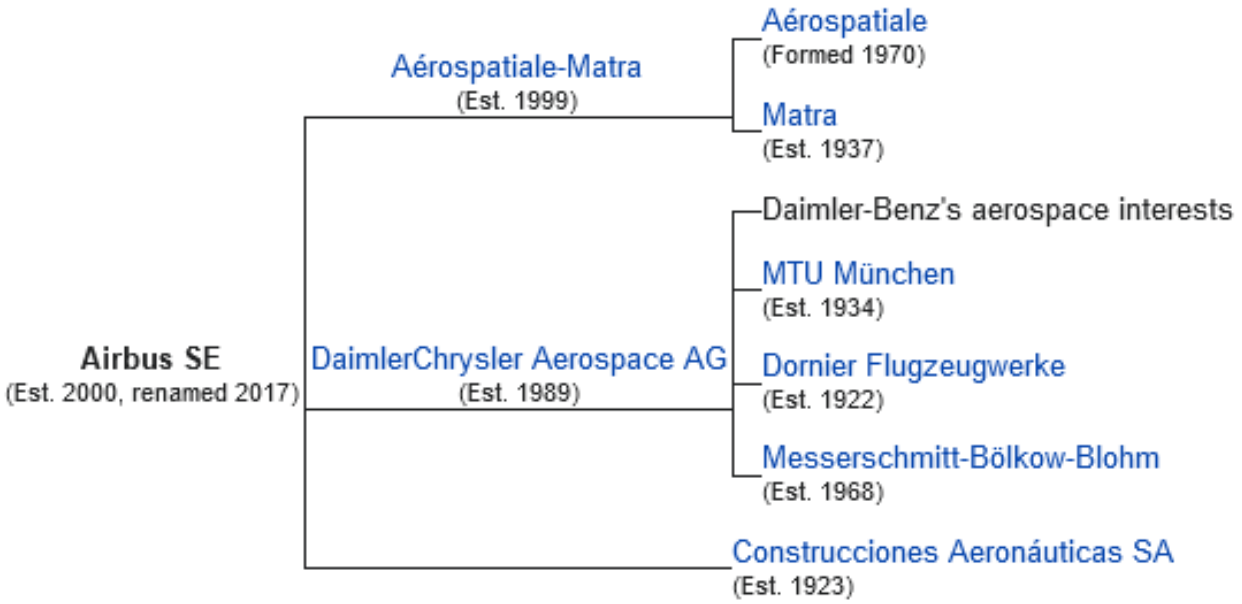
Commercial Air Wars:
Strategies That Changed Commercial Aviation

8

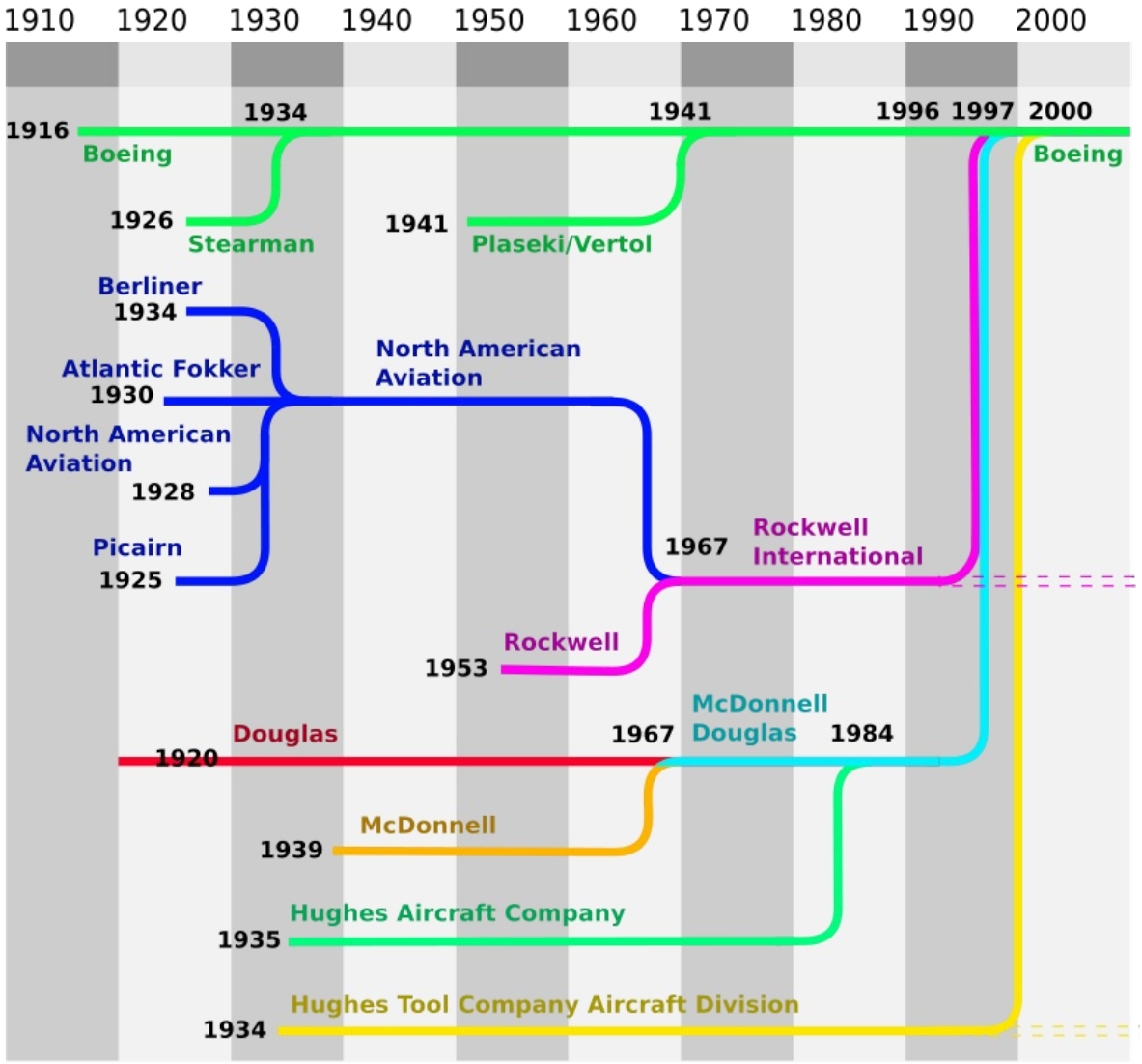
Airbus versus Boeing
Current and Future

Jim Rauf

European Collaboration-Formation of Airbus



American Consolidation - Boeing Today



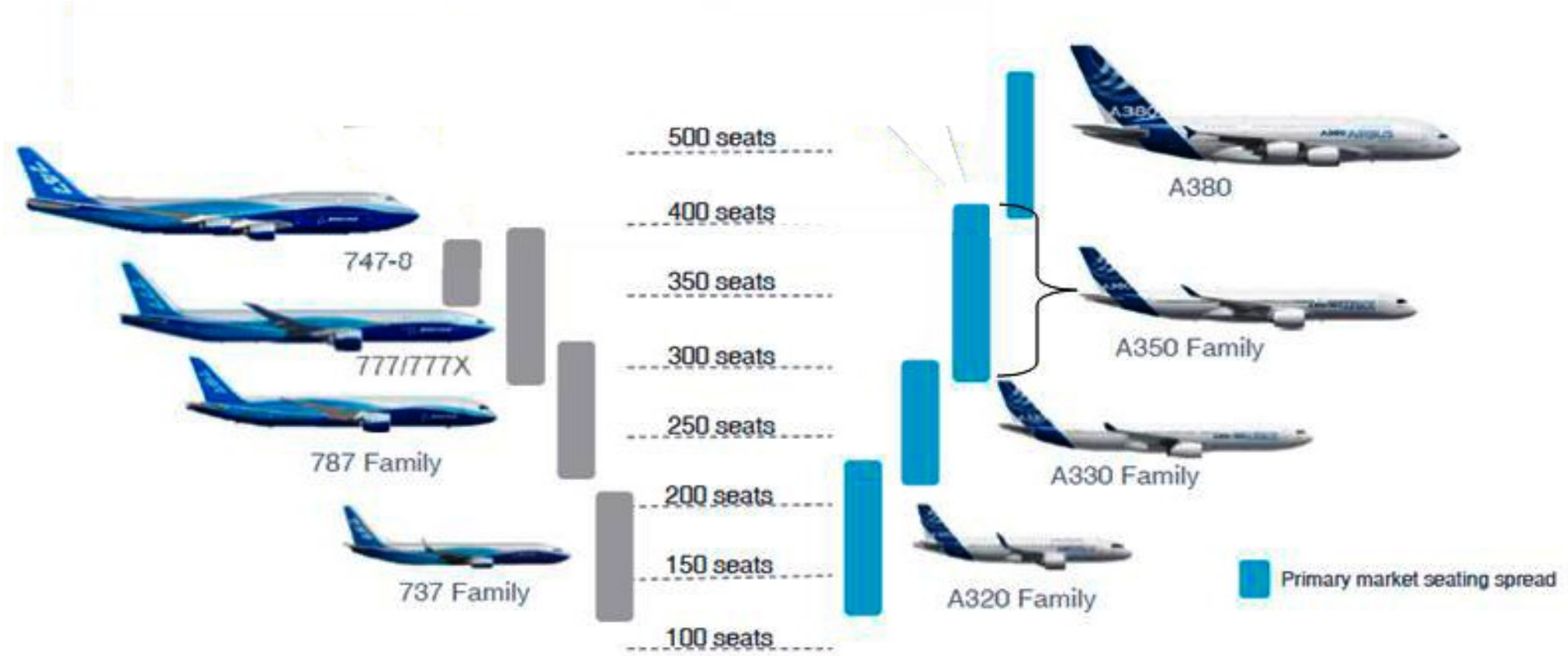
Airbus and Boeing
Cash, Revenues and Income

	Cash on Hand	
	Airbus	Boeing
2021	$21,150	$16,244
2020	**$21,655**	$25,590
2019	$15,820	$10,030
2018	$16,351	$8,564
2017	$18,255	$9,992
2016	$14,909	$10,029
2015	$12,056	$12,052
2014	$15,666	$13,092
2013	$16,063	$**15,258**
2012	$16,487	$13,558
2011	$13,312	$11,272

	Airbus	
	Revenue	Net Income
2021	$61,697	**$4,984**
2020	$57,014	($1,294)
2019	$78,935	($1,525)
2018	$75,238	$3,607
2017	$75,467	$3,247
2016	$73,679	$1,101
2015	$71,565	$2,994
2014	**$80,706**	$3,115
2013	$78,710	$1,946
2012	$72,639	$1,579
2011	$68,435	$1,439

	Boeing	
	Revenue	Net Income
2021	$62,286	($4,202)
2020	$58,158	($11,873)
2019	$76,559	($636)
2018	**$101,127**	**$10,453**
2017	$94,005	$8,452
2016	$93,496	$5,031
2015	$96,114	$5,172
2014	$90,762	$5,440
2013	$86,623	$4,578
2012	$81,698	$3,900
2011	$68,735	$4,009

Both Companies Cover Airlines' Capacity and Range Requirements



Airbus and Boeing Current Competing Products

- Single aisle or narrow body
  - Airbus A320 family
    - A319ceo/neo
    - A320ceo/neo
    - A321ceo/neo
    - A321LR
    - A321XLR
  - Boeing 737MAX family
    - 737MAX 8
    - 737MAX 9
    - 737MAX 10

- Wide body or twin aisle
  - Airbus A330 family
    - A330-200
    - A330-300
    - A330-800
    - A330-900
  - Airbus A350 family
    - A350-900
    - A350-1000
  - Boeing 787 family
    - 787-8
    - 787-9
    - 787-10
  - Boeing 777 family
    - 777
    - 777-

- Very large wide body or twin aisle
  - Airbus A380
  - Boeing 747-8

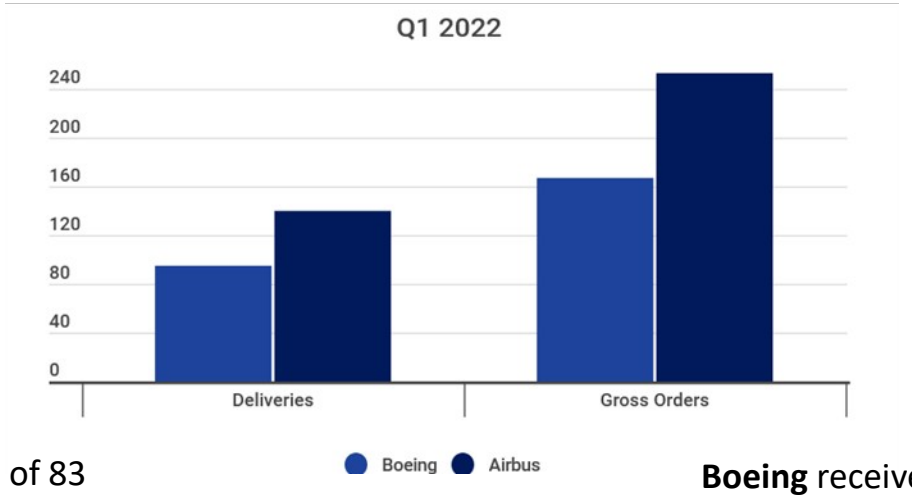
Airplane Families	Current Price $ million
737-700	89.1
737-800	106.1
737-900ER	112.6
737 MAX 7	99.7
737 MAX 8	121.6
737 MAX 200	124.8
737 MAX 9	128.9
737 MAX 10	134.9
747-8	418.4
747-8 Freighter	419.2
767-300ER	217.9
767-300 Freighter	220.3
777-200ER	306.6
777-200LR	346.9
777-300ER	375.5
777 Freighter	352.3
777-8	410.2
777-9	442.2
787-8	248.3
787-9	292.5
787-10	338.4

Airbus versus Boeing – First Quarter 2022 Deliveries

- **Airbus** delivered **140** aircraft
- **Airbus** was unable to deliver two **A350-900**s to **Aeroflot** due to international sanctions imposed on Russia
- Airbus deliveries:
- 58 Airbus **A321neos**
- 49 Airbus **A320neos**
- 14 Airbus **A350s**,
- 11 Airbus **A220s**
- 6 Airbus **A330s**
- 2 Airbus **A319s**

- **Boeing** delivered **95** aircraft
- **Boeing's** deliveries:
- 86 Boeing **737s**
- 5 five Boeing **767s**
- 3 Boeing **777s**
- 1 Boeing **747**

No 787s



Airbus won 253 gross orders, with a net total of 83

Boeing received 167 aircraft orders

Airbus versus Boeing

Airbus A350XWB

	Orders	Deliveries	Unfilled
A350-900	743	416	327
A350-1000	153	64	89
A350F		22	– 22
A350 family	**918**	**480**	**438**

Airbus A380

Net orders	A380-800	251
	A380F	0
Deliveries	**A380-800**	**251**

A320neo family

	Orders	Deliveries	Backlog
A319neo	72	6 66	
A320neo	3,843	1,474	2,369
A321neo	4,163	742	3,421
A320neo family	**8,078**	**2,222**	**5,856**

A330 family

	Orders	Deliveries	Backlog
A330-200	664	650	14
A330-300	784	773	11
A330-800	11	4	7
A330-900	262	73	189
A330 family	**1,759**	**1,538**	**221**

Airbus versus Boeing

Boeing 777

	Total orders	Total deliveries	Unfilled
777-200	88	88	–
777-200ER	422	422	–
777-200LR	61	61	–
777-300	60	60	–
777-300ER	838	832	6
777F	305	220	85
777X *	334	–	334
Total	**2,108**	**1,683**	**425**

Boeing 787

	Total orders	Total deliveries	Unfilled
787-8	416	377	39
787-9	887	568	319
787-10	182	61	121
Total	**1,485**	**1,006**	**479**

737 Max family

Orders	Deliveries	Unfilled
4,890	**798**	**4,092**

* 777X Certification delayed to mid/late 2023
Deliveries 2025

Airbus and Boeing 2020 and 2021 Aircraft Deliveries

DELIVERIES	AIRBUS	BOEING	BOTH
2021	611	340	951
2020	566	157	723
% Change	8%	117%	32%
Mkt share			
2021	64%	36%	
2022	78%	22%	
GROSS ORDERS	**AIRBUS**	**BOEING**	**BOTH**
2021	771	909	1680
2020	383	184	567
% Change	101%	394%	196%
Mkt share			
2021	46%	54%	
2022	68%	32%	
NET ORDERS (1)	**AIRBUS**	**BOEING**	**BOTH**
2021	507	479	986
2020	268	-471	-203
% Change	89%	N/A	N/A
Mkt share			
2021	51%	49%	

Airbus 2021 2020

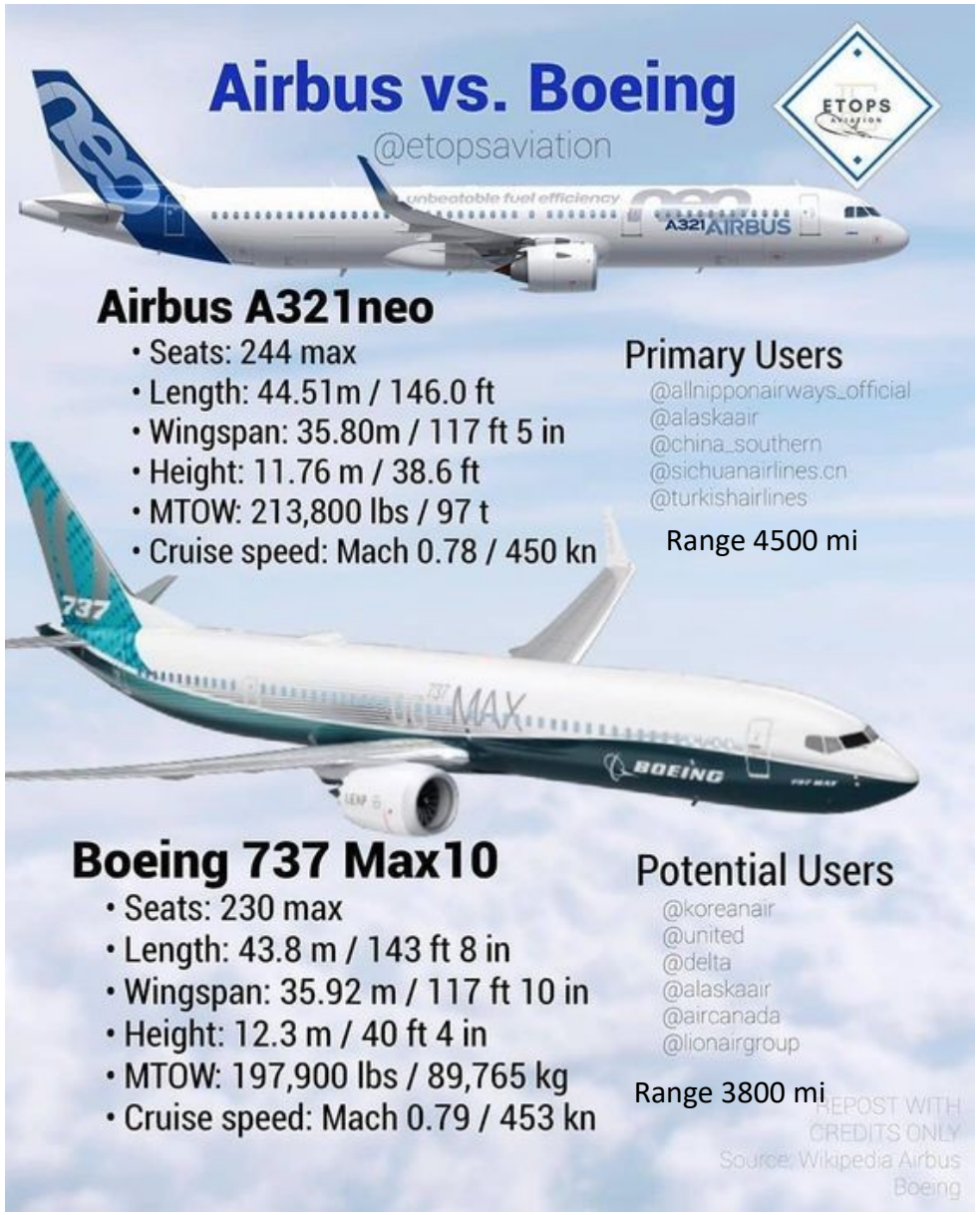
- Total 611 566
- A320 483
- A350 55
- A220 50
- A330 18
- A380 5

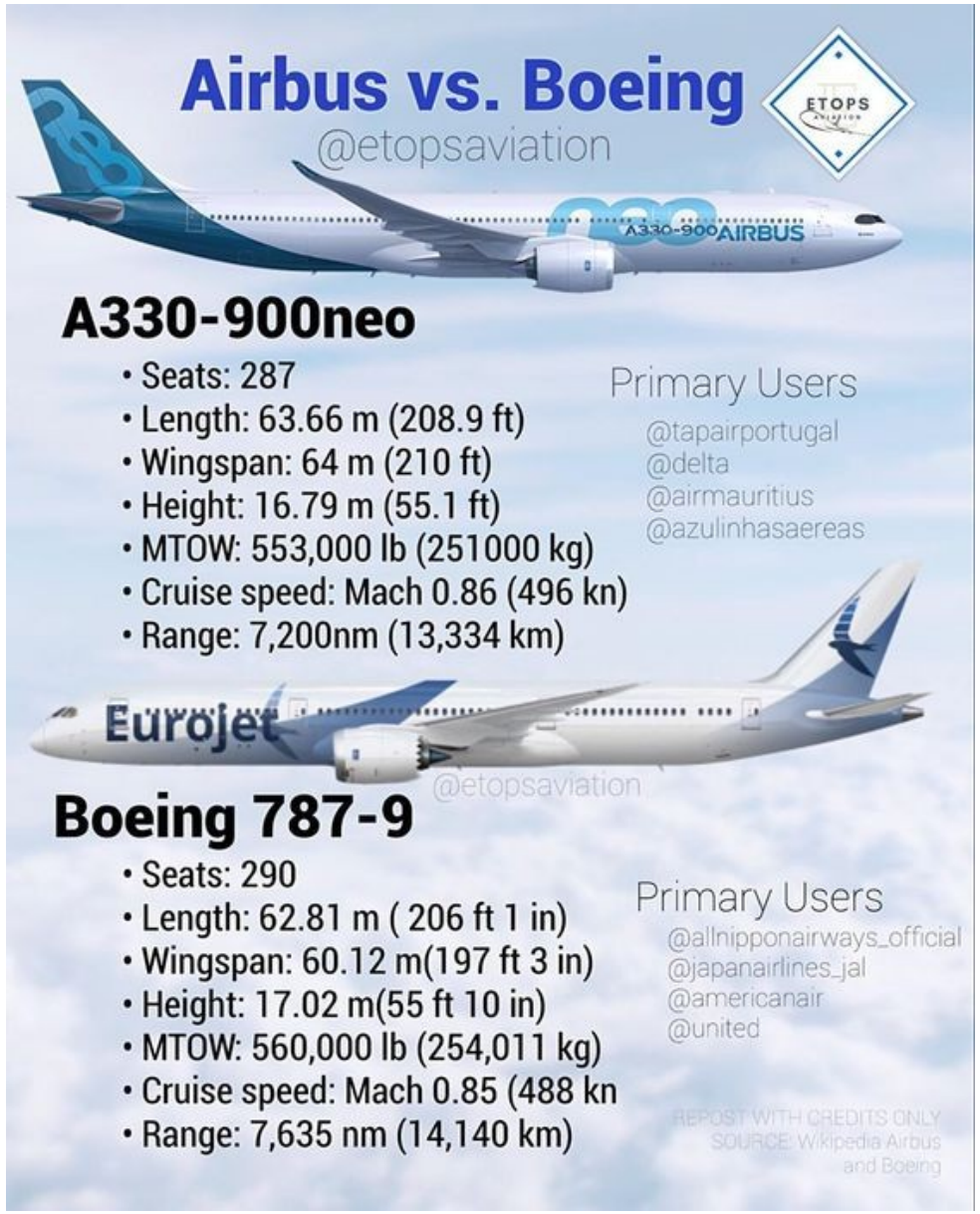
- Net Orders 507

Boeing 2021 2020

- Total 340 157
- 737 263
- 767 32
- 777 24
- 787 14
- 747 1

- Net Orders 535


Airbus vs. Boeing
@etopsaviation
ETOPS
unbeatable fuel efficiency
A321 AIRBUS
Airbus A321neo
• Seats: 244 max
• Length: 44.51m / 146.0 ft
• Wingspan: 35.80m / 117 ft 5 in
• Height: 11.76 m / 38.6 ft
• MTOW: 213,800 lbs / 97 t
• Cruise speed: Mach 0.78 / 450 kn
Primary Users
@allnipponairways_official
@alaskaair
@china_southern
@sichuanairlines.cn
@turkishairlines
Range 4500 mi
737 MAX
BOEING
Boeing 737 Max10
• Seats: 230 max
• Length: 43.8 m / 143 ft 8 in
• Wingspan: 35.92 m / 117 ft 10 in
• Height: 12.3 m / 40 ft 4 in
• MTOW: 197,900 lbs / 89,765 kg
• Cruise speed: Mach 0.79 / 453 kn
Potential Users
@koreanair
@united
@delta
@alaskaair
@aircanada
@lionairgroup
Range 3800 mi
REPOST WITH CREDITS ONLY
Source: Wikipedia Airbus Boeing


Airbus vs. Boeing
@etopsaviation
ETOPS
A330-900 AIRBUS
A330-900neo
• Seats: 287
• Length: 63.66 m (208.9 ft)
• Wingspan: 64 m (210 ft)
• Height: 16.79 m (55.1 ft)
• MTOW: 553,000 lb (251000 kg)
• Cruise speed: Mach 0.86 (496 kn)
• Range: 7,200nm (13,334 km)
Primary Users
@tapairportugal
@delta
@airmauritius
@azulinhasaereas
Eurojet
@etopsaviation
Boeing 787-9
• Seats: 290
• Length: 62.81 m (206 ft 1 in)
• Wingspan: 60.12 m(197 ft 3 in)
• Height: 17.02 m(55 ft 10 in)
• MTOW: 560,000 lb (254,011 kg)
• Cruise speed: Mach 0.85 (488 kn
• Range: 7,635 nm (14,140 km)
Primary Users
@allnipponairways_official
@japanairlines_jal
@americanair
@united
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SOURCE: Wikipedia Airbus and Boeing

Twins replace four engine aircraft

777

	777-200LR	777-300ER
Seats (2-class)	317	396
Range nm (km)	8,555 nmi (15,843 km)	7,370 nmi (13649 km)
Length	63.7 m (209 ft 1 in)	73.9 m (242 ft 4 in)
Wingspan	64.8 m (212 ft 7 in)	64.8 m (212 ft 7 in)
Height	18.6 m (61 ft 1 in)	18.5 m (60 ft 8 in)
Engine	GE90-115BL	GE90-115BL

777X

Delivery 2025

	777–8	777–9
List Price	$410.2 million	$442.2 million
Program Launch	November 2013	
Seats (Typical 2-class)	384	426
Range	Up to 8,730 nmi (16,170 km)	7,285 nmi (13,500 km)
Length	229 feet (69.79 m)	251 feet, 9 in (76.72 m)
Wingspan	Extended: 235 feet, 5 in (71.75 m) On ground: 212 feet, 8 in (64.82 m)	
Cabin	Spacious and comfortable, 16 in. wider than the competition; new customizable architecture; and comfort innovations from the 787 Dreamliner (more)	
Configuration	Twin-aisle (widebody)	

787

Estimated development cost
$32 Billion

Planned development cost
$6 Billion

	787-8 Dreamliner	787-9 Dreamliner	787-10 Dreamliner
Passengers (two-class)	248	296	336
Range nmi (km)	7,305 nmi (13,530 km)	7,565 nm (14,010 km)	6,330 nm (11,730 km)
Length	57 m (186 ft)	63 m (206 ft)	68 m (224 ft)
Wingspan	60 m (197 ft)	60 m (197 ft)	60 m (197 ft)
Height	17 m (56 ft)	17 m (56 ft)	17 m (56 ft)
Engine	GEnx-1B / Trent 1000	GEnx-1B / Trent 1000	GEnx-1B / Trent 1000

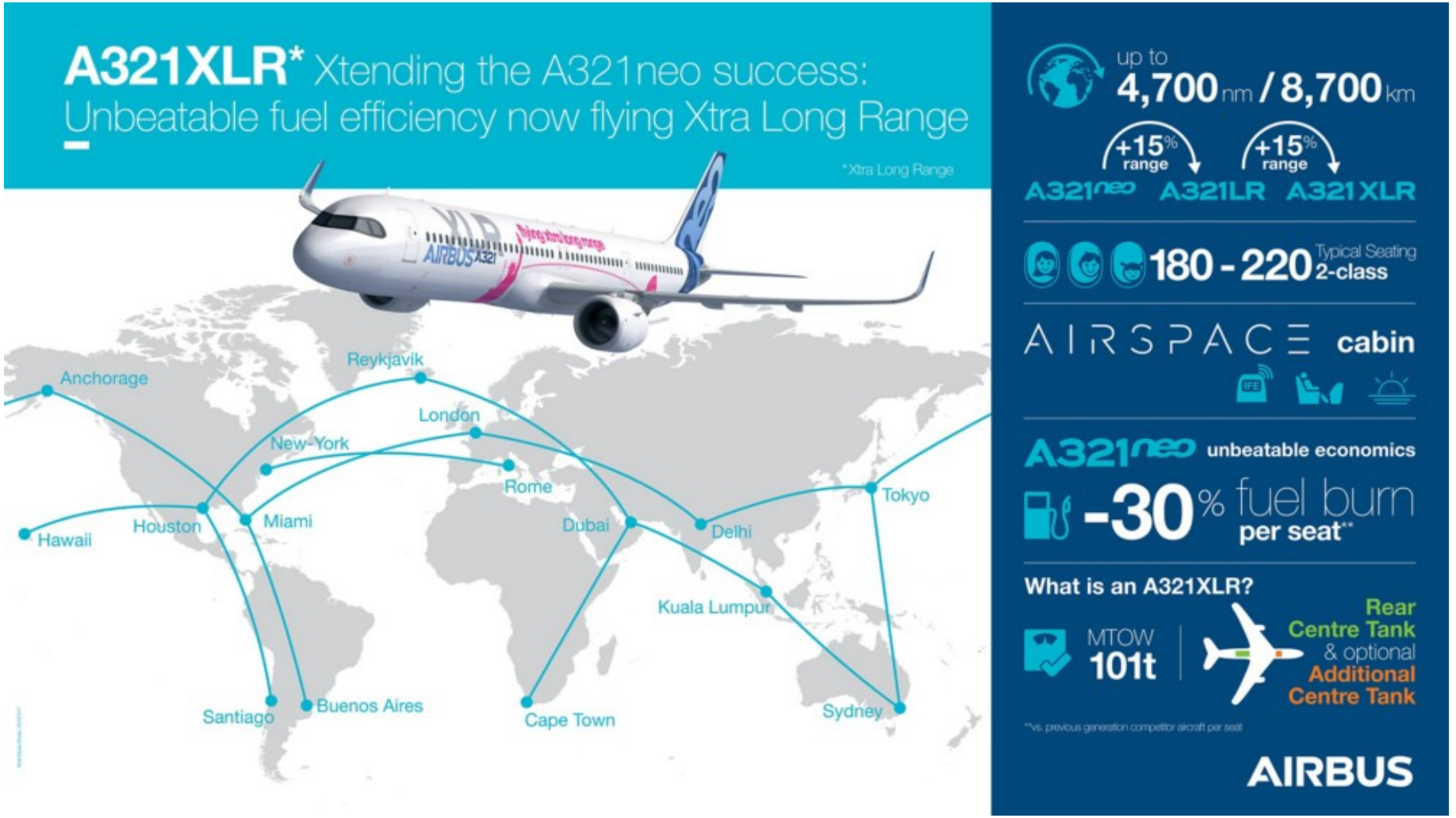
Airbus A350-1000		versus	Boeing 777-9	
73.78 m	242 ft 1 in	length	76.72 m	251 ft 8 in
64.75 m	212 ft 5 in	wingspan	72.80 m	238 ft 10 in
443.00 m^2	4,768 ft^2	wingarea	516.70 m^2	5,562 ft^2
17.08 m	56 ft	height	19.53 m	64 ft 1 in
2		engines	2	
432 kN	97,100 lb_f	thrust per engine	467 kN	105,000 lb_f
864 kN	194,200 lb_f	total thrust	934 kN	210,000 lb_f
308,000 kgs	679,000 lbs	MTOW	351,534 kgs	775,000 lbs
14,800 km	7,992 nm	range	13,500 km	7,290 nm
M0.85		cruise speed	M0.84	
369 passengers		capacity	426 passengers	

Airbus A321XLR		versus	Boeing 737 MAX 10	
44.51 m	146 ft	length	43.80 m	143 ft 8 in
35.80 m	117 ft 5 in	wingspan	35.92 m	117 ft 10 in
123.00 m^2	1,324 ft^2	wingarea	127.00 m^2	1,367 ft^2
11.76 m	38 ft 7 in	height	12.30 m	40 ft 4 in
2		engines	2	
156 kN	35,000 lb_f	thrust per engine	130 kN	29,317 lb_f
312 kN	70,000 lb_f	total thrust	260 kN	58,634 lb_f
101,000 kgs	223,000 lbs	MTOW	92,000 kgs	203,000 lbs
8,700 km	4,698 nm	range	6,110 km	3,299 nm
M0.78		cruise speed	M0.79	
206 passengers		capacity	204 passengers	
240 passengers		max. capacity	230 passengers	

Airbus A380-800		versus	Boeing 747-8I	
73.00 m	239 ft 6 in	length	76.25 m	250 ft 2 in
79.80 m	261 ft 10 in	wingspan	68.45 m	224 ft 7 in
845.00 m^2	9,096 ft^2	wingarea	554.00 m^2	5,963 ft^2
24.10 m	79 ft 1 in	height	19.35 m	63 ft 6 in
4		engines	4	
334 kN	75,152 lb_f	thrust per engine	296 kN	66,500 lb_f
1,336 kN	300,608 lb_f	total thrust	1,184 kN	266,000 lb_f
548,000 kgs	1,208,000 lbs	MTOW	448,000 kgs	988,000 lbs
15,000 km	8,100 nm	range	14,800 km	7,992 nm
M0.85		cruise speed	M0.855	
525 passengers		capacity	467 passengers	

Airbus A330-900neo		versus	Boeing 787-10	
63.66 m	208 ft 10 in	length	68.27 m	224 ft
64.00 m	210 ft	wingspan	60.17 m	197 ft 5 in
0.00 m^2	0 ft^2	wingarea	347.00 m^2	3,735 ft^2
16.79 m	55 ft 1 in	height	17.00 m	55 ft 9 in
2		engines	2	
320 kN	72,000 lb_f	thrust per engine	338 kN	76,000 lb_f
640 kN	144,000 lb_f	total thrust	676 kN	152,000 lb_f
242,000 kgs	534,000 lbs	MTOW	252,651 kgs	557,000 lbs
12,130 km	6,550 nm	range	13,001 km	7,021 nm
M0.86		cruise speed	M0.85	
287 passengers		capacity	323 passengers	

Single Aisle Twin Aircraft Flying Long Thin Routes - ETOPS



Boeing 777-9		versus	Boeing 747-8I	
76.72 m	251 ft 8 in	length	76.25 m	250 ft 2 in
72.80 m	238 ft 10 in	wingspan	68.45 m	224 ft 7 in
516.70 m^2	5,562 ft^2	wingarea	554.00 m^2	5,963 ft^2
19.53 m	64 ft 1 in	height	19.35 m	63 ft 6 in
2		engines	4	
467 kN	105,000 lb_f	thrust per engine	296 kN	66,500 lb_f
934 kN	210,000 lb_f	total thrust	1,184 kN	266,000 lb_f
351,534 kgs	775,000 lbs	MTOW	448,000 kgs	988,000 lbs
13,500 km	7,290 nm	range	14,800 km	7,992 nm
M0.84		cruise speed	M0.855	
426 passengers		capacity	467 passengers	
Boeing 787-9		**versus**	**Boeing 747-8I**	
63.00 m	206 ft 8 in	length	76.25 m	250 ft 2 in
60.17 m	197 ft 5 in	wingspan	68.45 m	224 ft 7 in
347.00 m^2	3,735 ft^2	wingarea	554.00 m^2	5,963 ft^2
16.90 m	55 ft 5 in	height	19.35 m	63 ft 6 in
2		engines	4	
316 kN	71,000 lb_f	thrust per engine	296 kN	66,500 lb_f
632 kN	142,000 lb_f	total thrust	1,184 kN	266,000 lb_f
252,651 kgs	557,000 lbs	MTOW	448,000 kgs	988,000 lbs
15,394 km	8,313 nm	range	14,800 km	7,992 nm
M0.85		cruise speed	M0.855	
280 passengers		capacity	467 passengers	

Some Things That Changed Commercial Aviation

- Metal Aircraft – Strength and Durability
- Multi engine Aircraft – Larger Aircraft
- Pressurized Cabins – Higher Altitude Flight
- Turbojet Engines – More Thrust and Reliability than Piston Engines
- High Bypass Turbofan Engines – More Thrust ,Lower Noise than Turbojets
- Wide Body (Twin Aisle) Aircraft – Greater Capacity-Lower Cost per Seat mile
- Hub and Spoke Airline Systems – Narrow Body and Wide Body Aircraft
- Aircraft Manufacturing Mergers – Reduced Competition
- European Collaboration-Formation of Airbus
- Boeing Management Emphasis – Emphasis on Financials/Stock Price
- Airbus Boeing Competition – “Matching” Other’s Products
- Deregulation of Airlines-U.S. and Global – Reduced Real Air Fares –Airlines’ Businesslike Management
- Rise of Narrow Body (Single Aisle) Aircraft – Support Increased Passenger Traffic
- ETOPS – Twin Engine Long Distance Aircraft

Some Things That Changed Commercial Aviation

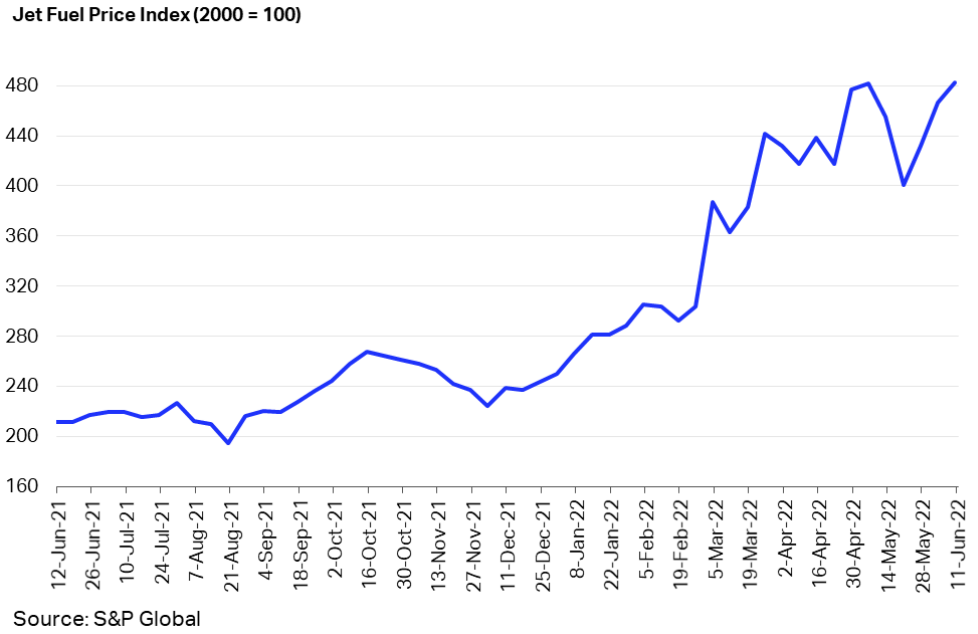
- Decline of Hub and Spoke Systems-Point to Point
- Fuel Price Volatility – Airlines seek low Fuel Consumption Aircraft
- Longer Range Narrow Body Aircraft-ETOPS-Displace Wide Bodies
- Composite Materials in Aircraft Structures – Lighter Weight Than Metal
- Increases in High Bypass Engines' Thrust and Efficiency – Reduced Fuel Burn and Emissions
- Derivative Aircraft Models vs New Design Models – Reduced Capital Investment for Manufacturers
- Increased Cost of Aircraft Development – Fewer New Designs
- Potential Challenges to the Airbus Boeing Duopoly
- Narrow Body Aircraft Development in China - **Comac C919**
- Wide Body Aircraft Development in Russia - **CRAIC CR929**
- Environmental Challenges Facing Airlines and Manufacturers - Governments' Regulations of CO2 Emissions

Airbus and Boeing Challenges

- **Financial management**
- **Financing new aircraft**
- **Deciding to build new aircraft**
  - Market needs
  - Competition
  - Technology
  - Engine availability
  - Risk sharing
- **Partner work splits**
  - Oversight
- **Passenger growth**
- **Airline profitability**
- **Fuel prices**
- **Chinese competition**
- **Emissions regulations**

Fuel Price

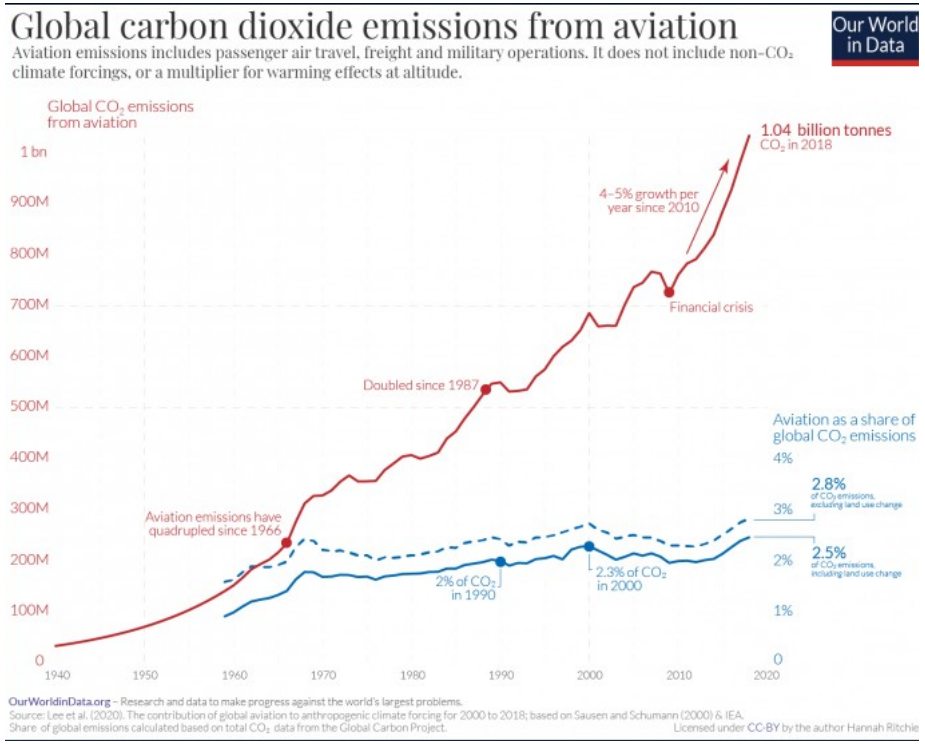
10 June 2022	Share in World Index	cts/gal	$/bbl	$/mt	Index Value 2000 = 100	vs. 1 week ago	vs. 1 month ago	vs.1 yr ago
Jet Fuel Price	100%	420.38	176.56	1394.25	482.65	3.6%	6.1%	128.1%
Asia & Oceania	22%	407.47	171.14	1351.97	488.98	5.4%	20.7%	124.0%
Europe & CIS	28%	431.91	181.40	1431.25	488.75	5.4%	12.9%	134.6%
Middle East & Africa	7%	410.48	172.40	1361.25	514.84	5.1%	17.8%	128.5%
North America	39%	419.86	176.34	1393.09	468.80	1.1%	-6.4%	125.7%
Latin & Central America	4%	430.93	180.99	1429.84	501.37	2.1%	10.5%	127.0%

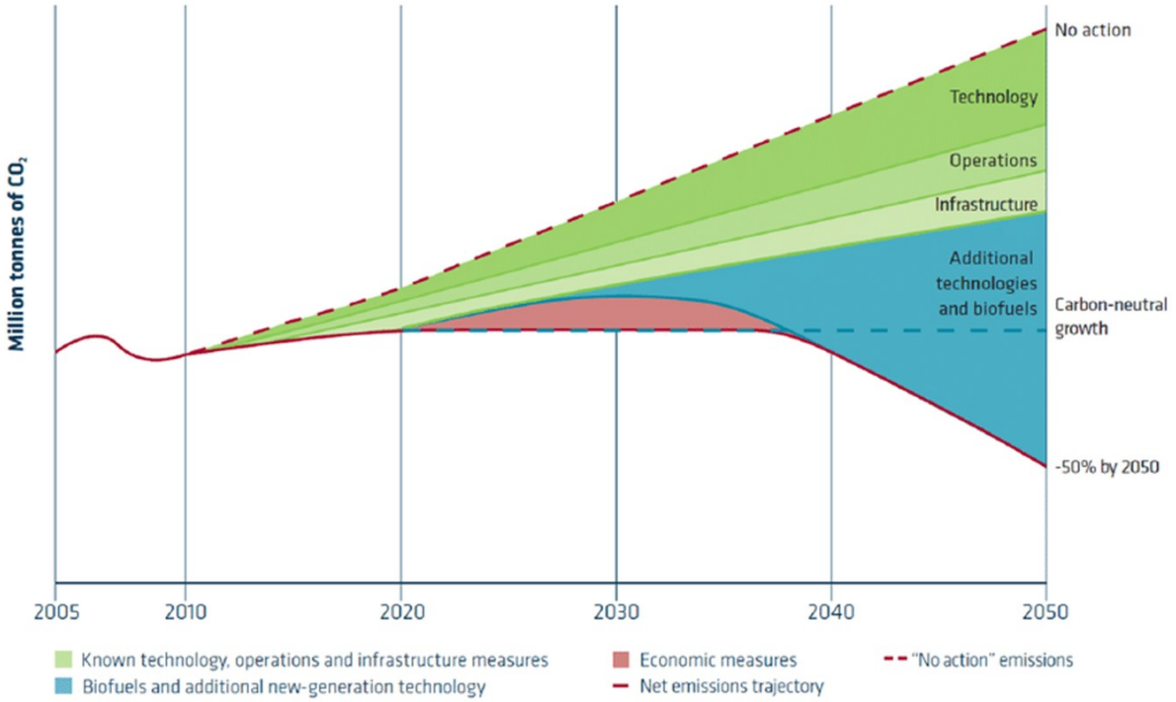


Source: S&P Global

Commercial Aviation Emission Regulations

Aviation overall accounts for only 2.5% of global carbon dioxide (CO_2) emissions





Airbus and Zero Emission Aviation

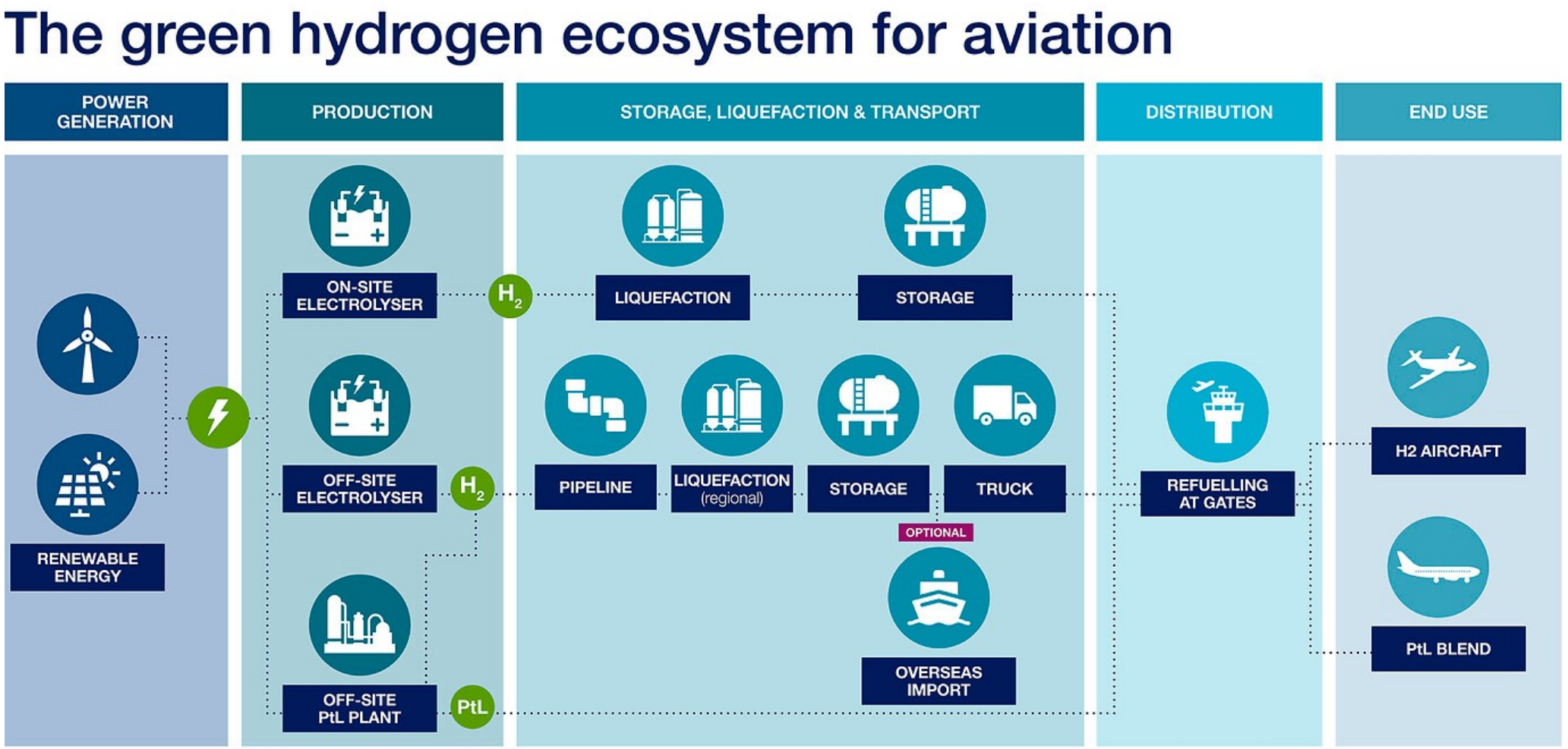
- September 2020 - **Airbus** has revealed three concepts for *zero-emission* commercial aircraft which could enter service by 2035
- All rely on **hydrogen** as a primary power source

- A **turbofan design** (120-200 passengers) with a range of 2,000+ nautical miles, powered by a **hydrogen** burning modified engine
- The liquid hydrogen will be stored and distributed via tanks located behind the rear pressure bulkhead

- A **turboprop design** (up to 100 passengers) powered by **hydrogen** in gas-turbine engines, which would be capable of traveling more than 1,000 nautical miles

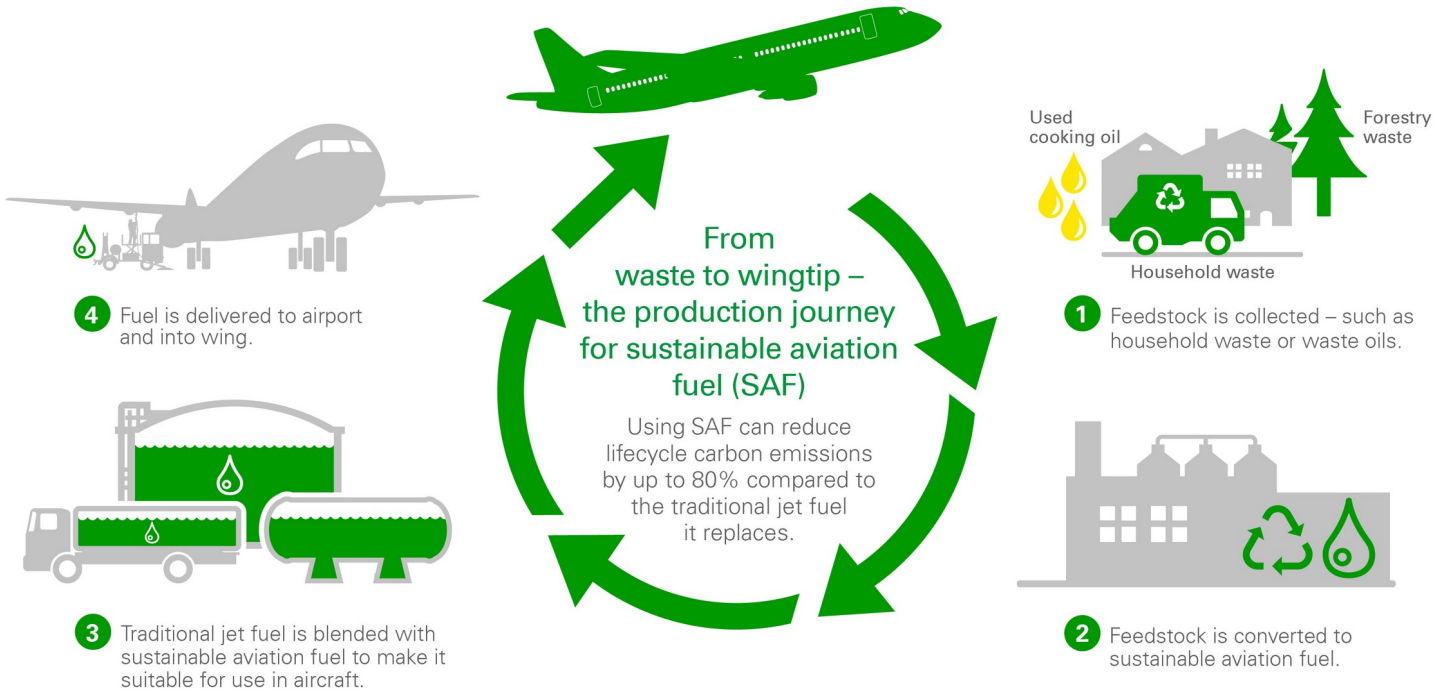
- A "**blended-wing body**" design (up to 200 passengers) concept in which the wings merge with the main body of the aircraft with a range similar to that of the turbofan concept
- The exceptionally wide fuselage opens up multiple options for **hydrogen** storage and distribution, and for cabin layout

Airbus and Green Hydrogen



Boeing and Sustainable Aviation Fuel (SAF)

How is sustainable aviation fuel made?



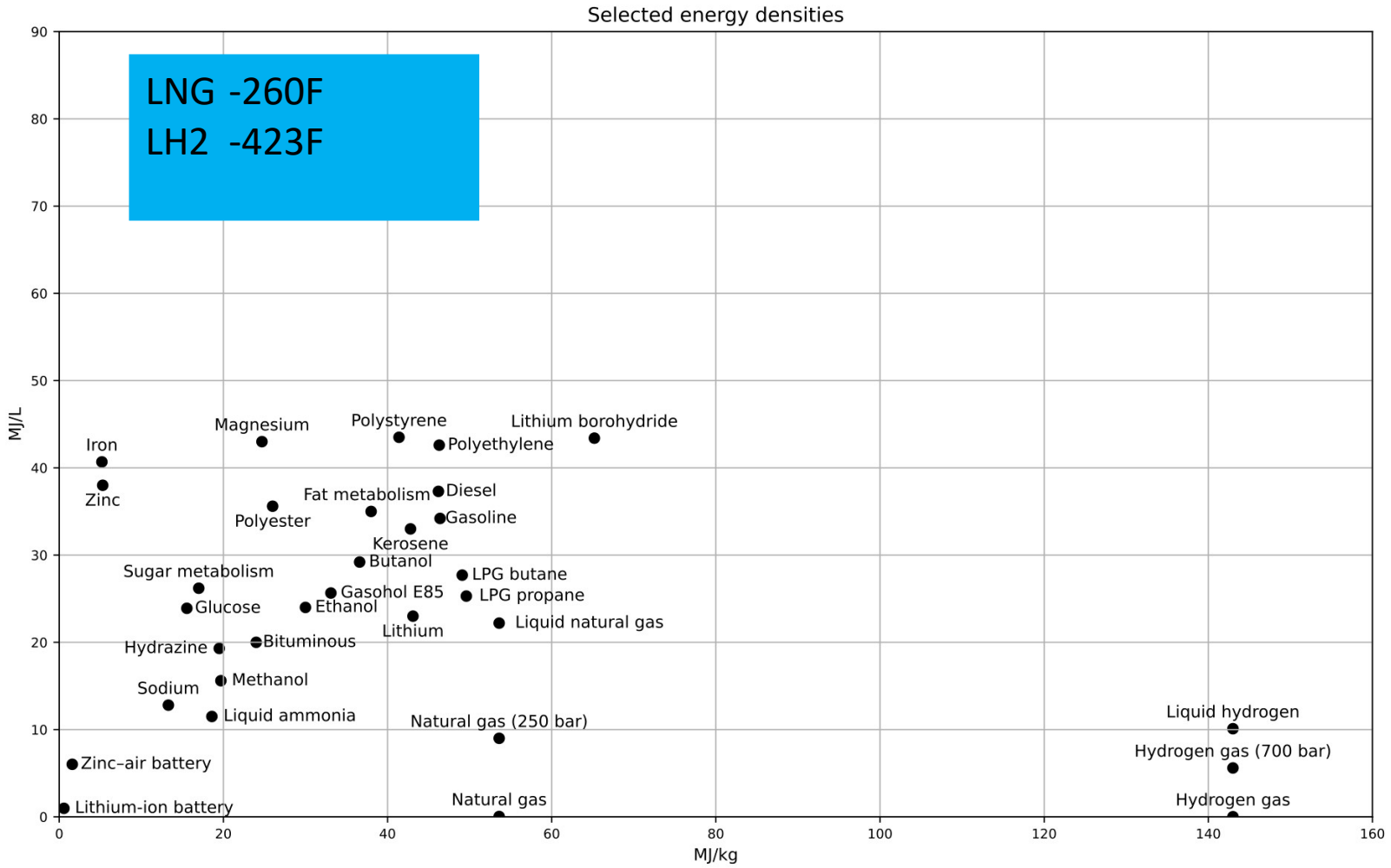
air bp Fuelling a sustainable future

Boeing and Airbus Zero Emission Aircraft

- **Boeing**
- CEO **David Calhoun** said:
- "I have a fair amount of experience with hydrogen, our company has an incredible amount of experience with hydrogen
- At least in the size of airframe that we are all talking about
- We experiment at the low end, but that's not going to be a meaningful market here
- "And the advent of sustainable fuel already, already we're capable of living with that sustainable fuel
- I believe that's going to be the 15-year answer to 2050 guidelines and approaches because we have all worked with it, experimented with it, we know it works, and *now we have to develop a supply line for it*
- But I believe it's the only answer between now and 2050."

- **Airbus** Holds Its Ground – But Likes **SAF**
- "**SAF** is very important for us as a complement to **hydrogen**
- It's the only alternative for the existing fleet and a future long-range aircraft
- Our **SAF** support has drowned in the interest in our **hydrogen** work
- But **hydrogen** is one part of the solution, **SAF** is the other
- **Hydrogen** is the solution for regional and intra-continental traffic as it has better operating economics
- For long-range aircraft, the **volume demands** of **hydrogen** make **SAF** the only carbon-free alternative."

Fuel and Battery Energy Densities



Commercial Aviation

- Commercial aviation has benefited from technology and engineering developed for military aviation
- Manufacturers merging and forming partnerships has created the Airbus Boeing duopoly
- Barriers to entry are high
- Deregulation of airlines changed the industry –more businesslike, increased competition, lower fares
- Manufacturers rely on global sourcing
- Manufacturers compete to offer what airlines need and “match” the other company’s technology
- Manufacturing requires skilled work force and astute management
- Industry is highly regulated - globally
- Commercial aircraft manufacturing is still a high risk business
- Manufacturers that “guessed wrong” or were unwilling to take risks and invest in with new products are gone
- Safety is vital to commercial airlines and commercial aircraft design and manufacturing
- It is a challenging industry – but can also be fun- to work in

Books

- *Air Wars The Global Combat Between Airbus and Boeing*
  - Scott Hamilton 2021
- *The World's Greatest Civil Aircraft An Illustrated History*
  - Paul E. Eden 2015
- *Evolution of the Airliner*
  - Ray Whitford 2007
- *Boeing the First Century and Beyond*
  - Eugene E. Bower 2008
- *The Sporty Game*
  - John Newhouse 1982
- *Barons Of The Sky*
  - Wayne Biddle 1991
- *Higher 100 Years of Boeing*
  - Russ Banham 2015
- *Twenty First Century Jet The Making and Marketing of the Boeing 777*
  - Karl Sabbagh 1996
- *From Props to Jets Commercial Aviation's Transition to the Jet Age 1952-1962*
  - Jon Proctor , Mike Machat and Craig Kodera 2010
- *McDonnell Douglas DC-10*
  - Terry Waddington 2000
- *Lockheed L1011 Tristar*
  - Phillip Birtles 1998
- *Turbulent Skies The History of CommercialAviation*
  - T.A. Heppenheomer 1995
- *Boeing 787 Dreamliner*
  - Guy Norris and Mark Wagner 2009
- *The Boeing 787 Dreamliner*
  - Claude G. Luisada and Steven D. Kimmell 2014
- *Flying Blind: The 737 Max Tragedy and the Fall of Boeing*
  - Peter Robison 2021