Next Generation Single Aisle Aircraft - How Soon? - Implications for the Supply Chain

September 2019

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Contents

Current market position in single aisle 737 MAX vs A320neo

- A320neo has a clear market lead overall and dominates at the top end
- There has been relatively little order activity since the MAX grounding
- 737 MAX has seen only one definite cancellation Flyadeal – 30 a/c, but others threatened
- Net A320 orders have been modest
- Airbus A220 is now increasing its presence in this space

				Known Market Share	
Boeing Variant	**Orders**	**Airbus Variant**	**Orders**	**Boeing**	**Airbus**
737 MAX 7	**82**	A319neo	**36**	**69.5%**	**30.5%**
737 MAX 8	**3,053**	A320neo	**3,903**	**43.9%**	**56.1%**
737 MAX 9 & 10	**991**	A321neo	**2,699**	**26.9%**	**73.1%**
737 MAX TBD	**930**	-	**-**	**-**	**-**
Total 737 MAX	**5,056**	**Total A320neo**	**6,638**	**43.2%**	**56.8%**

Reasons for early MAX replacement

Design age – EIS 1968

- Low wing (height of wing from ground vs A320)
- No FBW (envelope protection)
- Fuselage diameter (less important)

Reputational damage to MAX

- Current situation without precedent; size and importance of grounded fleet
- 787 most recent example of grounding, but no crashes or fatalities
- Historically A/C in a similar situation have recovered e.g. DC-10, but social media influence now

Reasons for early MAX replacement

Market position vs A320neo

- Boeing is already behind – 43% share
- Boeing's share is likely to get worse;
  - Backlog of undelivered A/C will constrain production 2020 - 2021 while Airbus ramps up A320
  - Reputational damage likely to have some effect on orders

Boeing will have the engineering capacity

- NMA likely to go ahead once MAX grounding is lifted
- Engineering resources from Embraer should allow NSA as well

Airbus will follow with its own NSA

Probably not immediately

- Large order book
- Still developing A320 family e.g. A321XLR
- Has A220 – potential for stretch to -500 (Air France interested)

But ultimately will need to compete directly with an all-new Boeing NSA

- A320 – EIS 1988
- Has the engineering resources
- Already preparing e.g. wing of the future

New technologies on NSA

- **Timescale leads to a conventional design**
- **Innovation concentrated on airframe & systems**

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The NSA will almost certainly be a conventional design

- **Twin engine, under wing nacelle, conventional tail**
- **Focus on airframe and systems optimisation**
- **Significant advantages with a clean-sheet design**
- **New technology introduction will depend on maturity at programme launch**
  - Need to rapidly ramp up to 70+ per month
  - Rigours of single aisle operations

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Aerostructures

A composite wing is almost certain

- significant performance advantages
- cost coming down
- compatible with rates of up to 100/month?
- out-of-autoclave?

Fuselage almost certainly conventional aluminium

- Aluminium-Lithium too expensive
- In the longer-term thermoplastic composites could be attractive but will not be ready for NSA

More thermoplastics likely

Systems

More electric is certain - the question is how much

Possible more electric systems

- 787-type bleed-less architecture; electrically powered ECS, electrothermal de-icing
- Landing gear; electric braking, nose-wheel steering
- Flight controls;
  - main PFC hydraulic with EHA back-up
  - electrically powered spoilers
  - possibly electric motors for high-lift and HSTA
- Utilities; widespread EMA

Engines

New developments likely to be limited – LEAP and GTF relatively new to the market

- Bleed-less architecture
- More innovation possible on the APU
- An opportunity for Initium (Boeing/Safran JV)

Are we getting close to the limits for the high by-pass turbofan?

General Electric GEnx

Pratt & Whitney R-4360 Wasp Major

Supply chain for NSA

- **Engine OEMs' experiences on LEAP and GTF show the challenges**

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Supply chain for NSA

The experiences of CFMI and P&W on LEAP and GTF show the challenges

- Dual or triple sourcing → more make-to-print vs design and build?
- Focus on critical hard to manufacture components

Boeing

- Continuation of current initiatives; PFS, in-sourcing, focussed factory
- Composite wing – in-house manufacture and assembly
- Fuselage; reduced dependence on Spirit AeroSystems likely

Airbus

- More manufacturing adjacent to local FALs in the US and China?
- Will composite wing manufacture stay in the UK post Brexit?

Prospects for NSA

- **Will it be overtaken by new technology?**
- **Will demand continue to rise?**

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Commercial air transport landscape 1979 vs 2019

Incremental development over last 40 years

LCA in production 1979

- ***Airbus A300***
- ***Boeing 727***
- ***Boeing 737***
- ***Boeing 747***
- ***Lockheed L-1011***
- ***MD DC-9***
- ***MD DC-10***

LCA in production 2019

- ***Airbus A220***
- ***Airbus A320***
- ***Airbus A330***
- ***Airbus A350***
- ***Airbus A380***
- ***Boeing 737***
- ***Boeing 747***
- ***Boeing 767***
- ***Boeing 777***
- ***Boeing 787***

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Commercial air transport landscape 2019 vs 2059

Nobody really expects incremental development only

- Over the last 5 years it has become clear - more electric/hybrid propulsion is coming
  - New aircraft and propulsion configurations
  - Revolution rather than slow evolution
- NSA will not be like Boeing 737 and A320
  - 30+ year production life
  - Plus 20-year extra aftermarket
  - 50+ year programme
  - NSA programmes likely to be significantly shorter

How quickly can technology change?

Example from rail transport 1950s/1960s

- Technologically mature transport system
- Steam locomotives – typical working life 30 years – up to 50
- 1951 British Rail introduced new Standard Class steam locos
- Incorporating all best practice, emphasis on low running costs, ease of maintenance
- 999 manufactured 1951-1960
- 1960; last locomotive ‘Evening Star’ completed, retired 1965 at first major overhaul
- 1968; last steam locomotives retired from British Rail

BR Standard Class 9F 92220 Evening Star

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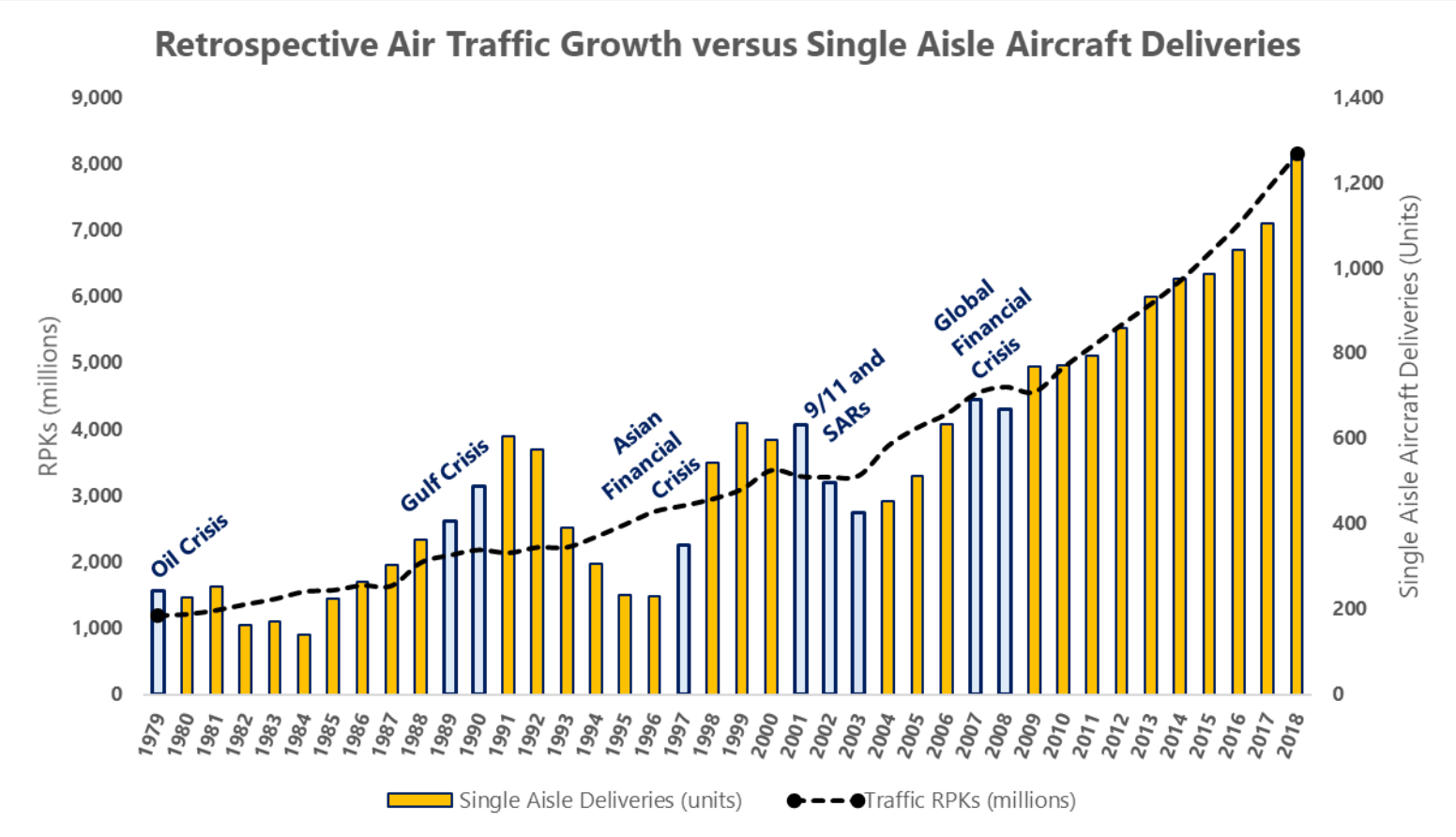
Air traffic growth

Is the current growth rate sustainable?

Air traffic growth over the last 40 years

Air traffic growth has been rising on an exponential-like curve

- Strong correlation with GDP growth, negative yield
- Resilient to shocks
- Single aisle deliveries show a strong correlation



Air traffic growth over the next 40 years

The next 40 years are likely to be different – growth will slow

- Climate change
  - Targets to reduce CO_2 incompatible with unchanged growth rate
  - Government action e.g. French eco-tax on plane tickets, pressure for EU – wide action
  - Changing social attitudes e.g. ‘flygskam' translates as 'flight shame'
  - ACARE Flightpath 2050 Targets - Noise, NO_x and CO_2
  - Pressure is greatest in Europe but likely to spread worldwide
- Tourist hot-spot overcrowding
  - Local authorities taking action
  - A worldwide issue

Conclusions

There are good reasons to think that Boeing will launch an NSA quite soon

- Lower market share of MAX relative to A320neo – not likely to improve
- Once it completes on Embraer it will have sufficient engineering resources to do NSA as well as NMA

Airbus will follow with its own NSA

- Will need to compete directly with Boeing; A320 is also an old design

The forthcoming NSAs are likely to be stop-gap aircraft

- More electric/hybrid aircraft are coming
  - Once everything is aligned technology change can happen fast

The next 40 years will be different from the last 40 years

- Technology revolution not evolution
- Expect to see changes in the demand for air travel

Conclusions – suppliers

NSA will be here sooner than had been expected

- Very rapid production ramp up to ~ 70 A/C per month
- Dual sourcing – more build to print?
- Relatively short production run ~ 15 years?

Aerostructures

- Composite wing, conventional aluminium fuselage, more thermoplastics

Systems

- More electric; trade studies to determine extent

Engines

- Relatively little change; APU innovation?

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Any questions?

Richard Apps

Tel: +44(0)1235 868051

Mob: +44(0)7741 035969

richardapps@cpmil.com

www.cpmil.com

An aerospace and defence consultancy specialising market analysis

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