

# The New Airport for Berlin – Has Willy-Brandt (BBI) Airport enough Capacity for the Future? A Simulation Approach

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partner/sponsor:



## Personal Background

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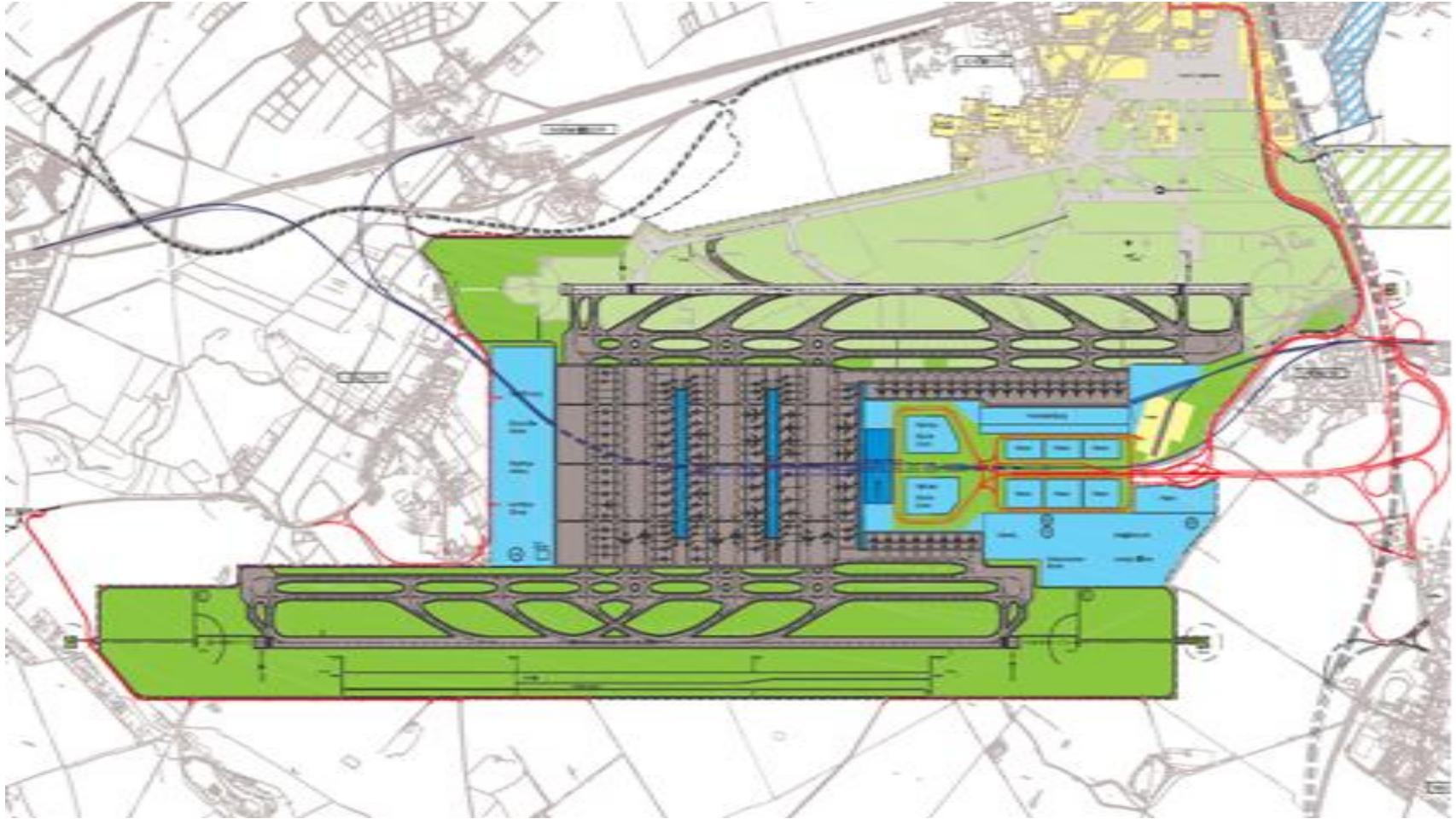
- Graduate in Business Administration and Engineering from Berlin School of Economics and Law (BSEL) and University of Applied Sciences Berlin
- Diploma Thesis (2009): “Benchmarking Airport Productivity and the Role of Capacity Utilization”
- 4<sup>th</sup> year in German Airport Performance Research Project at Berlin School of Economics and Law
- Conducted Benchmarking studies of European Airports and Airlines (75 Airports, 50 Airlines)
- Consultation in MIME Project, funded by EU Commission, studying Noise mitigation around airports, by market-based instruments
- Looking for new opportunities in Air Transportation Research & Development and PhD position

# Contents

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1. Berlin Airports Today and Tomorrow
2. European Comparisons to BBI
3. SIMMOD Study on Airside Capacity of BBI
4. Extension Plans for similar Airports
5. Vision

# Plan of Berlin-Brandenburg International Airport



# Why is Airport Runway Capacity so important

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## Economical Perspective:

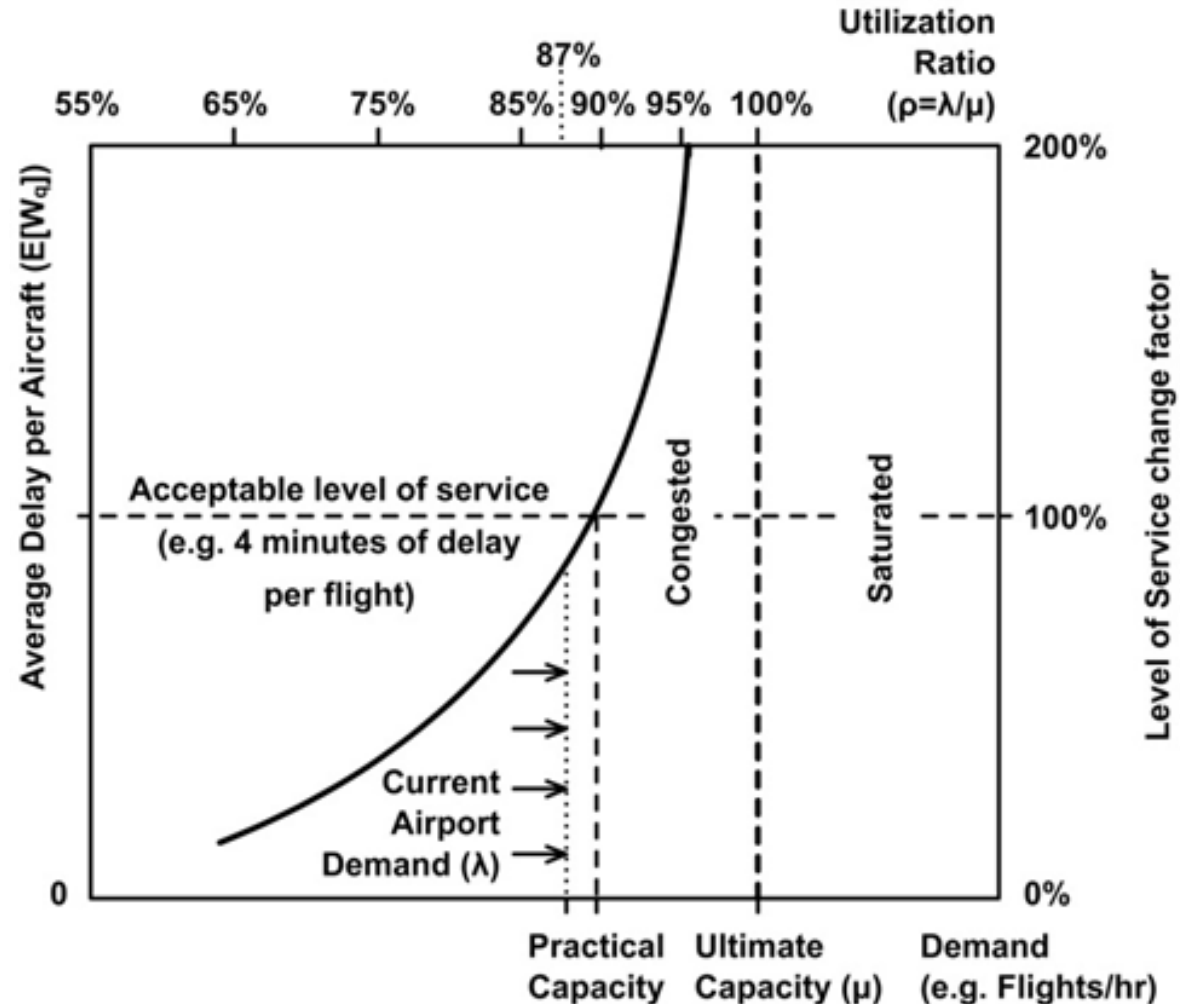
- **Global Competition** of Regions which makes air interface vital
- **Attracting Airlines and Business**, Tourists and Transit Passengers
- **Reducing Costs** for Flying, by providing enough slots for demand and increasing future demand

## Technical Perspective:

- **Operating at Practical/Sustainable Capacity** is important for Airport System Stability, Reliability (Scheduling!) and Service Quality (level-of-service (LOS) of e.g. 4 minutes of mean delay/flight)
- **Operating at Maximum capacity leaves no margin-of-safety** for unscheduled random events, e.g. weather (snow!), unscheduled flights (Business jets, Charter, General Aviation (GA)), emergency landing etc.)
- **Delays increase exponentially at high utilization rates**
- **Knock-on delay effects make operating at airport costly for airlines**

# Relationship between Demand, Capacity and Delay

- As airport demand increases towards its (ultimate) capacity, the airport system becomes congested and average delays per flight increase exponentially.



Modified from Horonjeff 2010, p.488

## Berlin Airports today and tomorrow

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- **From 3 (Tegel (TXL), Schoenefeld (SXF), Tempelhof (THF) airports) make 1 (Willy-Brandt Airport (BBI))**
- **Existing airports (SXF and TXL) will be replaced fully by BBI on October 2011**
- **Political Dimension and Relevance** for a study of BBI capacity and future development:

**“When the Number of Runways at the existing Airports will be reduced from 4 to 2, Bottlenecks are bound to occur.”**

(German Federal Transport Minister Peter Ramsauer,  
Tagesspiegel, June 7<sup>th</sup>, 2010)

## European Comparisons

- **Peer group of independent, far parallel-runway airports**  
(Separation of at least 1500 meters and alternate-mode operations)
- **Best Practices** with similar runway layout and highest productivity (2008) in comparison to BBI (SXF + TXL): **London-Heathrow and Munich**
- **BBI has the potential to rank third-biggest European airport** (before Palma-de-Mallorca (PMI) and Oslo (OSL)) **in peer group by 2012**

Airport	Annual PAX (million)	Annual Flights (thousand)	PAX per Flight	Peak Hour Throughput
London-Heathrow	67.2	473	142	103
Munich	34.5	409	84	93
BBI (TXL+SXF 2008)	21.2	212	100	48
<b>BBI Planned Final 2023 (Planning Permission 2004)</b>	<b>30</b>	<b>301-329</b>	<b>100-91</b>	<b>90</b>
<b>BBI Sustainable Final at 2024 (60% growth from 2008 at 3%; SIMMOD study 2010)</b>	<b>28.1</b>	<b>303</b>	<b>93</b>	<b>76</b>



## BBI Study Background

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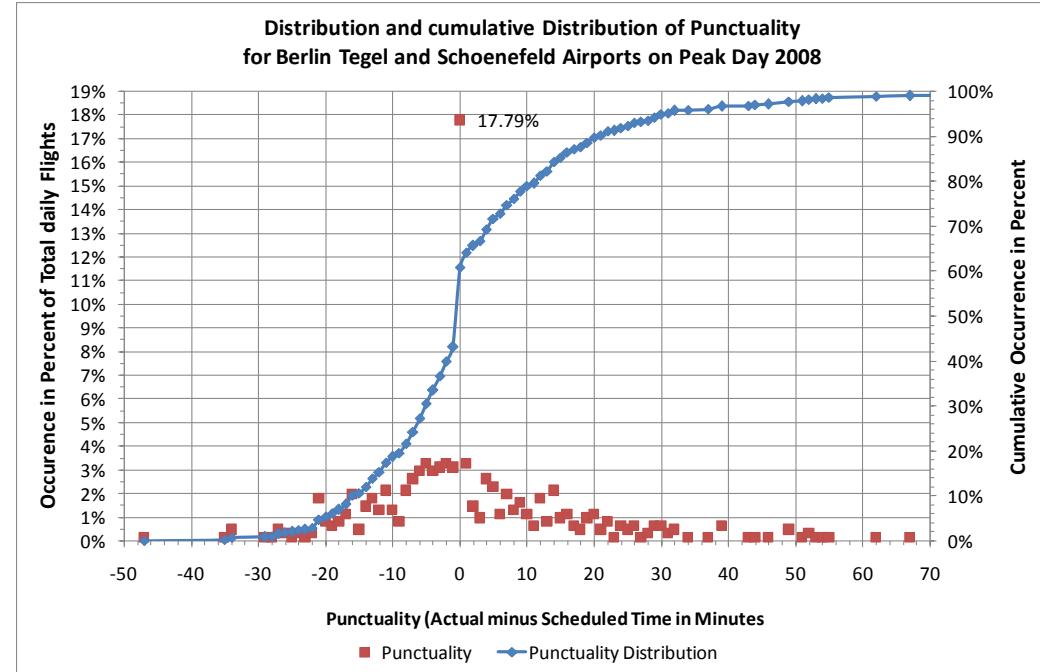
- Study prepared for International Conference on Operations Research "Mastering Complexity" Munich 2010 with Prof. Joachim Daduna (BSEL)
- Full study available in September 2010
- Software: GUI: Visual SIMMOD  
Engine: FAA SIMMOD Engine
- Flight schedule data: Flightstats.com
- Basic Information: Official Planning Permission Documents for BBI
- Sensitivity Analysis towards 6 Scenarios with different traffic mixes (shares of aircraft wake turbulence classes: Small (<7 tons MTOW), Large (7-136 tons MTOW) and Heavy (>136 tons MTOW))
- 11 growth scenarios (-20%,0%,20%,40%,...,200%) at 10 iterations each
- Based on predefined Design Peak Day 2008 (June 26<sup>th</sup> 2008)

# Simulated Scenarios and Traffic Mixes

					Scenario 0		Scenario I		Scenario II		Scenario III	
Airport	SXF		TXL		BBI		BBI		BBI		BBI	
Turbulence Class	Share	Flights	Share	Flights	Share	Flights	Share	Flights	Share	Flights	Share	Flights
HEAVY	0%		3%	12	2%	12	5%	32	15%	95	5%	32
LARGE	100%	155	95%	454	96%	609	95%	603	80%	508	84%	533
SMALL	0%		3%	14	2%	14	0%	0	5%	32	11%	70
Sum	100%	155	100%	480	100%	635	100%	635	100%	635	100%	635
Mix Index (MI)	100%		102%		102%		110%		125%		99%	
MI = 3 x (% HEAVY) + (% LARGE)												

# BBI SIMMOD Study Assumptions

- Realistic assumptions resulting from combined actual traffic data of Berlin Tegel (TXL) and Schoenefeld (SXF) airports and Planning Permission documents:
- Delay per Flight will be Key Performance Indicator
- Schedule
- Traffic Mix
- Runway Layout
- Parking Stands
- Punctuality & other Random Distributions
- 20 Additional Business Jet or GA Flights in morning & evening Peaks (7-12 & 15-20; Scenario 0a)

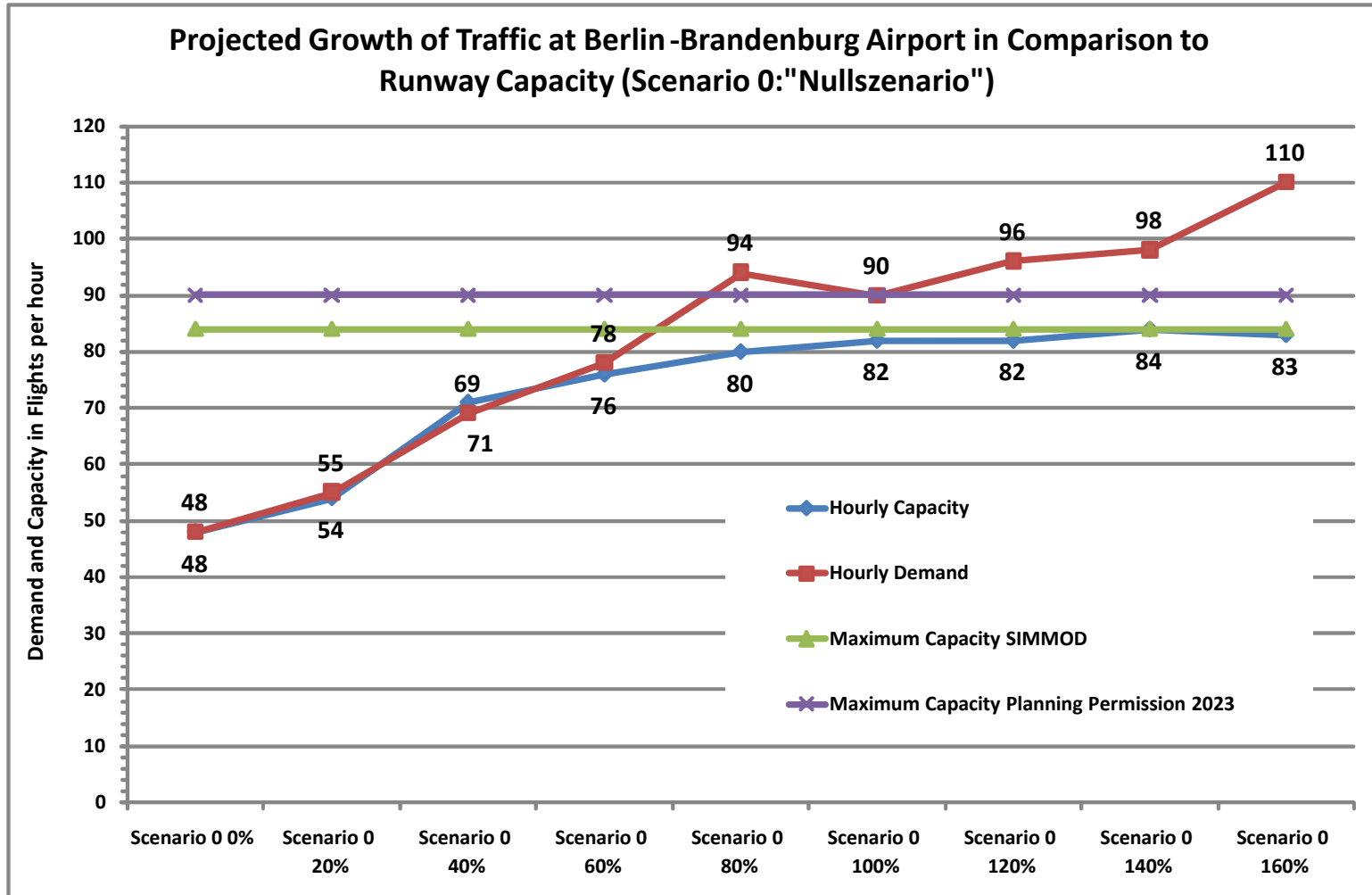


## Presenting Interim Results

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- **Scenario 0** (baseline, 2 independent parallel runways, current SXF+TXL=BBI traffic mix):
- **Simulated throughput Capacity of 82-84 Flights per hour at 120-140%! Further increase of traffic resulted in grid locking queues and therefore flight cancellations.**
- **Sustainable long-term throughput/capacity of 76 Flights per hour!** (1 operation every 47 seconds) The animation proves this.
- **Demand higher than Capacity at 60% Growth**, based on 2008 busy day schedule and Level-of-Service of 5-6 minutes of Avg. Delay per flight.
- **Delays will increase exponentially beyond 60% growth.**
- Upper and lower boundaries of historic growth rates at TXL and SXF underline the assumption that **demand=capacity reached between 2016-2024** (at 3-6% annual growth).
- **Each 20% growth increment results in doubling of daily delays**

# Results Scenario 0: Simulated Peak Throughput at BBI



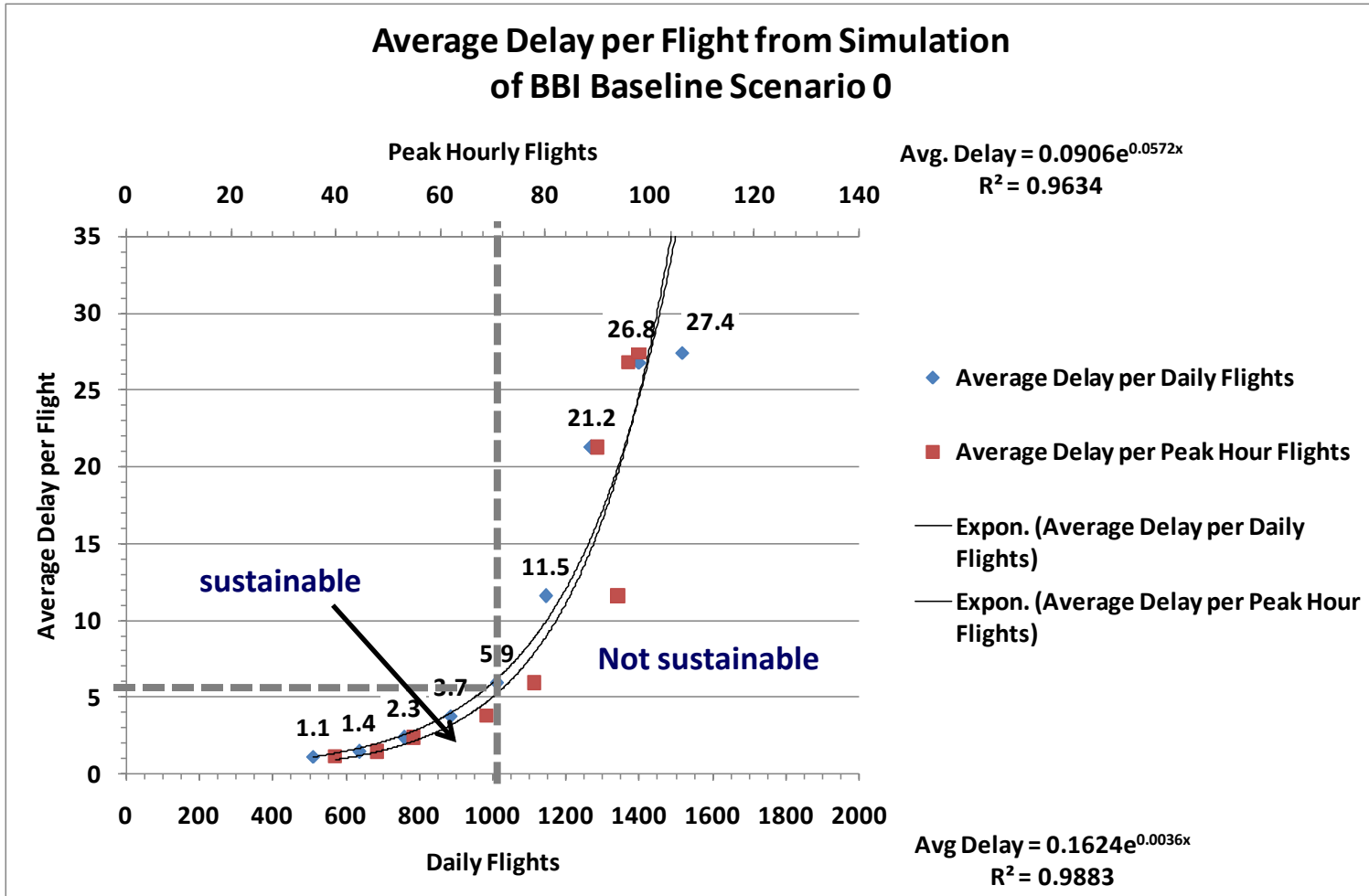
## Results: Simulated Delays at BBI:

- Scenario 0

(\*Note: 42€ cost per minute of delay (Eurocontrol 2009: “Standard Inputs for CBA Analyses”))

Growth from Baseline	Daily Flights	Peak Hour Demand	Hourly Capacity	Mean Delay per Flight	Daily Delay Minutes	Daily Delay Costs at 42€ * (without cancellation costs)	Cancellations
-20%	511	40	40	1.1	543	EUR 22,806	0
0%	635	48	48	1.4	887	EUR 37,254	0
20%	758	55	54	2.3	1760	EUR 73,920	0
40%	886	69	71	3.7	3287	EUR 138,054	0
60%	1012	78	76	5.9	5955	EUR 250,110	0
80%	1145	94	80	11.5	13223	EUR 555,366	0
100%	1270	90	82	21.2	26968	EUR 1,132,656	1
120%	1400	96	82	26.8	37501	EUR 1,575,042	134
140%	1517	98	84	27.4	41538	EUR 1,744,596	440
160%	1639	110	83	58.2	95364	EUR 4,005,288	807

# Results: Simulated Delays at BBI



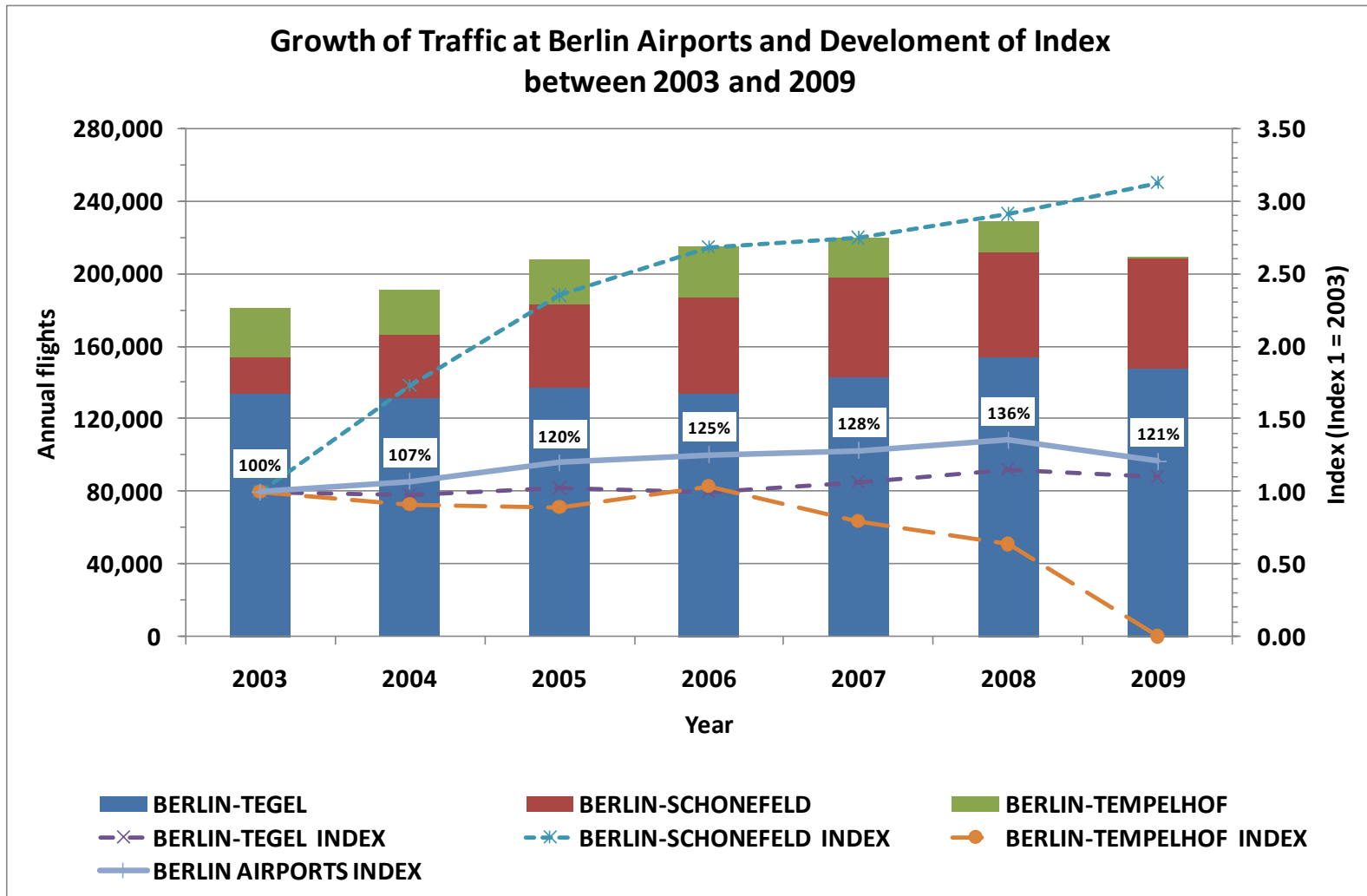
## Capacity limits reached at BBI

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- The Sustainable Capacity of 76 Flights per Hour and 60% growth can be reached after:
- 16 years at 3% average growth of traffic (2008-2024)  $(1+r)^n - 1 = (1+0.03)^{16} - 1 = 60\%$
- 12 years at 4% average growth of traffic (2008-2020)  $(1+r)^n - 1 = (1+0.04)^{12} - 1 = 60\%$
- 10 years at 5% average growth of traffic (2008-2018)  $(1+r)^n - 1 = (1+0.05)^{10} - 1 = 63\%$
- 8 years at 6% average growth of traffic (2008-2016)  $(1+r)^n - 1 = (1+0.06)^8 - 1 = 59\%$
- The planning timeline for a third runway at BBI depends on the economic developments in the region in the next months and years.
- We must start discussing a 3<sup>rd</sup> runway at BBI in 2014 the latest, as a result from Scenario 0 (3% growth), if 10 years until realisation are considered.
- Legal, political and environmental approval time will increase further in the future, so do the opportunity costs from building a runway too late.

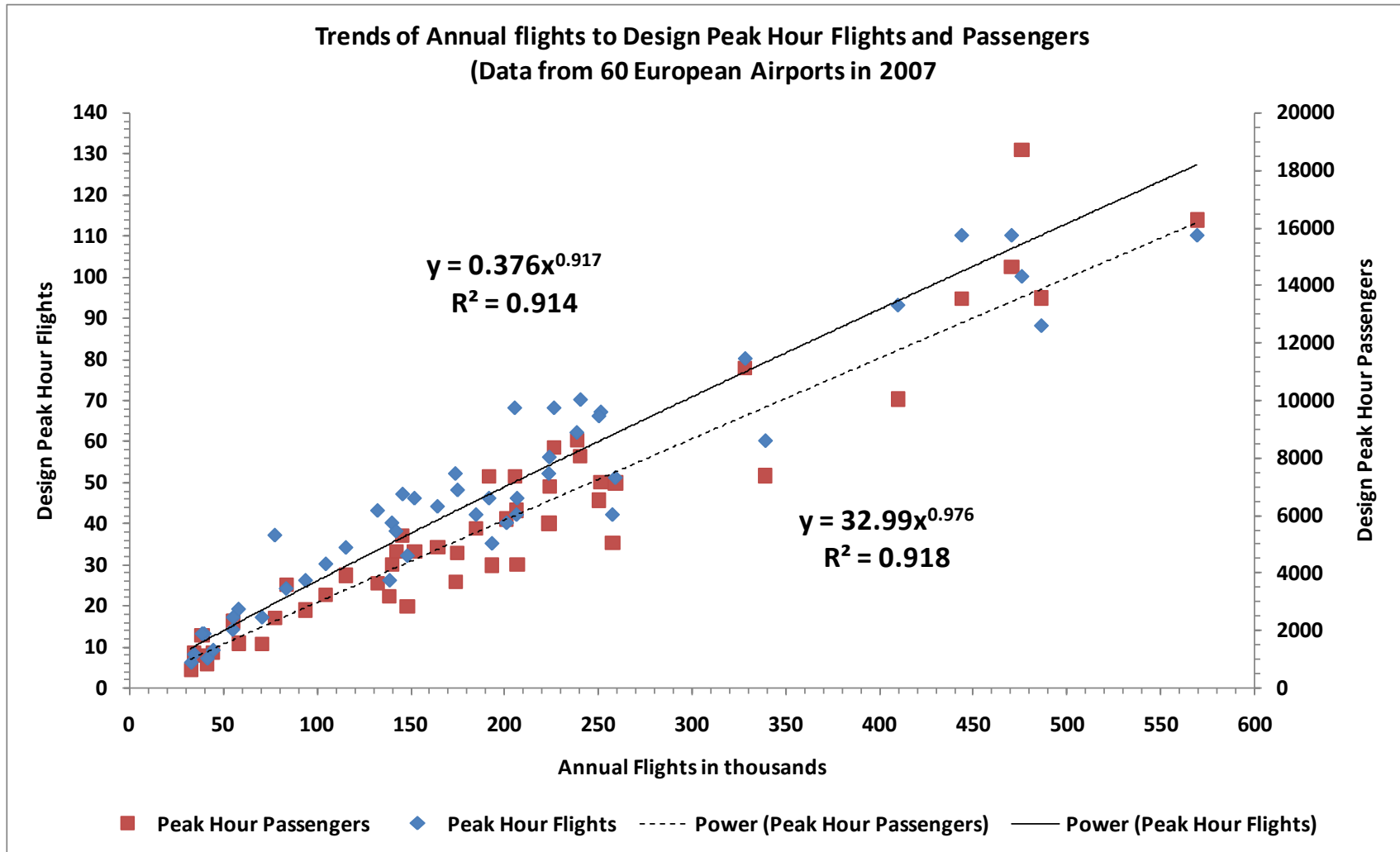


# Growth of Berlin Airports

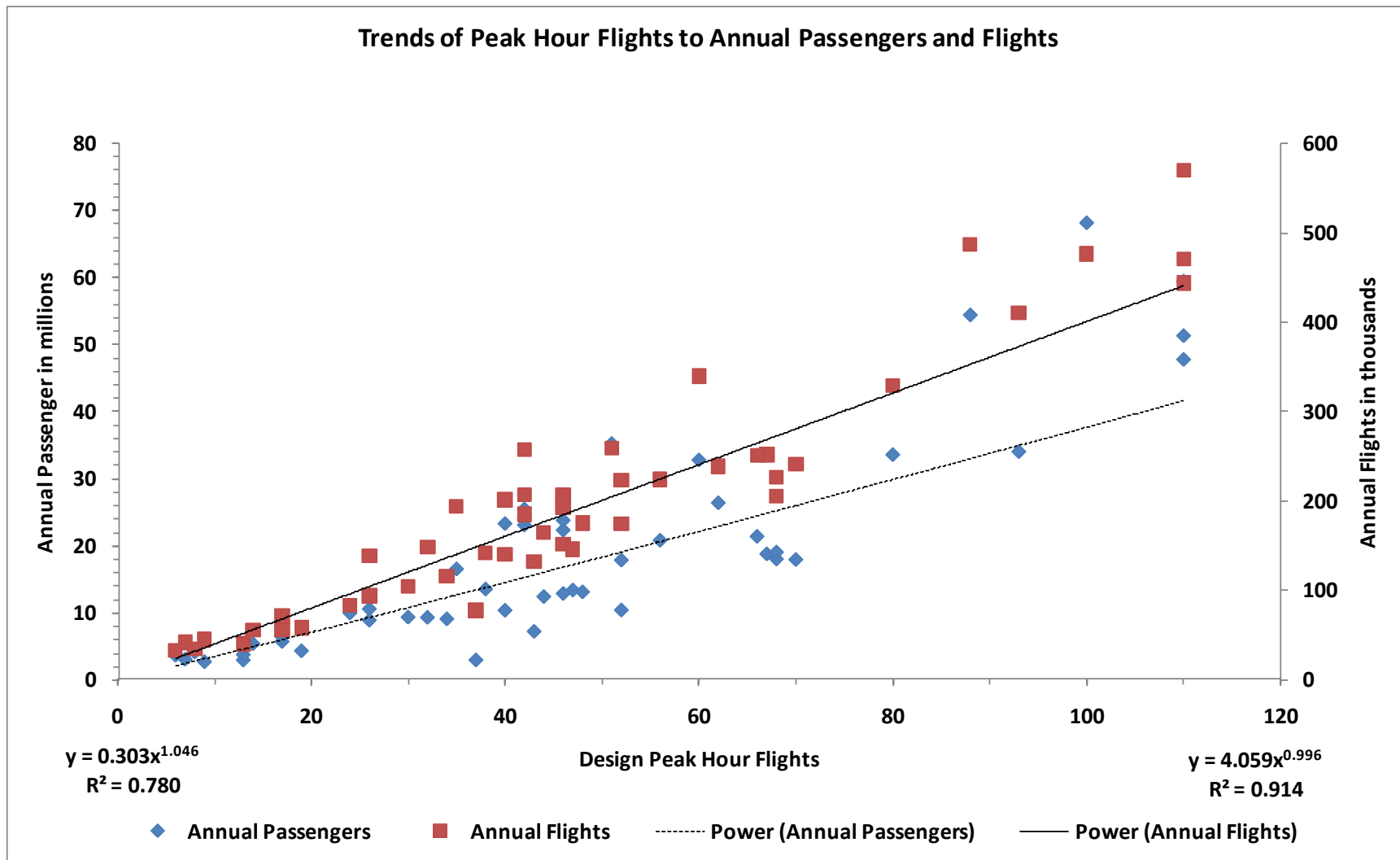


Source: Eurostat

# Trends of Annual and Peak Hour Flights in Europe



# Trends of Peak Hour and Annual Flights in Europe



## Approximation Functions established from 60 EU airports

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If Annual Flights are known from forecasts:

1. Peak Hour Flights =  $0.376 * \text{Annual Flights (in thousand)}^{0.917}$
2. Peak Hour Passengers =  $32.99 * \text{Annual Flights (in thousand)}^{0.976}$

If Peak Hour Flights are known from forecasts or simulations:

3. Annual Flights in thousand =  $4.059 * \text{Peak Hour Flights}^{0.996}$
4. Annual Passengers in million =  $0.303 * \text{Peak Hour Flights}^{1.046}$

Source: Bubalo 2010

## Testing Assumptions Using Approximation Equations

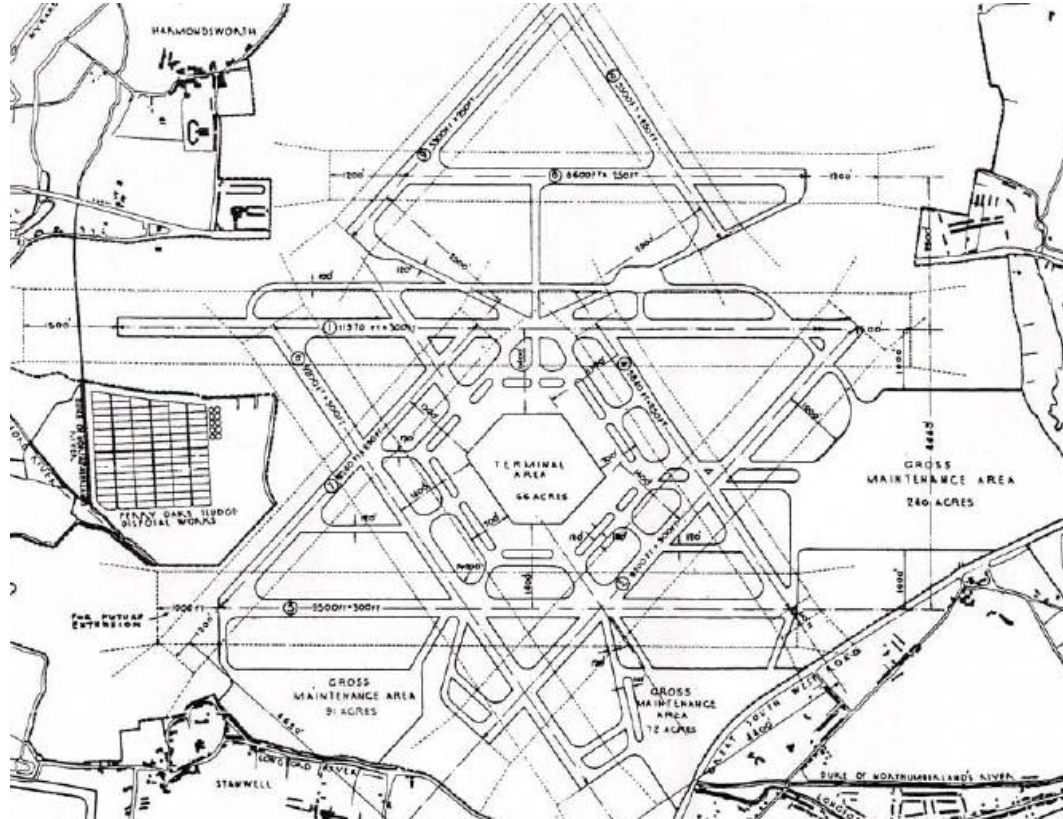
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- BBI Planning Permission Forecast 2023 (2004):
  - **355.000 Flights per year and 90 Movements per hour.**  
With 1. & 2.: 355.000 annual flights -> 82 Peak Hour Flights and 10173 Peak Hour Passengers  
With 3. & 4.: 90 Peak Hour Flights -> 359.000 Annual Flights and 33.5 million Passengers
- BBI SIMMOD Study (2010):
  - **Sustainable Capacity at 76 Flights per hour after 60% growth**  
With 3. & 4.: 76 Peak hour flights -> 303.000 flights and 28.1 million PAX
  - **Capped Capacity at 82-84 Flights per hour after 100%**  
With 3. & 4.: 82 Peak Hour flights -> 327.000 Annual Flights and 30.4 million annual Passengers

## Resulting BBI Forecasts based on 2008 traffic schedule

Airport	Annual PAX (million)	Annual Flights (thousand)	PAX per Flight	Peak Hour Flights	Capacity
BBI 2008 (TXL+SXF 2008)	21.2	212	100	48	48
BBI Planned Capacity 2023 (Planning Permission 2004, at 3%)	30	301-355	100-85	90	90
BBI Sustainable Capacity 2024 (60% growth from 2008 at 3%; this study)	28.1	303	93	76	82
BBI Sustainable Capacity 2018 (60% growth from 2008 at 5%, this study)	28.1	303	93	76	82
BBI Maximum Capacity (100%)	33.5	359	93	90	82

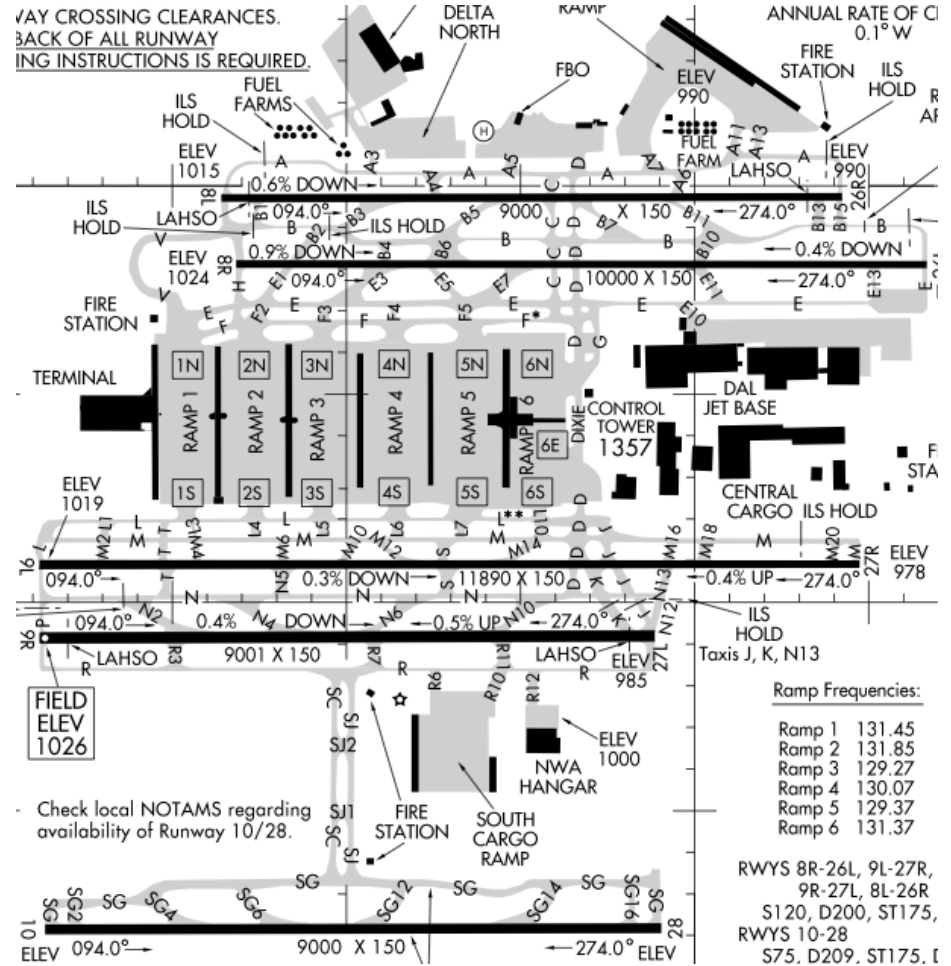
## How far should we think for the future of BBI?



- Should we develop a vision for an ultimate stage of development for BBI, despite of political concerns?
- Runway configuration Master plan of London-Heathrow after 1945

# The World Busiest Airport

- Atlanta Int. (2008):  
88 million passengers  
970,235 flights



- How far is too far?

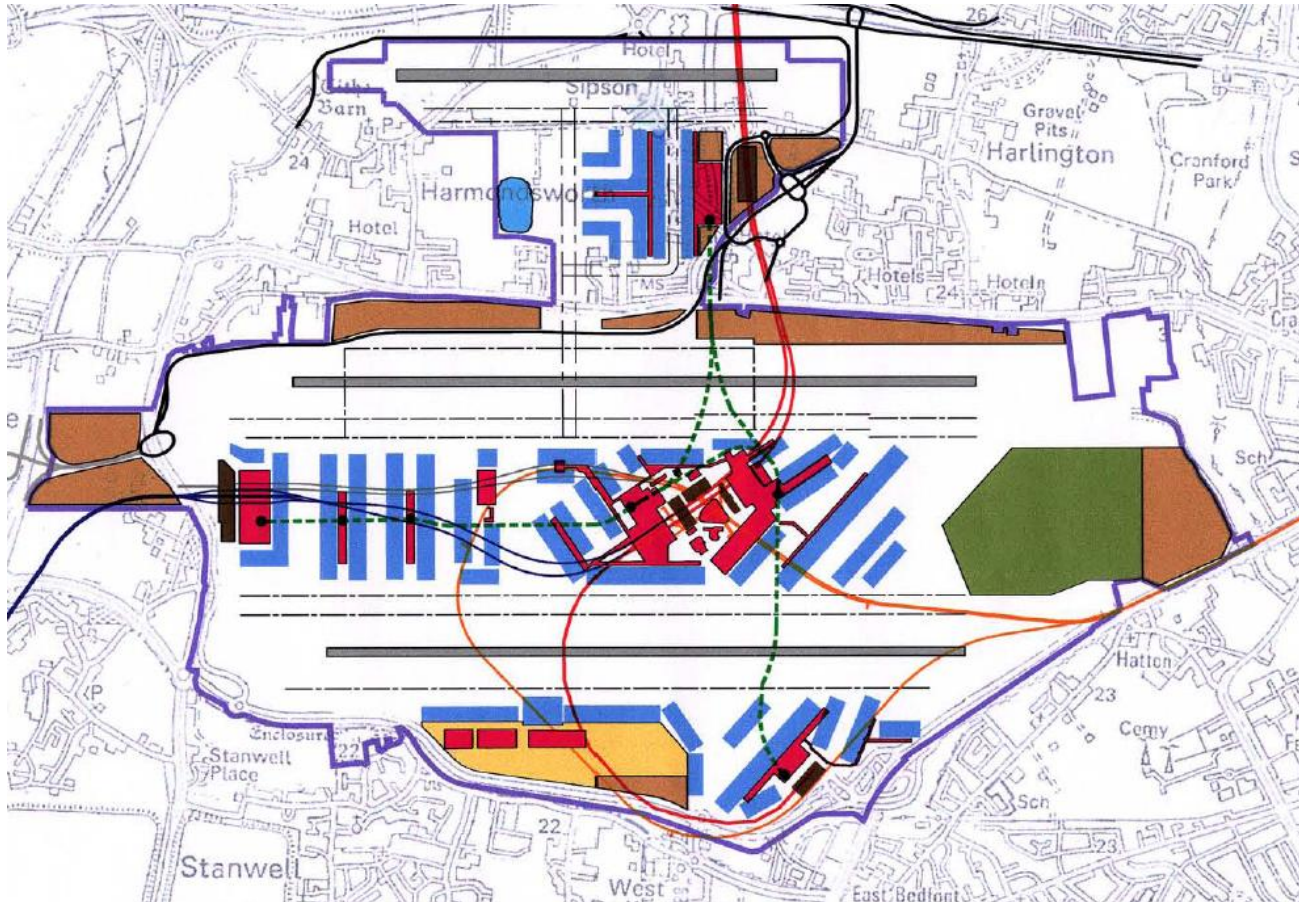


## How far should we think for the future of BBI?

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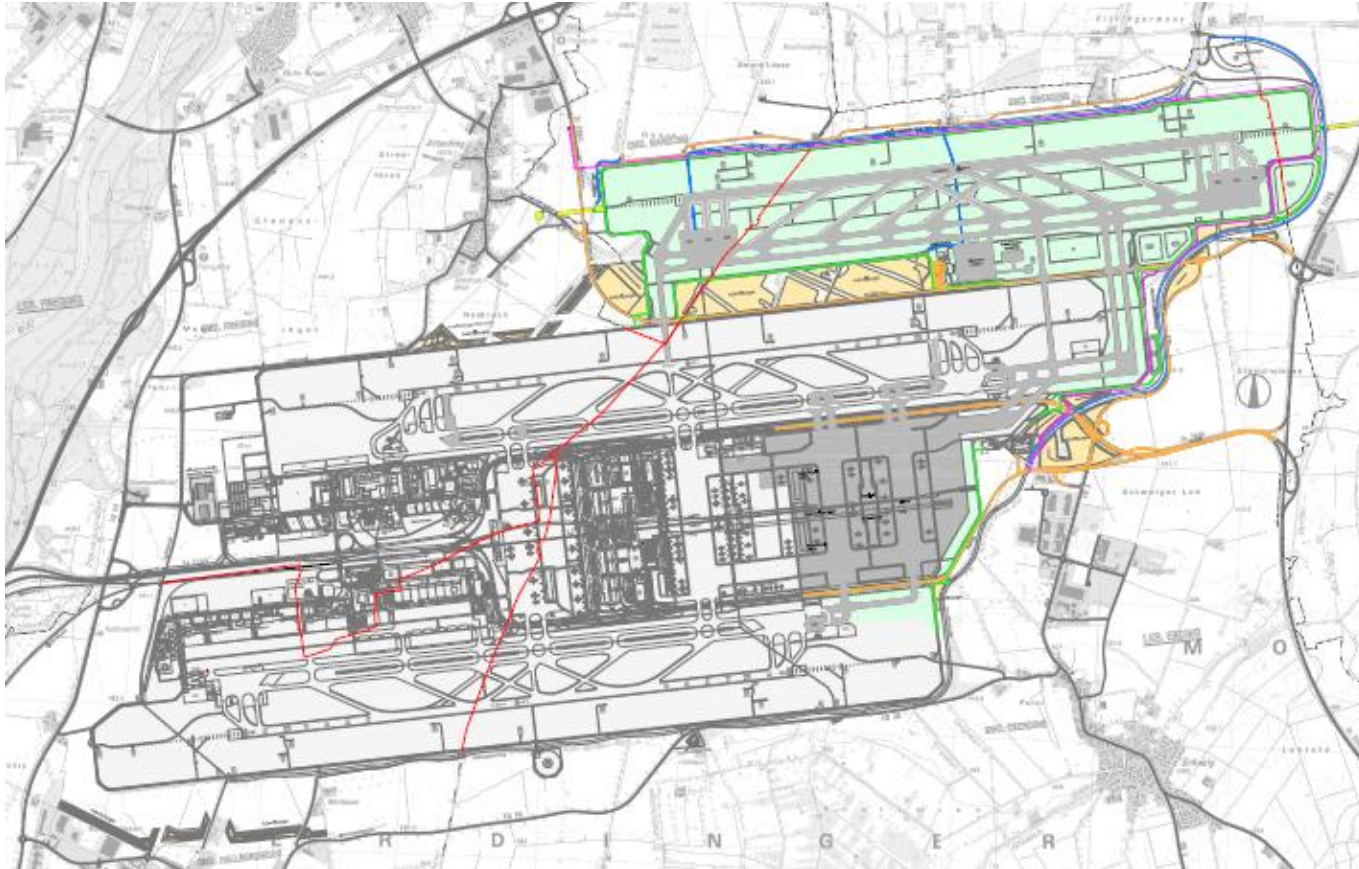
- Regional and airport planners must be creative and realistic in their forecasts and long term views.
- Runways take 10 years of planning, approval and construction time (economical life 40-100 years)
- Noise and local air quality increasingly important, but very difficult to quantify & monetize for compensations
- The future is uncertain, but market outlooks predict further growth of air transportation
- We can learn from other airports already:
  - London Heathrow in 2010: saturated most of the day
  - Munich in 2010: congested during daily peak hours
- Possible near Future for BBI? ->

## Current Plan London Heathrow (2020?)



- Strong public opposition against 3<sup>rd</sup> runway
- Environmental and Legal battle will be endless

## Current Plans for Munich (2020?)



- Munich 2 had been under restrictions from 1993 on.
- 3<sup>rd</sup> runway is strongly opposed, but will be built

## Vision

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- Commitment and Continuing Discussion towards aviation needs (including General and Business Aviation).
- Neighbours of airports should be kept well informed about future developments, even if 20 years or more in advance.
- Master plans must present long-term views with high and low growth forecasts.
- Runways are long-term investments, which are depreciated over 50 to 100 years, so long-sided visions needed.
- Apart from looking at runway capacity, environmental capacity could become more critical in the future.
- Simulation is the tool to make airport capacity planning and (noise) impact forecasts, realistic, transparent, safe and fair.

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Thank you for your attention! Questions?

Suggestions and Comments are welcome.

Full study available after:  
**International Conference  
OPERATIONS RESEARCH  
MUNICH 2010**

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