe would be of order of magnitude 1,000 extra flights. We do not believe that more precision than an order of magnitude is possible at this stage.

It is clear that there will be a lot more UAS in future, but largely outside current IFR airspace. A significant issue will be the pressure this puts on aviation to cede airspace to new uses. There will be pressure to raise the 150m ceiling for low-level UAS operations, and there will be some airspace need for very high-level, long-endurance UAS during ascent or descent. Military and some civil projects (Loon, Aquila) are already operating here.

We conclude from the consultation that industry is far from a consensus or even a broad understanding of the prospects for growth in this area, so more work is needed.

**Figure 10 /** Outlook for additional flights from drones in IFR airspace, rather than replacements, is moderate. But the upside risks are high.



## AIRPORT CAPACITY PLANS ARE NOT ENOUGH

Airport capacity expansion plans, even if they can be delivered, are not sufficient. Plans are better focused than they were in 2013, with more capacity expansion where we predict more traffic growth. Even so, by 2040, there will be 1.5M flights more in demand than can be accommodated, 8% of demand in the most-likely scenario, *Regulation and Growth*. That is 160 million passengers. The gap is spread across 17 States. In *Global Growth*, the gap is 3.7M flights and 16% of demand.

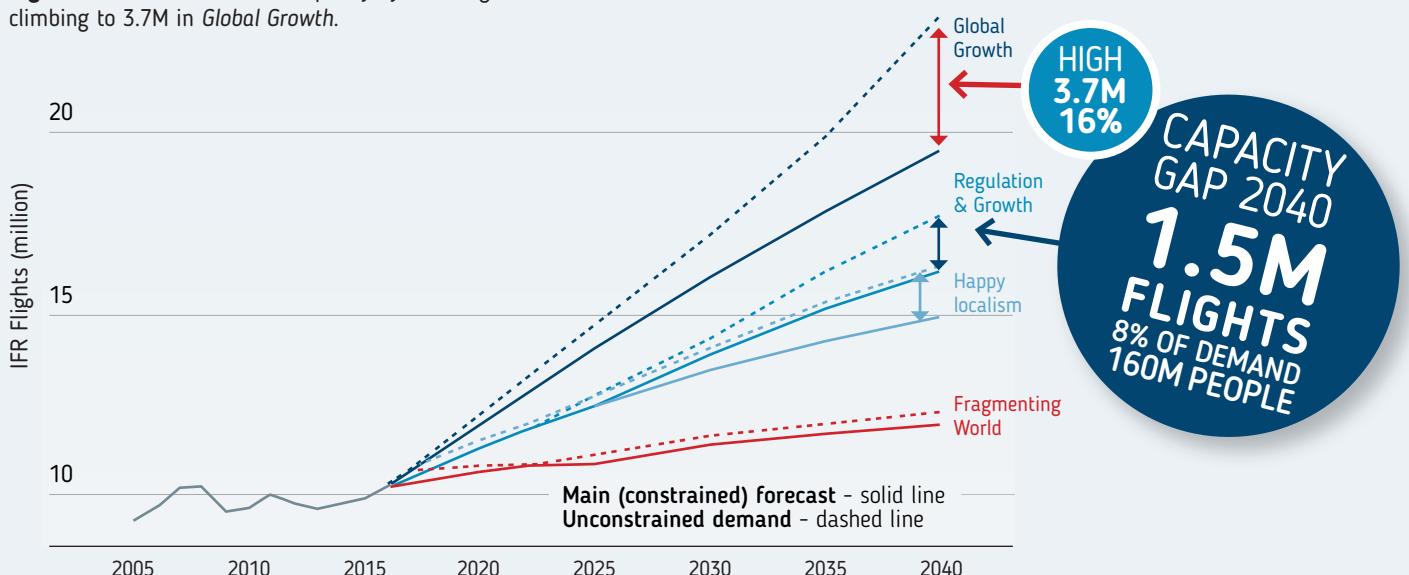
Even if it is possible to deliver all of the plans reported (and experience suggests that this will not be the case) the 16% planned increase in airport capacity is not sufficient to meet demand. In *Regulation and Growth*, the capacity gap is some 1.5M flights, which is 8% of underlying demand, or 160 million passengers unable to fly. In the high-growth, *Global Growth* scenario, that climbs to 3.7M flights unaccommodated, or 16% of demand, 360 million passengers. The results from all four scenarios are shown in Figure 11. This shows how the gap widens steadily in later years for *Regulation and Growth*, but accelerates in *Global Growth*, jumping by 80% in the last five years as the forecast pushes past the horizon of most capacity expansion plans that were reported to the Airport Corner.

Challenges of Growth 2013 looked out to 2035. At this horizon the 2018 situation has improved; unaccommodated demand has dropped from 1.9 to 1.0M in *Regulation and Growth*. This change is made up of:

- lower demand at that horizon: a net reduction of about 0.6M flights made up of larger falls for Turkey and Germany, for example, not entirely balanced out by increases in Spain and France;
- better-used capacity: where UK and Netherlands, for example, manage to accommodate more flights on lower total capacity plans, because the plans are better targeted to where we expect to find the growth.

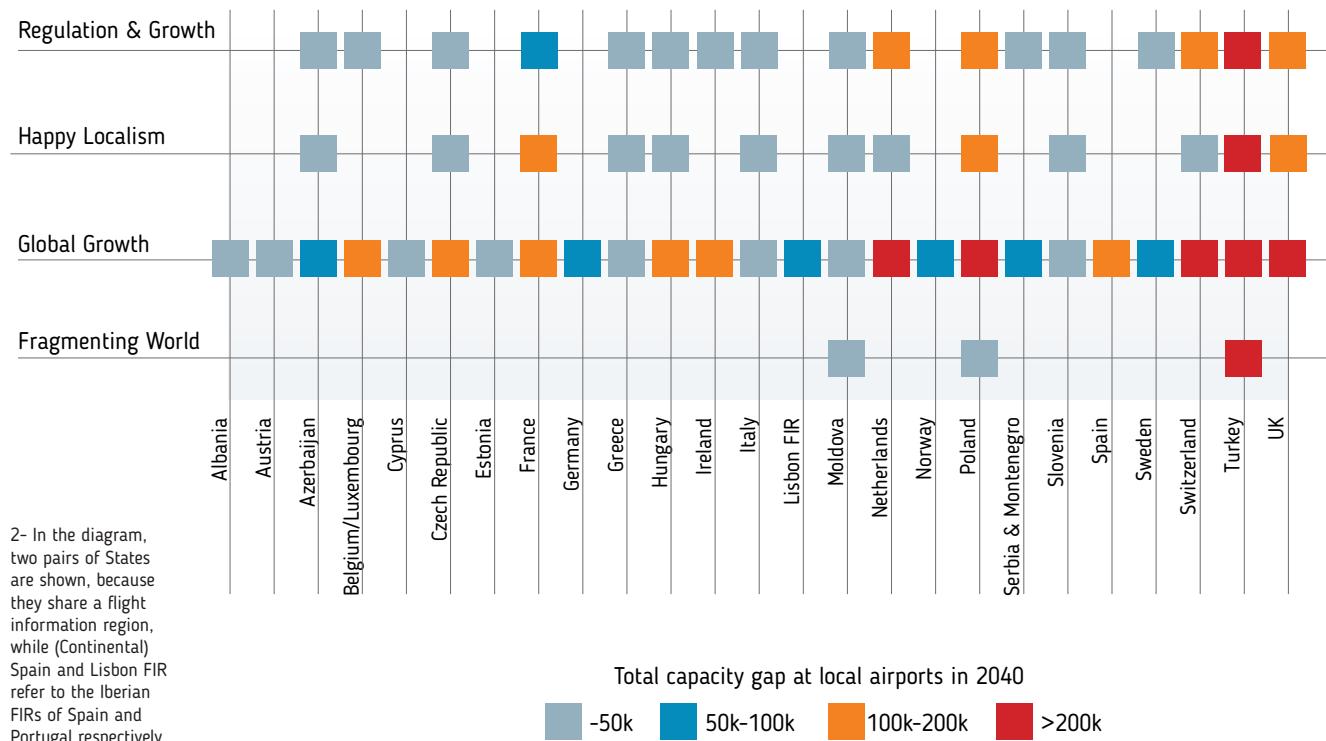
One of the aims of the Challenges series of studies is to raise awareness of the scale of the future needs, if aviation is to meet demand. The fact that there has been some improvement in capacity is, in respect of this goal, a positive sign, even if a million unaccommodated flights in 2035 is still a critical capacity gap.

**Figure 11** / Demand exceeds capacity by 1.5M flights in 2040, climbing to 3.7M in *Global Growth*.



The most-likely capacity gap of 1.5M flights is equivalent to 7 or 8 busy runways. But the gap is not conveniently located for that to be the solution. It is spread over 17 different States, as shown in Figure 12. Even with their ambitious capacity expansion plans, both Turkey and UK are forecast still to have additional capacity gaps.

**Figure 12 / In Regulation and Growth, the capacity gap is felt in 17 States<sup>2</sup>.**



	Unaccommodated IFR Movements (million)				Unaccommodated demand (%)			
	2025	2030	2035	2040	2025	2030	2035	2040
Global Growth	0.7	1.1	2.1	3.7	5%	7%	10%	16%
Regulation & Growth	0.3	0.5	0.9	1.5	2%	3%	6%	8%
Happy Localism	0.3	0.6	1.0	1.4	2%	4%	7%	9%
Fragmenting World	0.2	0.2	0.3	0.4	2%	2%	2%	3%

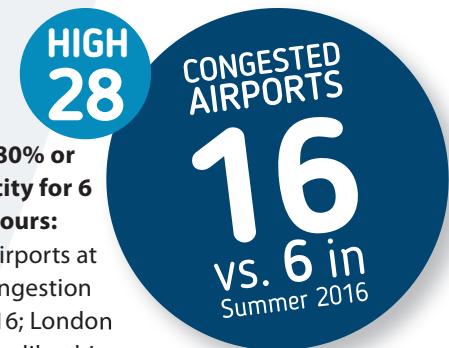
## INCREASING CONGESTION MEANS SEVERE DELAYS

Even with 1.5M flights unaccommodated and therefore lost, the network remains highly congested. The number 'Heathrow-like' airports operating near capacity for much of the day climbs from 6 in Summer 2016 to 16 in 2040, or even 28 in *Global Growth*. We have modelled delays from all causes, and find that in the Summer, these would jump from 12 minutes to 20 minutes per flight in 2040. In particular, the number of flights delayed by 1-2 hours increases by a factor of 7.

Flow management is the core responsibility of the Network Manager. It means regulating traffic to keep the network running smoothly and avoid the overloading of airspace by having too many flights arrive at one time. We have modelled the future traffic scenarios to see their impact on the network, taking two Summer months August and September as a busy traffic sample. The tool used allows us to model all causes of delay. So we see the development of primary delay, such as that from flow management regulations or from delays in loading baggage, as well as reactionary delay caused by late arrival of an aircraft from an earlier flight in the same day. There is more detail of this modelling in the congestion report (Ref. 9).

The results show that, even having lost 1.5M flights that are unaccommodated, there will still be a significant number of congested airports. There are a number of different ways to define congestion, but we focus on two here.

**Average delay per flight:** We assume that delays from causes other than congestion on the ground<sup>3</sup> remain constant. Then our modelling of the interaction of increased traffic and future capacity plans shows flow management delays climb from 1.2 mins flight in Summer 2016 to 6.2 in 2040. This is because the Network Manager needs to apply more and more flow management regulation to balance demand against the limited capacity. This drives the total delay from 12.3 minutes to 20.1 minutes on average, per flight (Figure 13).



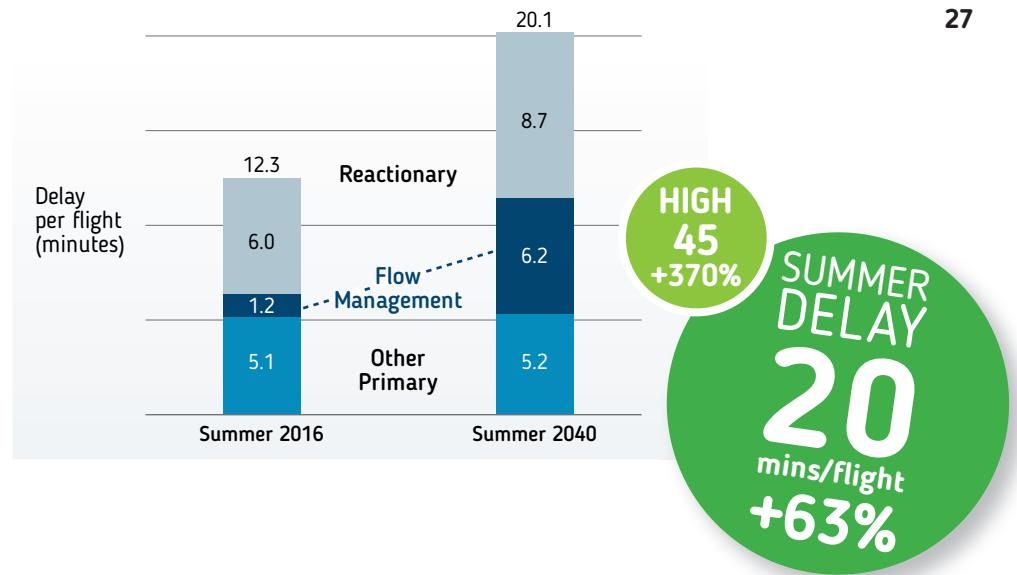
**Operating at 80% or more of capacity for 6 consecutive hours:**

There were 6 airports at this level of congestion in Summer 2016; London Heathrow being like this year-round. This is already an increase on the 3 airports observed in 2012, in the last report. The forecast is now for this to climb to 16 congested, 'Heathrow-like' airports by 2040, in *Regulation and Growth*, or even 28 in *Global Growth*. That is a small improvement on the 20 congested airports in the most-likely scenario from CG13, since the capacity growth is better targeted at the larger airports, as previously discussed.

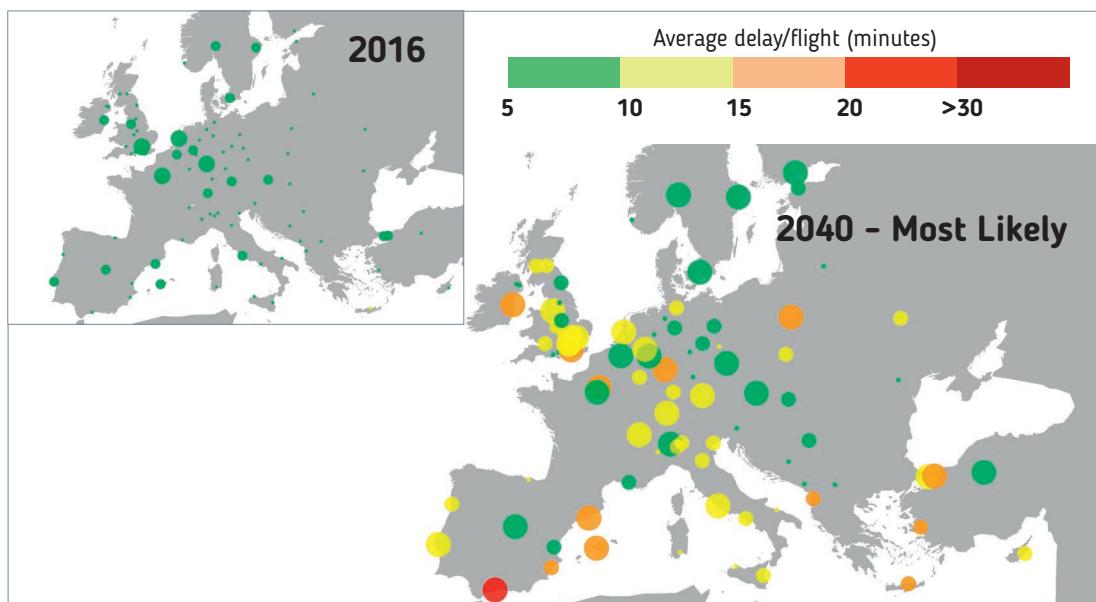
Another way of looking at this outcome is that in *Regulation and Growth*, more than 80% of the capacity of the top 20 airports will be being used for most of the operating day, up from less than 70% in 2016.

Airlines and airports adapt to a certain level of congestion, with operating procedures, processes, schedules and capital investment to provide a reasonable quality of service to their passengers. However, it is hard to see how quality of service could be maintained if average delays were nearly to double. There is a long tail to the distribution of delays: our modelling shows a significant increase in flights delayed by 60-120 minutes in this situation, with 7 times as many by 2040 in *Regulation and Growth*. This means around 470,000 passengers each day delayed by 1-2 hours in 2040, compared to around 50,000 today. We also modelled the cancellation of flights in response to strong delay, but at these levels of delay any cancellation model is working outside its calibration region. More details are in the congestion report (Ref. 9).

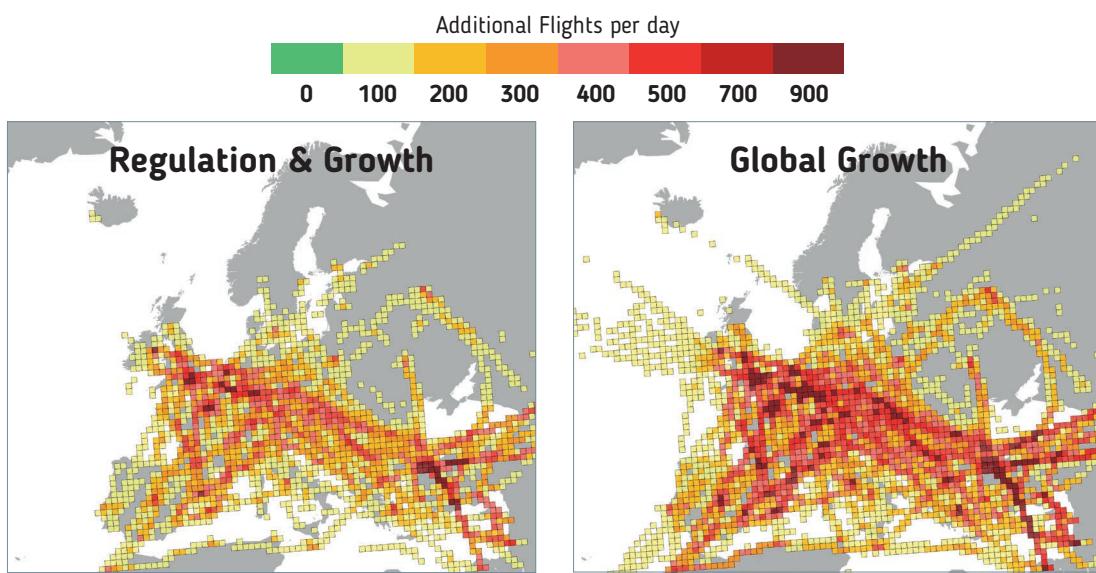
<sup>3</sup>- For simplicity we take this to include cases where airport constraints are more in the surrounding airspace than on the runway.



**Figure 14 /** The congestion challenge means degraded performance at a significant number of airports.



**Figure 15 /** Between 2017 and 2040, flights will increase most in what is already the most-challenging airspace.



Congestion is also a challenge for the airspace. Although for this study we did not model airspace congestion, we can look in more detail at where the traffic increases will be. By 2040 in *Regulation and Growth*, a majority of en-route airspace will face an increase in demand of between 50% and 80%, so some airspaces will see growth well ahead of the 53% average growth. For example, at this time horizon, Turkey will face 2.5 times as many flights. This expected growth will directly impact the neighbouring countries, so Romania, Bulgaria, Serbia, Cyprus and Greece will experience high level of traffic demand with expected growth around or greater than 80% compared to 2016.

The European core area will not be exempt, having an average demand growth between 40% and 55%. But here, in what is already today the most complex and busy airspace in Europe, even a small percentage change is an operationally-significant increase in traffic. Figure 15 shows that small segments of this airspace will receive more than 900 additional flights per day. To handle this growth where traffic is already dense and complex will surely represent as much of a challenge as a higher percentage growth elsewhere. EUROCONTROL Network Manager is part of the strategic airspace study for DGMOVE looking in detail at how airspace optimisation can reduce this en-route congestion problem.

## MITIGATION – MORE AIRPORT CAPACITY BY A VARIETY OF MEANS

Closing the capacity gap is a task for airports, providing more infrastructure, but also for airlines, regulators and others. Taking a cue from how industry has responded in the past, we modelled six different mitigations, apart from new runways. Of these mitigations, the most promising are the developments under SESAR Wave 1, which target busy airports at peak hours. These developments could reduce the most-likely capacity gap by 28% in 2040, if they can be successfully deployed.



The response to the capacity gap, the mitigation, will be led by airports but involve a broad range of actors in the industry: airlines, regulators, local authorities, passengers and shippers, air navigation service providers, research organisations amongst others. Airport congestion is not a new phenomenon, and looking into historic data we can identify a number of responses which industry has used in the past. In the mitigation study (Ref. 5) we investigated the possible impact of a range of such responses.

Building new airport infrastructure is clearly a principal response, and we have seen in earlier sections how well-targeted airport capacity plans can reduce the capacity gap, even if such plans are not always easy to deliver.

Beyond this, the mitigations are more speculative extrapolations of responses that

have been seen in the past or plans for what might be achieved in the future. The outcome of six such what-ifs is shown in Figure 16.

**SESR:** Wave 1 of SESAR has a package of 10 improvements to increase airport capacity at peak times. The SESAR target gains are around 7% in peak throughput. This gives around 1.5% increase in total capacity across the 111 airports but, since they are focused on peak hours, the effect in *Regulation and Growth* is to reduce the 1.5M flight capacity gap by 28% in 2040. They are much less effective in *Global Growth*, where the capacity challenge is much broader. Overall, this mitigation is more focused than in CG13 and as a result gives a bigger reduction where the saving was 19%.

**Local Alternative:** Major cities are typically not short of runways, but often they are not at the right airport and lack the right airport and ground access infrastructure, or they are not

well-placed relative to residential areas. Where these obstacles can be circumvented, airlines may focus their growth away from the principal airport to avoid congestion, either under their own or as a government initiative. In a what-if? analysis we looked at some city-specific options for this, and found that some 16% of the capacity gap would be mitigated, if these options could be delivered. This is probably an upper bound, given the difficulties in implementing such changes, it is also lower than that seen last time (21%).

**Consensus Benchmark:** For smaller airports, capacity plans sometimes seem to be driven as much by current demand as by fundamental limits to local physical capacity. We took, as a what-if?, the assumption that single-runway airports could if necessary reach the upper-quartile capacity of this whole group, 200,000 movements per year. This reduced the capacity gap by 13%, marginally better than in CG13 (10%).

**Schedule smoothing:** When airport slots at peak hours are unavailable, airlines add capacity at other hours. This can improve fleet utilisation, but has a cost impact due to lower yields.

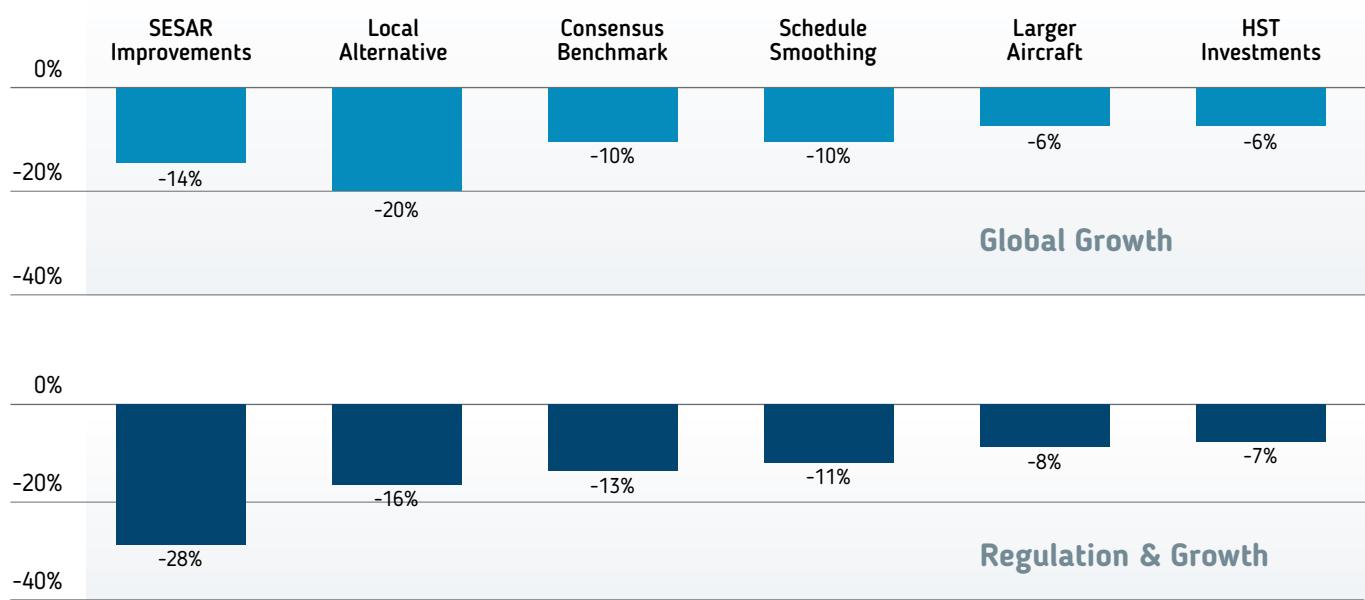
In aggregate historical data, we can see the effect of this as the quieter hours at an airport

fill up. Projecting the same forward, based on the current quiet-versus-busy-hour pattern at Heathrow, gives us the 'schedule smoothing' what-if? Here, the reduction in the capacity gap is 11%, considerably lower than in CG13 (20%).

**Larger aircraft:** Looking around Europe, and current traffic, we can see wide variation in the size of aircraft used to serve city pairs that are otherwise similar in distance, in total passenger numbers and in having competition between airlines. As a what-if?, we modelled the effects if the larger aircraft on such city pairs were more consistently used. This led to an 8% reduction in unaccommodated demand: more passengers able to fly, on fewer flights.

**HST investment:** The forecast scenarios already capture known plans for improving high-speed train (HST) infrastructure, and our forecast includes a model of the local reductions in air passenger demand that will result. As a what-if? we looked at 43 other city pairs which have significant numbers of flights, and at distances where HST is often competitive. If these additional HST links were possible, it would move more passengers from air to rail, and reduce the capacity gap by 7%. The obstacles to making that possible are large, including funding and acceptance by residents along the route.

**Figure 16 / Mitigation: What-if? reductions in capacity gap for 2040.**





## ADAPTING TO CLIMATE CHANGE NEEDS LONG-TERM PLANNING

The climate is changing. Over the medium and long term, there will be changes to temperatures, to rain, snow, wind and storm patterns and in the sea level. This will affect aviation infrastructure, patterns of demand, and daily operations. An updated and enlarged survey shows that the European aviation industry recognises that these challenges are coming. But there has been little change over the last five years in the proportion of organisations actually planning for adaptation to climate change impacts. This is a risk that needs further investigation.

Since Challenges of Growth 2013, the two main scientific documents on climate change that were referenced then, the IPCC Assessment Reports (eg. Ref. 10) and the European Environment Agency (EEA) Climate Change Impacts and Vulnerabilities report (Ref. 11), have both been updated. Their message remains consistent and clear: inertia in the climate system means that some degree of climate change is inevitable. Figure 17 summarises the principal

changes to the climate and effects on aviation, which include damage to infrastructure, delays and disruption on the day of operation, and changes to underlying demand: when and where tourists will want to go.

The CG18 environment report (Ref. 12) describes the background and impact in more detail. It also begins to address some of the adaptation measures that are available.

**Figure 17** / Summary of the principal climate change impacts on aviation

Climate Effect	Aviation Impact
<b>Temperature</b>  Europe continues to warm more quickly than the global average: Scandinavia more in Winter, southern Europe in Summer.	Aircraft performance Seasonal and geographical changes in tourism demand patterns Heat damage to infrastructure
<b>Changes to Rain &amp; Snow Patterns</b>  Less snow overall, but heavier events Less rain in the South, more in the North More heavy rainfall events	Delays and cancellations Flooding of airports and access routes Change in snow clearance needs
<b>Changes to storm patterns</b>  More uncertainty in the climate modelling here, but increase in frequency of strong and damaging storms	Delays, re-routing, increased fuel burn Loss of en route capacity Convective weather affecting multiple airports simultaneously
<b>Sea Level</b>  Over longer term, sea level rise Uncertainty over storm surges	Permanent or temporary loss of airport capacity, infrastructure and access. Network disruption
<b>Changes to wind patterns</b>  Change in jet stream strength, position and curvature Shifts in prevailing wind direction Increase in extreme wind speeds in North and centre.	Increase in clear air turbulence Increased variability in trans-Atlantic times and routes Crosswind changes affecting airport capacity Operational disruption

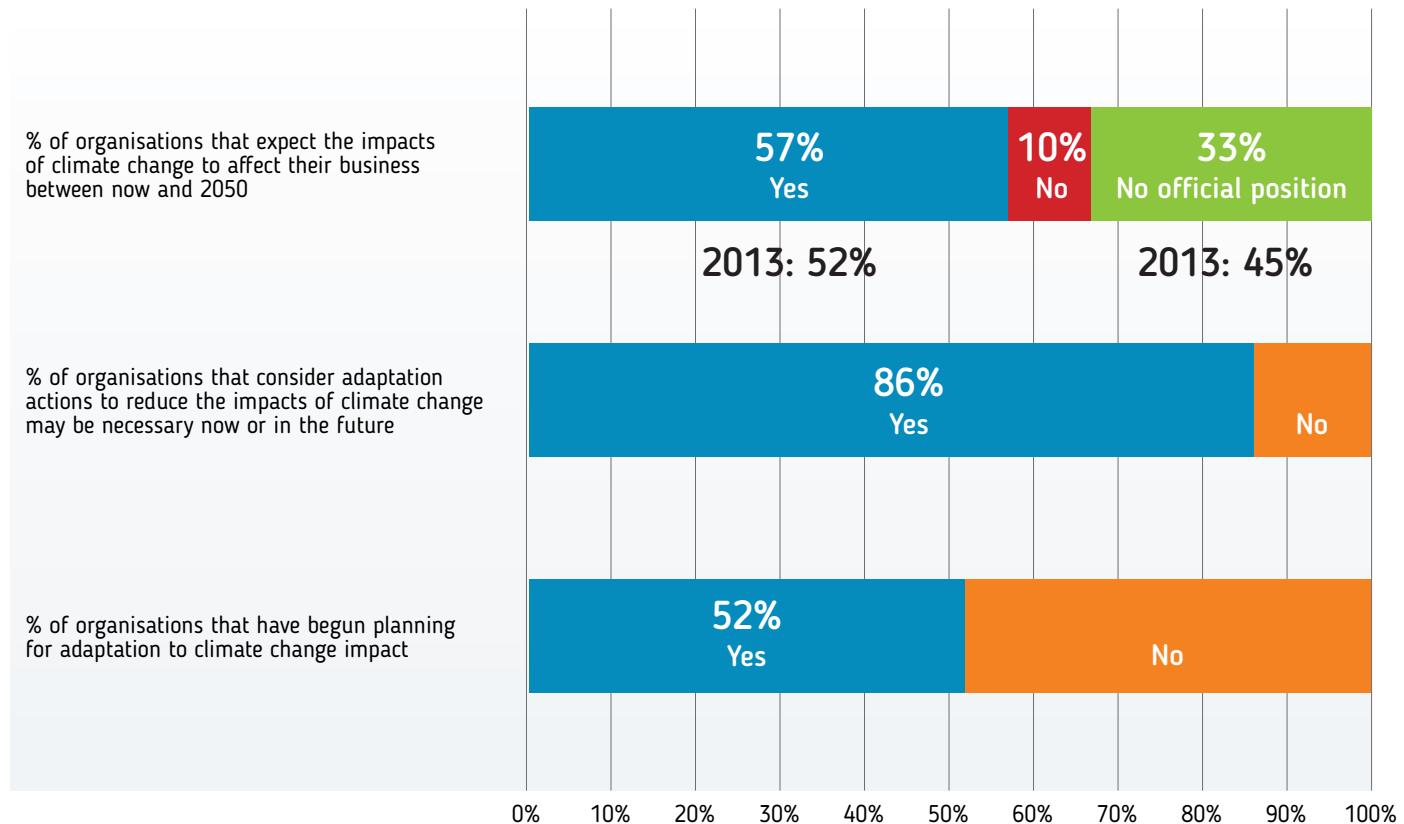
In CG13, we consulted industry to assess the extent to which it was ready for climate change. We re-ran this survey for Challenges of Growth 2018, receiving more than 90 replies, a much larger response than five years ago.

A clear majority of respondents believe that their businesses will be affected by climate change (Figure 18). Indeed, around a quarter of total respondents think that their businesses are already being affected. There have been a number of well-reported severe weather events recently. While climate scientists would be cautious about jumping to the conclusion that this was climate change, the events help to persuade that there will be challenges ahead, since 86% believe that they will have to respond (Figure 18).

Given the long-term horizons of investments in aviation infrastructure, some of these climate change effects are within planning horizons, eg before 2040. But only half (52%) reported that their organisations had begun to plan for adaptation to climate change impacts. This is a proportion that has hardly moved in the last five years (although the response size was small last time). Respondents gave reasons for not taking action that included lack of information and lack of resources, but this delay in taking action is a clear risk for the future.

A theme of Challenges of Growth is sounding an early warning, leading to actions that are taken in good time. We need to do more here to understand the gap between need and real planning for action: what are the reasons for this gap? Are they valid? If not, what can be done to encourage investments that take climate change into account?

**Figure 18 / A majority believe climate change will affect their business**





# THE MAIN CHALLENGES

In summary, we have explored the future outlook by means of four scenarios. We identified three principal challenges linked to airport capacity.

**Airport capacity** plans are more focused on where the capacity is needed, ie at the busiest airports, but they are still not enough to meet forecast demand. In the most-likely scenario Regulation and Growth, the gap of 1.5M flights is roughly 8 runways, but impossibly shared across 17 different States. We looked at other options, but with that scale of gap, new airport capacity has to be part of the solution. We do not need to look far for evidence of how difficult it can be to deliver it, so the challenge is to plan and deliver enough future capacity.

Lack of airport capacity means unaccommodated demand, but will also bring Summer **network delays** more than 60% higher than today. The number of flights delayed by 1-2 hours will go up by a factor of 7. It will be a challenge to provide an acceptable quality of service to passengers and shippers with this level of delays at airports, and that is without including the en route challenge of adding high volumes of flights to what are today already the most complex and congested parts of the airspace.

An updated survey shows that the European aviation industry recognises that climate change is coming. Over the medium and long term, there will be changes to temperatures, to rain, snow, wind and storm patterns and in the sea level. This will affect aviation infrastructure, patterns of demand, and daily operations. Industry recognises the need for **adaptation**, but only half have begun to plan.

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CAPACITY  
GAP 2040  
**1.5M**  
FLIGHTS  
8% OF DEMAND  
160M PEOPLE

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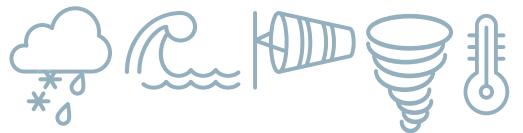
HIGH  
3.7M  
16%

2040  
SUMMER  
DELAY  
**20**  
mins/flight  
**+63%**

HIGH  
45  
+370%

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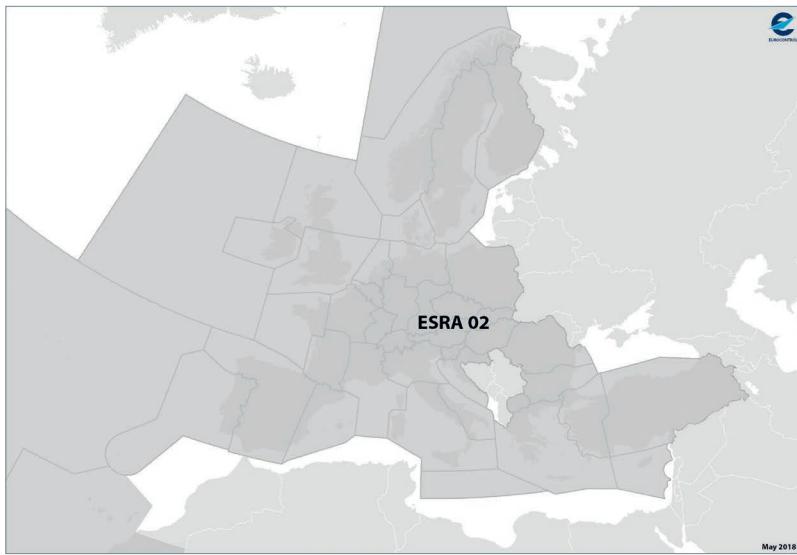
NEED TO ADAPT



## A. COMPARISON WITH PREVIOUS CHALLENGES STUDIES

To achieve a like-for-like comparison with previous Challenges studies, we use the ESRA02 region (Figure 19), since the ECAC region was not analysed in 2004. We are also limited because the 2004 study only reached to 2025, and the 2008 study to 2030. The comparison for the most-likely scenario, and the most challenging scenario is shown in Figure 20.

**Figure 19 / ESRA02 region**



**Figure 20 / Comparison with previous studies for the ESRA02 region**  
*(Results are different in the main text, which uses the larger ECAC region.)*

	Global Growth			Regulation & Growth		
	Demand (million)	Flights (million)	Capacity gap	Demand (million)	Flights (million)	Capacity gap
<b>2025</b>						
Challenges to Growth 2004	20.9	17.2	18%	16.7	15.1	10%
Challenges of Growth 2008	23.6	19.9	16%	17.6	16.7	5%
Challenges of Growth 2013	15.1	13.9	8%	12.8	12.3	4%
Challenges of Growth 2018	14.3	13.6	4%	12.4	12.1	3%
<b>2030</b>						
Challenges of Growth 2008	29.1	22.1	24%	20.4	18.2	11%
Challenges of Growth 2013	17.7	15.4	13%	14.4	13.2	8%
Challenges of Growth 2018	16.6	15.5	6%	13.9	13.4	3%
<b>2035</b>						
Challenges of Growth 2013	16.9	21.3	21%	15.9	14.0	12%
Challenges of Growth 2018	19.2	17.2	10%	15.6	14.7	6%

In terms of demand and accommodated flights, we see clearly the effects of:

- the economic downturn, which has led to a nine-year hiatus in traffic growth, meaning that the 2008 peak was not passed until 2017 (ECAC figures). That nine-year shift is nearly 5 million flights in Regulation and Growth.
- An economic forecast for future years which continues to be reduced, leading to increasing divergence of the current flight forecast from previous forecasts.

In Regulation and Growth, the forecast is relatively stable. The capacity gap is slightly lower in 2025, and significantly lower in 2030 and 2035, for example because of the better-targeted growth plans that have been discussed. Since we are now five years closer to these dates, such an improvement would be hoped for; for one thing it suggests that the message of Challenges of Growth has been heard.

## B. GLOSSARY

AAGR	Average annual growth rate
ATM	air traffic management
CG13, CG18	Challenges of Growth 2013, 2018
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
drone	(we use this interchangeably with 'unmanned air systems' here)
ECAC	European Civil Aviation Conference
ETS	emission trading system
EU	European Union
Europe	unless otherwise specified, this refers to airspace of the ECAC States ( <i>Figure 21</i> )
IATA	International Air Transport Association
IFR	instrument flight rules
FIR	flight information region
GDP	gross domestic product
high	refers to the <i>Global Growth</i> scenario
HST	high-speed train
most-likely	refers to the <i>Regulation and Growth</i> scenario
ICAO	International Civil Aviation Organisation
RPK	revenue passenger kilometre
SESAR	Single European Sky ATM Research
SJU	SESAR Joint Undertaking
STATFOR	Statistics and Forecast Service of EUROCONTROL
SUG	STATFOR User Group
UAS	unmanned air systems (we use this interchangeably with 'drone' here)
Unaccommodated demand	the forecast flights that exceed an airport's reported capacity

**Figure 21** / European Civil Aviation Conference (ECAC) Area



## C. REFERENCES

Published reports from the current and previous *Challenges of Growth* studies are available at [www.eurocontrol.int/articles/challenges-growth](http://www.eurocontrol.int/articles/challenges-growth).

- 1- *Study on Constraints to Growth*, Volume 1, ECAC-EUROCONTROL, 2001.
- 2- *Challenges to Growth 2004 Report*, ECAC-EUROCONTROL, December 2004
- 3- *Challenges of Growth 2008, Summary Report*, EUROCONTROL November 2008
- 4- *Challenges of Growth 2013, Summary Report*, EUROCONTROL June 2013
- 5- *Mitigating the Challenges, Challenges of Growth 2018 report*, EUROCONTROL, June 2018
- 6- *Flight Forecast, Challenges of Growth 2018 report*, EUROCONTROL, June 2018
- 7- *Airport Corner*, public version [https://ext.eurocontrol.int/airport\\_corner\\_public/](https://ext.eurocontrol.int/airport_corner_public/)  
last accessed 10 April 2018.
- 8- *European Drones Outlook Study*, SESAR Joint Undertaking, November 2016.
- 9- *Air Traffic Congestion in 2040, Challenges of Growth 2018 report*, EUROCONTROL, June 2018
- 10- *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.
- 11- *Climate change, impacts and vulnerability in Europe 2016. An indicator-based report*. European Environmental Agency, 2016.
- 12- *The Environmental Challenge*, Challenges of Growth 2018 report, EUROCONTROL, 2018 (forthcoming)







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