ENGINES@EASYJET

Gary Smith
Head of Engineering

ISABE
September 2017

easyJet

AGENDA

- Our operation and the operating environment
- Efficiency drivers & Cost per seat reduction
- Project Eagle – Aircraft Selection
- Project Vulcan – Engine Selection
  - Technical evaluation
  - Lifecycle cost evaluation
  - Negotiation, Risk & mitigation
- Selection and entry into service

OUR OPERATION - SEPTEMBER 2017

Flight Operations
- 3,485 Pilots

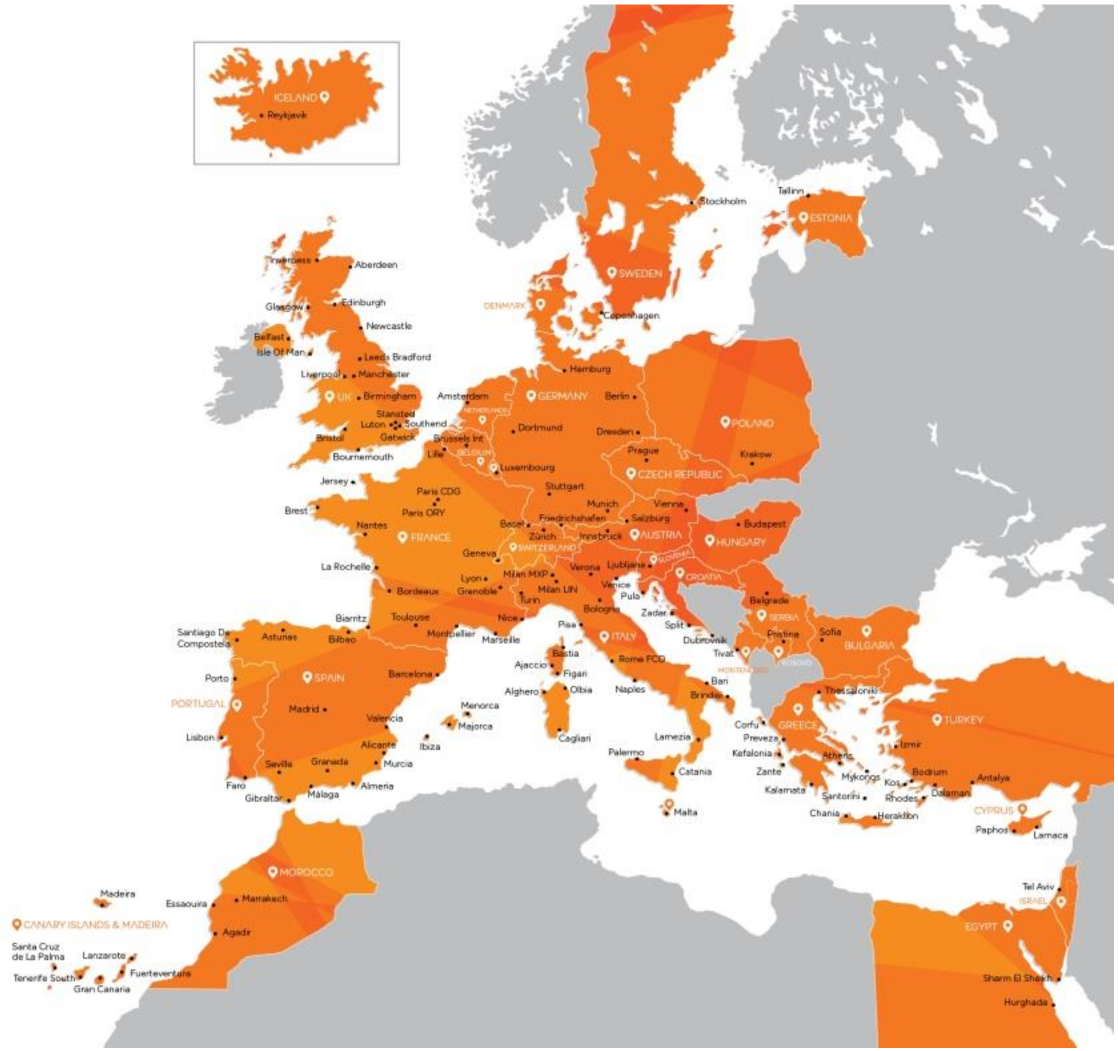
Cabin Services
- 6,855 Cabin Crew

Ground Operations
- 809 routes across 136 airports in 30 countries

Engineering & Maintenance
- 280 aircraft
- 5 maintenance bases
- 32 nightstop line maintenance bases

Operations Control
- Swiss, Austrian & UK AOCs
- 28 aircraft & crew bases
- c. 1670 sectors/day

People
- Ops total M&A 700
- Head office 230; Network 470



EASYJET OPERATING MODEL

Europe's leading short haul airline for safety on a point to point network offering low fares

Point to point

- Leading presence on top 100 routes
- Market leading route frequencies
- No.1 & 2 positions at slot constrained airports

Single type fleet

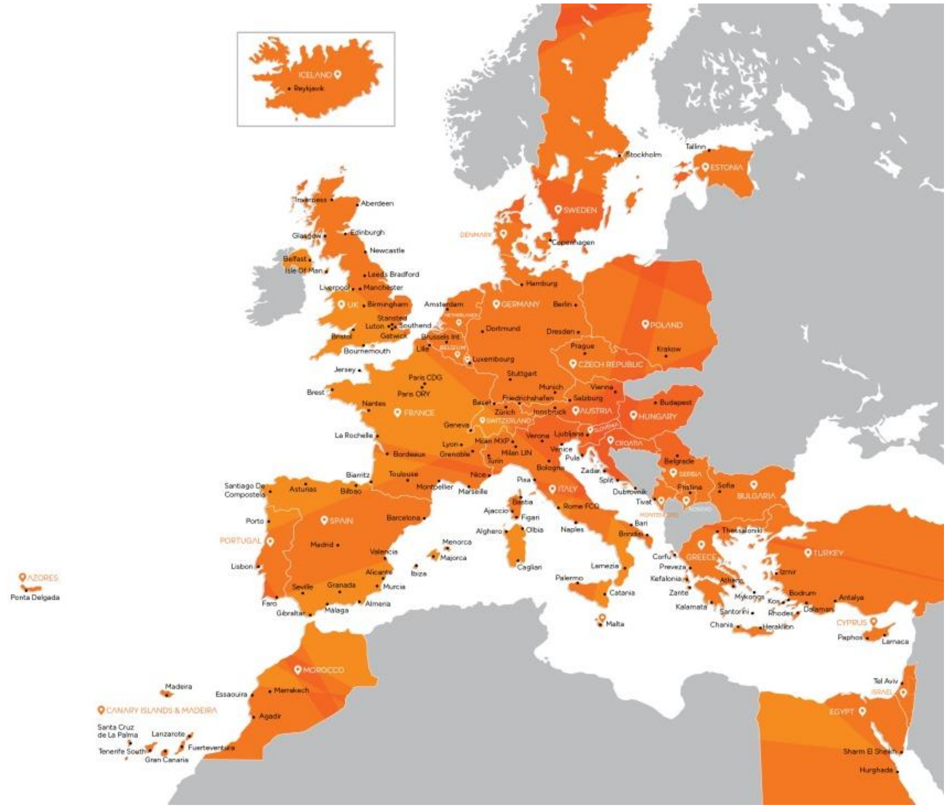
- 2 gauge A319 (159 seats); A320 (180 seats, up-gauging to 186)
- First of 130 A320NEOs delivered June 2017
- A321's from July 2018

Bases

- Crew employed at base
- Aircraft overnight

Heavily outsourced

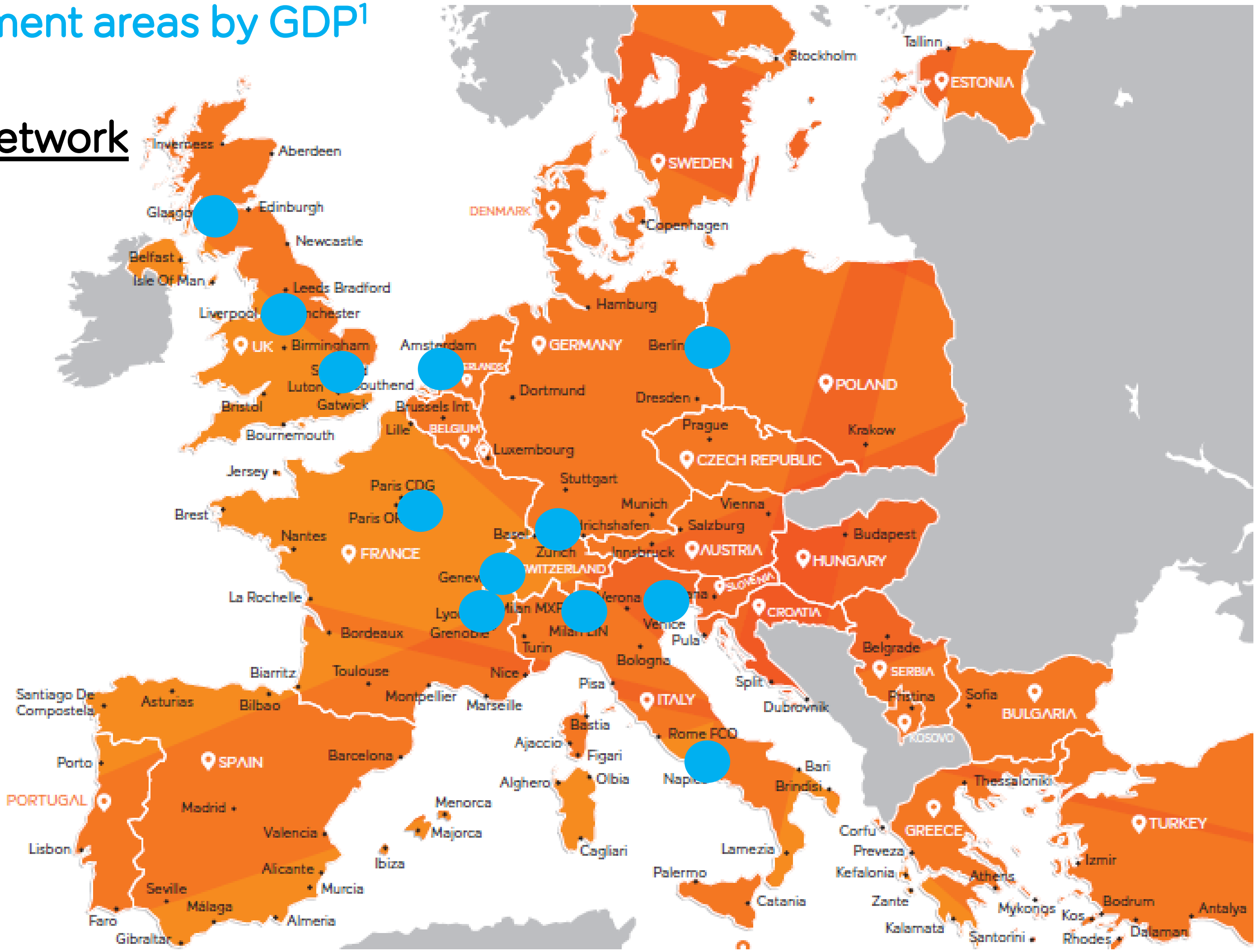
Demand for simple airport infrastructure



EASYJET OPERATES IN PRIMARY AIRPORTS ACROSS EUROPE

- Number 1 or 2 position in the primary airport in 12 of Europe's top 25 catchment areas by GDP[1]

easyJet network



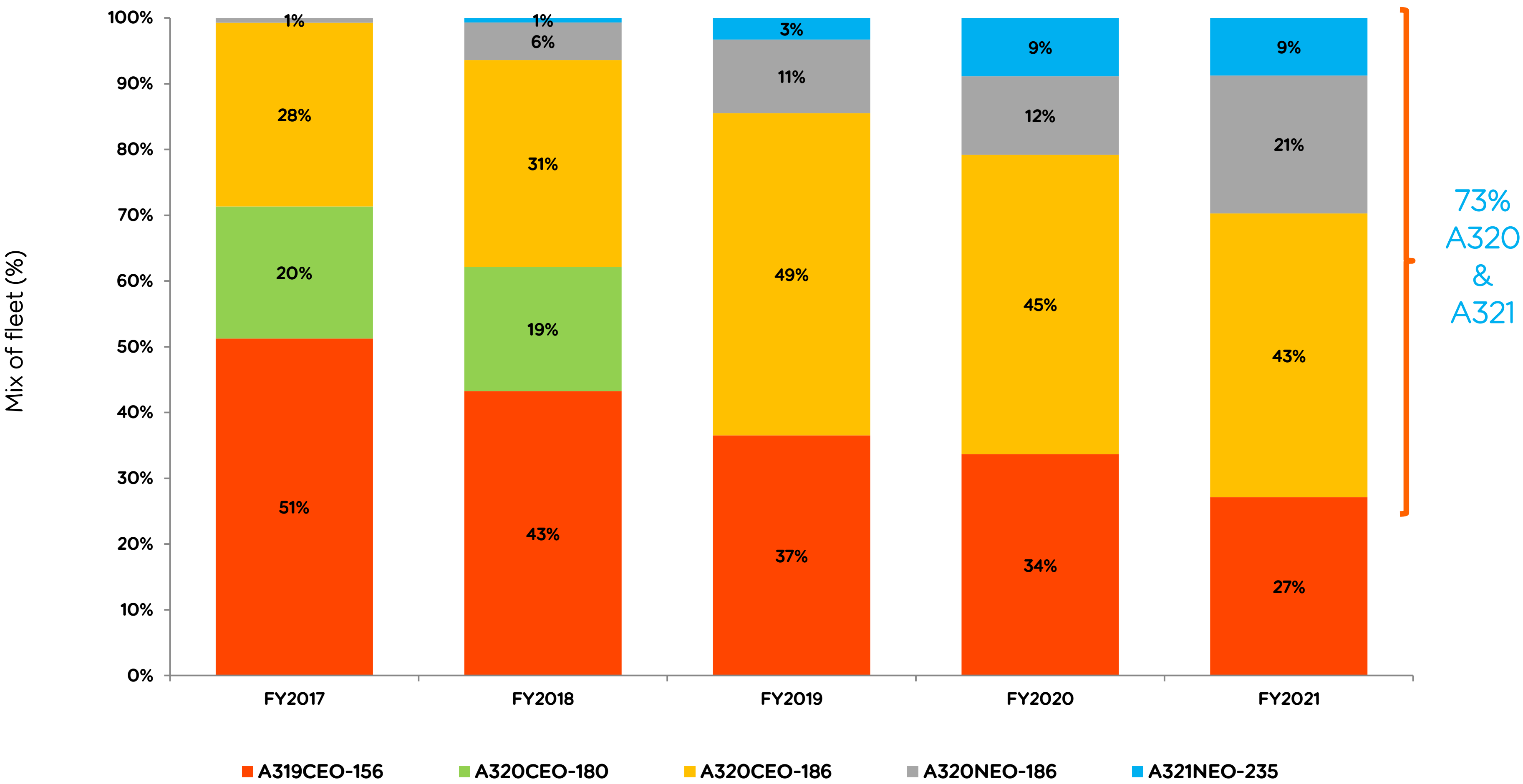
1) Catchment areas defined as population living within 50km of airports within the market and ranked according to GDP for that area; 2) Rank of short haul capacity for the 12 months to September 2015; 3) Manchester catchment includes Liverpool airport; 4) Dusseldorf catchment includes Cologne, Dortmund, Friedrichshafen, Nuremburg and Paderborn; 5) Zurich catchment includes Basel

AGENDA

- Our operation and the operating environment
- Efficiency drivers & Cost per seat reduction
- Project Eagle – Aircraft Selection
- Project Vulcan – Engine Selection
  - Technical evaluation
  - Lifecycle cost evaluation
  - Negotiation, Risk & mitigation
- Selection and entry into service

UP-GAUGING DELIVERING CPS SAVINGS

easyJet fleet mix



1. At the end of the relevant Financial Year
2. Based on fleet plan – base case
3. Maximum fleet does not include the purchase rights

OUR JOURNEY TO MINIMISE CPS

-28%

SINCE 2003

2003

'03

A319 baseline CPS

2009

'09

A320 with Tech Insertion Engines

24 more seats

more efficient engines

-8%

2013

'13

A320 with Sharklets and lightweight seats

better aerodynamics

less weight

-3%

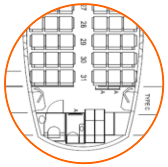
2016

'16

A320 configuration upgrade to 186 seats

6 more seats

-2.5%



2017

'17

A320 neo with new LEAP engine

more efficient engines

-9%

2018

'18

A321 neo with 235 seats

49 more seats

-9%

AGENDA

- Our operation and the operating environment
- Efficiency drivers & Cost per seat reduction
- Project Eagle – Aircraft Selection
- Project Vulcan – Engine Selection
  - Technical evaluation
  - Lifecycle cost evaluation
  - Negotiation, Risk & mitigation
- Selection and entry into service

PROJECT EAGLE

A320 NEO	BOEING 737 MAX	BOMBARDIER C-SERIES

PROJECT EAGLE

NEW FLEET DEAL

New deal was agreed with Airbus and announced in June 2013

- Contract provides for up to 230 neo aircraft
- 75 current generation A320 aircraft from 2015-2017 (existing order → 315 total)
- 100 A320 NEO aircraft for delivery from 2017-2022
- 30 additional A320 NEO agreed in Nov'15
- 100 further A320 NEO purchase rights (exercised by 2025)

AGENDA

- Our operation and the operating environment
- Efficiency drivers & Cost per seat reduction
- Project Eagle – Aircraft Selection
- Project Vulcan – Engine Selection
  - Technical evaluation
  - Lifecycle cost evaluation
  - Negotiation, Risk & mitigation
- Selection and entry into service

STRUCTURE OF TECHNICAL EVALUATION

OUR SELECTION CRITERIA

> easyJet's approach for the technical evaluation was mainly focussed on the technologies used, operability, reliability, lessons learnt from legacy programs, roadmap to certification and EIS rather than a deep scientific analysis of the engine's thermodynamic cycle!

TECHNICAL
- Engine technical suitability
- Technology risk assessment
- Potential for future development
- Ability to meet future environmental standards
- Equivalent reliability to current generation engines

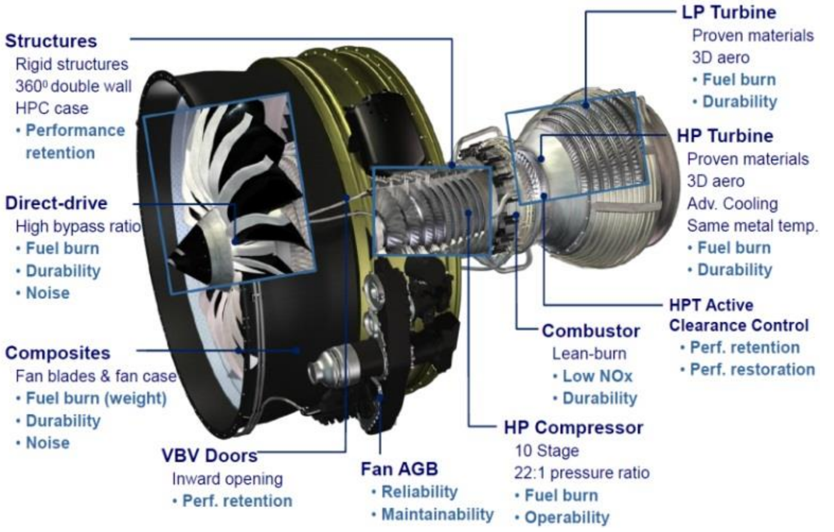
OPERABILITY
- Minimise fuel burn for A320neo family
- Sensitivity to change of mission
- Fuel burn guarantees

MAINTENANCE SUPPORT
- Validation of 'bare engine' economics
- Minimise support costs through an option on a Maintenance Support Agreement
- Suitability of maintenance programme for easyJet operational model
- Minimise complexity in technical support processes

PROJECT VULCAN

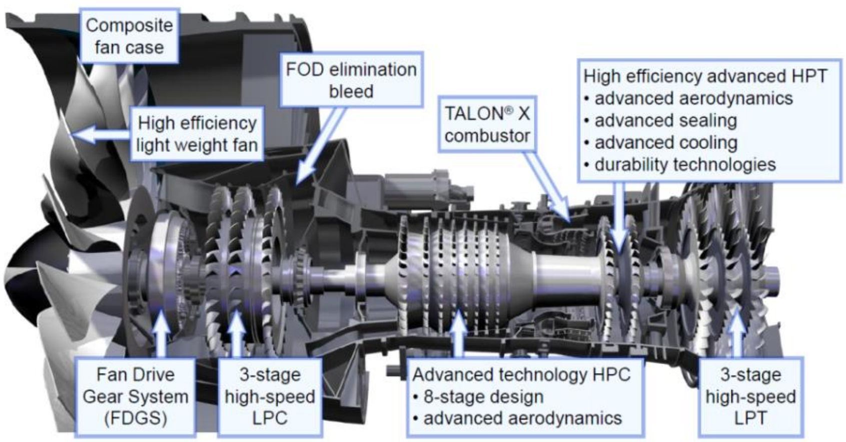
CFM LEAP

> LEAP-1A
> CFM is a joint venture of GE and Snecma
> CFM power the current easyJet A320 family with the CFM56
> The LEAP contains a range of technology proven in the GE90 (B777) and GEnx (B787)



P&W GTF

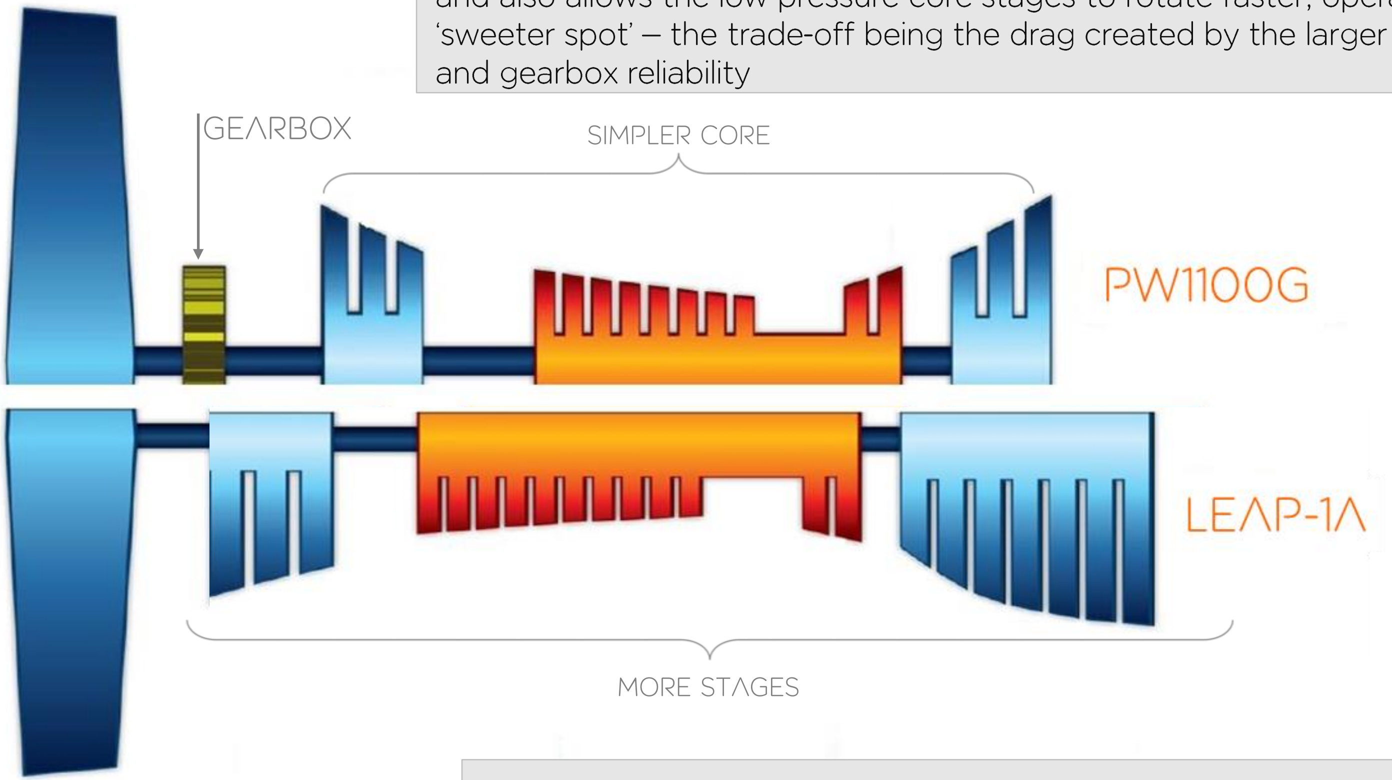
> PW1100G
> Pratt and Whitney are part of United Technologies, the aerospace and industrial giant
> The GTF stands for 'Geared Turbo Fan', the first application of a Fan speed reduction gearbox on a 150 seat plus aircraft



TECHNICAL EVALUATION

BASIC ARCHITECTURE COMPARISON

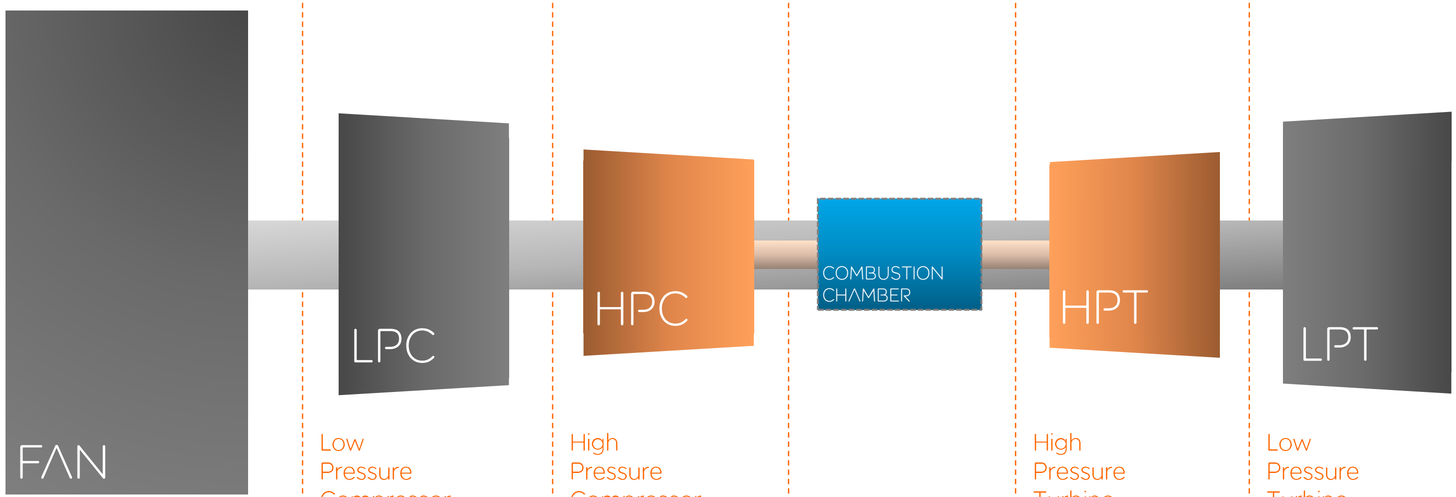
The core of the GTF is simpler with fewer parts; however the addition of a gearbox between the fan and the core allows a larger, slower turning fan, and also allows the low pressure core stages to rotate faster, operating in a 'sweeter spot' – the trade-off being the drag created by the larger engine and gearbox reliability



The core of the LEAP has more stages. Each Compressor and Turbine stage adds to the engines ability to extract rotational energy from fuel - however there is a trade-off in complexity and weight

TECHNICAL EVALUATION

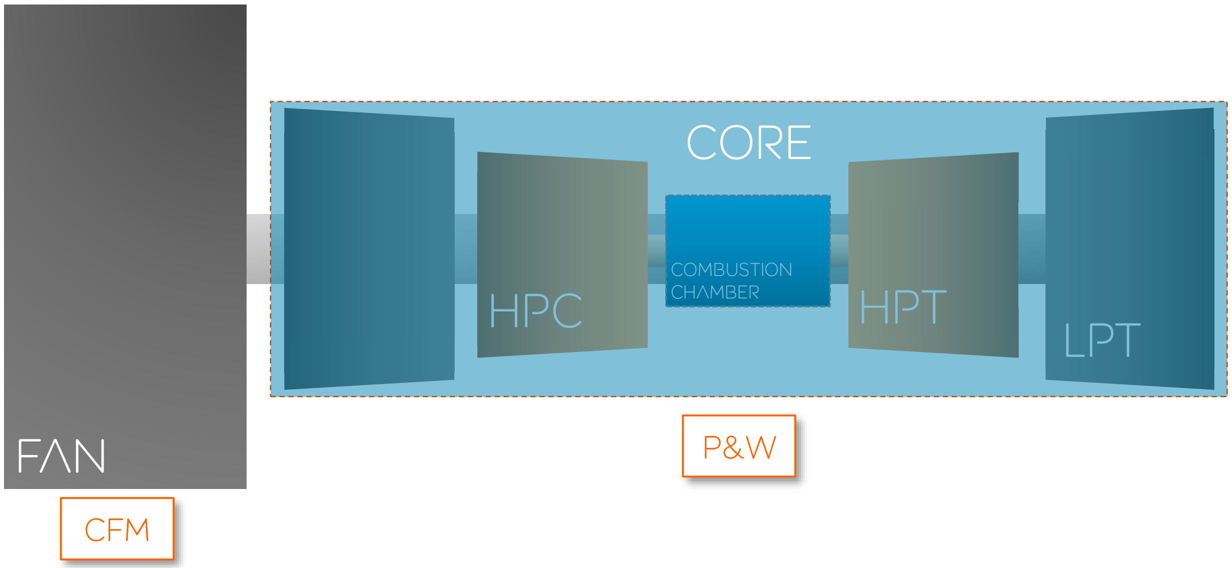
MODULAR OVERVIEW



	FAN	Low Pressure Compressor	High Pressure Compressor		High Pressure Turbine	Low Pressure Turbine
CFM LEAP-1A	- 18 carbon composite fan blades with titanium leading edge - No lubrication required - Full guarantee against repair or replacement	- 'Debris rejection system' with inward opening VBV doors to reduce FOD direct drive from fan - 3 stages	- 10 stages - 5 blisk plus 5 blade and disk - Optimised performance of each stage	- Pre-swirl combustor - One piece 3D printed fuel nozzles	- CMC HPT shrouds - Active turbine clearance control - Repairable blades	- Complex 3D aerofoils
P&W PW1100	- 20 metallic fan blades - No lubrication required - Expected reliability similar to current CFM56 (average 450 blades repaired or replaced p.a.)	- Driven by gearbox - 3x fan speed optimises performance and efficiency but possibly more susceptible to FOD	- 8 stages - All blisks - Reduced aerofoil count	- 'TALON-X' ceramic coated tiled combustor	- Conventional HPT design - 2 stages - All blades removed at 1st shop visit	- High speed LPT leveraging fan drive gear system

TECHNICAL EVALUATION

ENGINE ACCESSORIES



	CFM mounts the engine accessories on the Fan case	P&W mounts the engine accessories on the core engine
Advantages	- Cooler location; lower vibration. - Easier to engineer high-reliability.	- Lower drag; less pipework.
Disadvantages	- Higher drag. - Access to items on the base of the engine more difficult.	- Hotter, more challenging from an engineering perspective. - Need to open C-ducts to access.

Fan mounted accessories are the lower risk location from an engineering perspective, although this disadvantage can be overcome by good execution. A higher reliability risk remains with the GTF engine.

AGENDA

- Our operation and the operating environment
- Efficiency drivers & Cost per seat reduction
- Project Eagle – Aircraft Selection
- Project Vulcan – Engine Selection
  - Technical evaluation
  - Lifecycle cost evaluation
  - Negotiation, Risk & mitigation
- Selection and entry into service

LIFE CYCLE COST EVALUATION

DESCRIPTION

The business model of OEMs for the last 30 years has been to offer discounts at acquisition and then make a higher margin from maintenance services and spare parts.

Project Vulcan was a comparative evaluation process with an objective to select the lowest lifecycle cost engine, taking into account:

> The current technology (CEO) and future technology (NEO) family aircraft

> Acquisition and life cycle maintenance and fuel costs

> Technical and programme risk

> Support

Lifecycle cost = Acquisition cost + Fuel Burn + Maintenance Cost – Incentives/ Credits

Over a 20 year period

LIFE CYCLE COST EVALUATION
FINANCIAL MODELLING

> The engine life cycle cost was evaluated through a 20 years NPV looking at:
  - A/C type (A319/A320/A321)
  - A/C & engines acquisition cost
  - Fuel burn
  - LLPs cost
  - repair/restoration cost (different MSA structures)
  - commercial incentives on CEO fleet
  - ....

> With the ability to flex input parameters such as A/C utilization, type of mission, TOW intervals, … to understand sensibility of the final NPV to those parameters

> Because of the complexity of this modelling, development & validation of the model was done in collaboration with Ernst and Young (one of the biggest accounting & auditing firm in the world)

LIFE CYCLE COST EVALUATION
FINANCIAL MODELLING

LIFE CYCLE COST EVALUATION

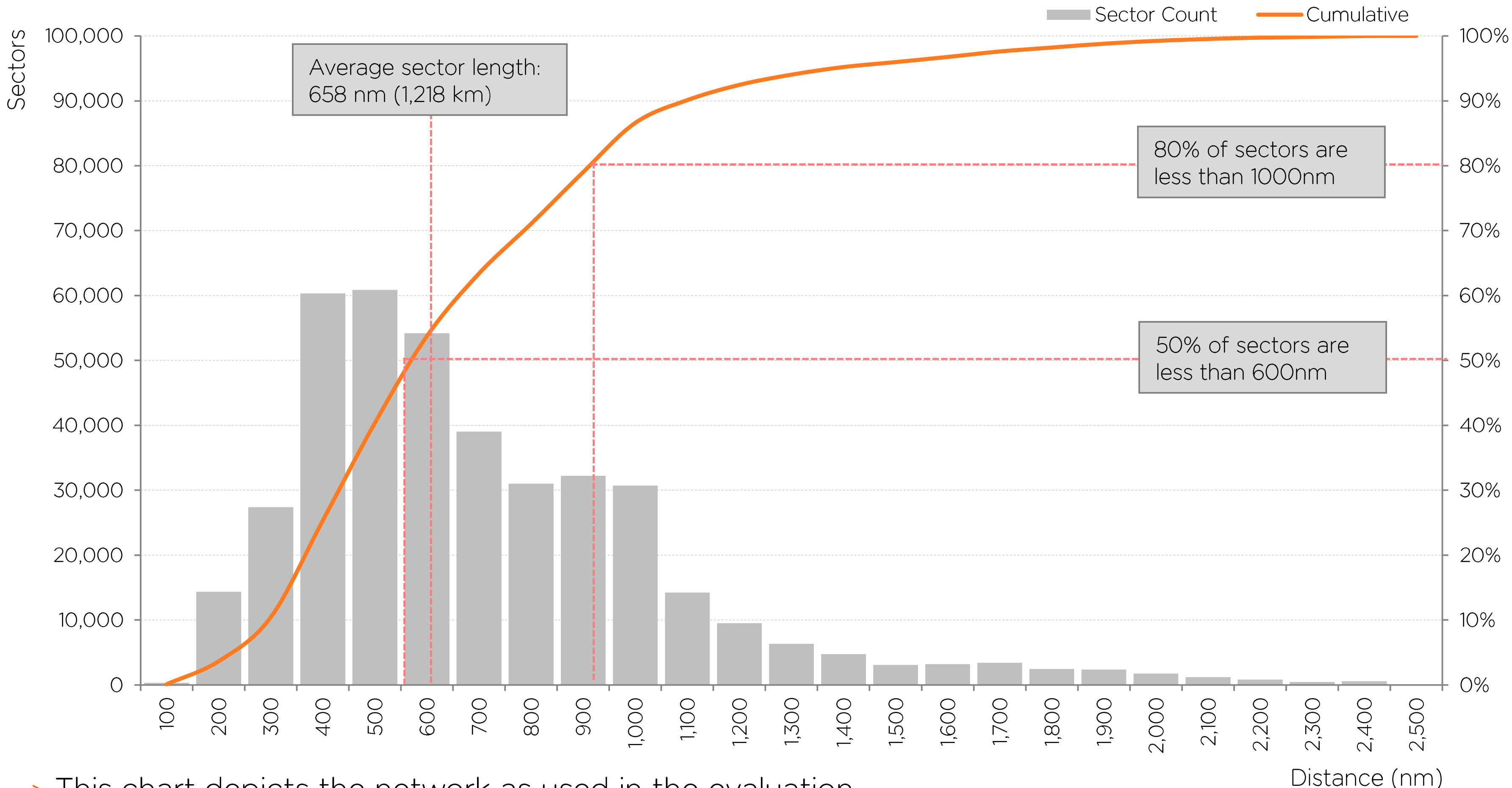
FUEL BURN CALCULATION - PROCESS

> The following process has been followed to calculate fuel burn comparisons:

Data request	Airbus processing	Data submission	easyJet processing	Financial model upload
Airbus were provided with a list of routes representative of the easyJet network and a set of operating parameters	Using their performance software, Airbus take data from both engine suppliers and model this into fuel burn at an aircraft level	Airbus then submit data detailing fuel burn (kg) for each easyJet route, for both engine types and all three aircraft variants	easyJet process the data to create two main outputs: 1. Multiplication of (sector burn x number of sectors operated) then averaged to give a block fuel burn for an average easyJet mission 2. Block fuel burn plotted against sector length (time), for each aircraft/engine variant	Data then uploaded into financial model to calculate fuel burn cost for a standard mission and to allow sensitivity of fuel burn against mission length to be analysed.

LIFE CYCLE COST EVALUATION

FUEL BURN CALCULATION - EZY NETWORK



> This chart depicts the network as used in the evaluation

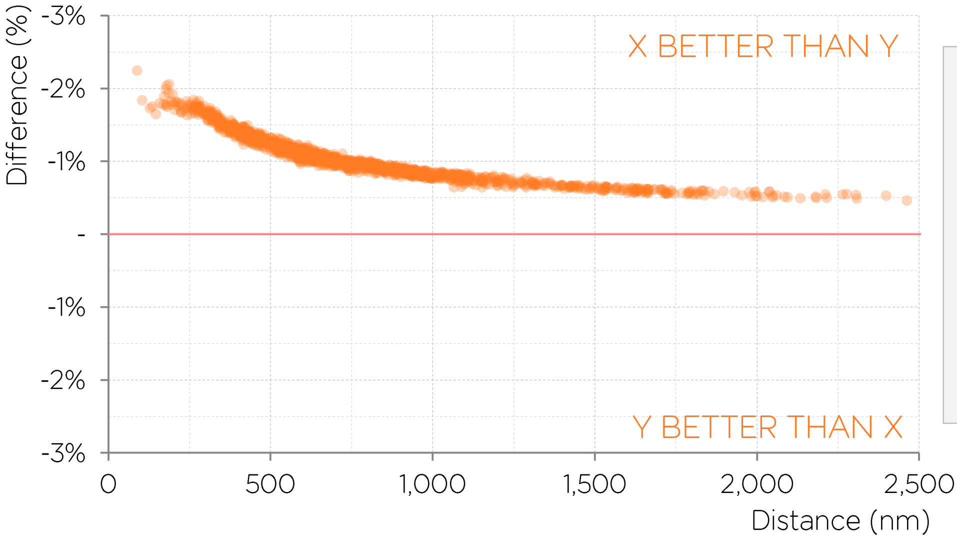
> Represents a total of c. 1,200 routes and over 400,000 sectors.

> The distances used are EZY track distances as supplied to manufacturers

LIFE CYCLE COST EVALUATION

FUEL BURN COMPARISON

> Example of block fuel burn comparison vs. sector length



Block fuel burn difference vs. sector length

> Comparison of block fuel burn between Supplier X and Supplier Y plotted for 1,200 sectors

> Supplier X has a better fuel burn than Supplier Y for any route, from 2% on the shortest sectors to 0.5% for sectors beyond 1,500 nm

> Fuel is the biggest driver in the life cycle cost evaluation but the difference between the 2 suppliers is actually quite small

> Fuel is not the deciding factor in the engine selection, however it is important to negotiate adequate fuel burn guarantees to eliminate/mitigate risk around performance shortfall at EIS and/or one engine improving at a faster pace than the other one

LIFE CYCLE COST EVALUATION

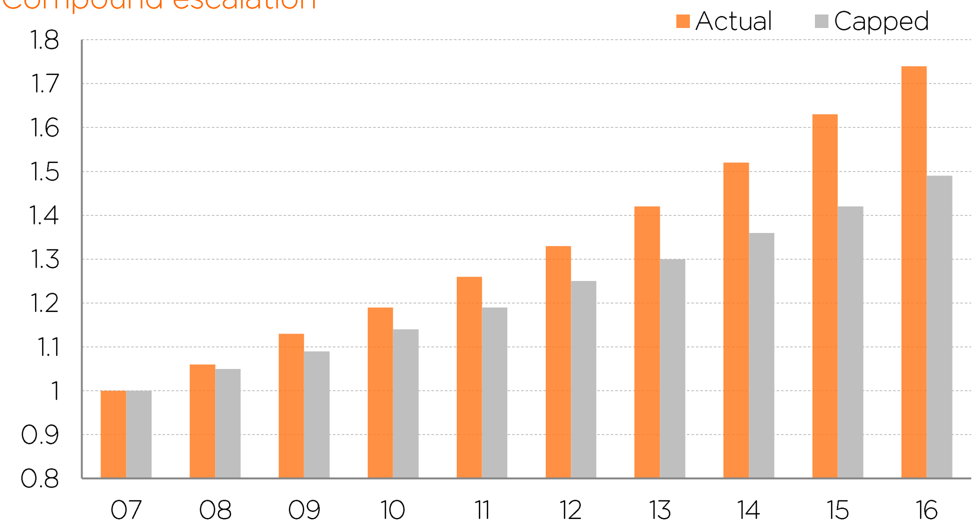
ESCALATION RATES & CAPS

> OEMs are increasing their prices on a yearly basis to take in account inflation, raw material price & labor costs increase. This is called price escalation

> Price escalation of installed & new spare engines is normally based on US labor public indices, i.e. a true representation of OEM costs increase

> Price escalation of spare parts is not based on any public indices but is at OEM discretion, leading to uncontrolled escalation rates

Compound escalation



> On a 20 years life cycle cost evaluation, a 1% advantage on spare parts escalation cap can completely offset a fuel burn disadvantage

> Escalation caps can give an airline a very significant competitive advantage against other airlines on the long term and are therefore key in the selection process

LIFE CYCLE COST EVALUATION
IMPORTANCE OF INSTALLED FLEET

> If an airline is already operating an engine from one of the OEMs (CFM56-5B or V2500), the OEM may try to offer concessions on this installed fleet as part of the new engine deal

> OEM will have a clear visibility of costs associated with those concessions (mature product, production costs of spare parts well known, …) and the airline will treat those incentives with the same level of certainty in their financial modelling

> Concession on profit margin for the OEM vs. pure cash incentive for the airline

> A large Installed fleet can be a significant advantage for the OEM and the airline can take this opportunity to resolve commercial issues on their current fleet

> Very few "switchers" so far, none within the airlines with a already large installed fleet

> What if easyJet had selected the V2500 engine for its CEO fleet in 2003? Strategic decision from engine OEMs, "betting on the right horse"

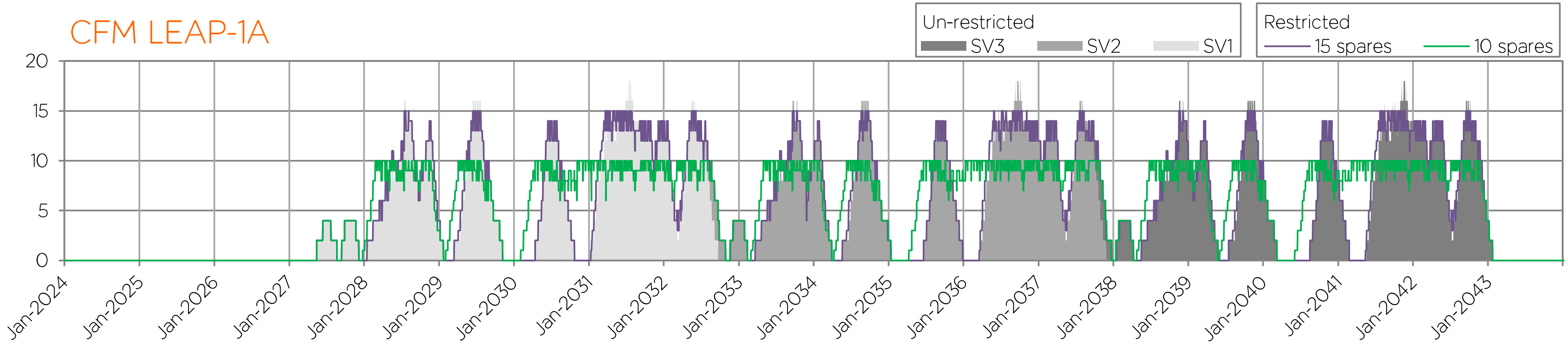
OPERATING COST COMPARISON
SHOP VISIT PLAN - SPARE ENGINES

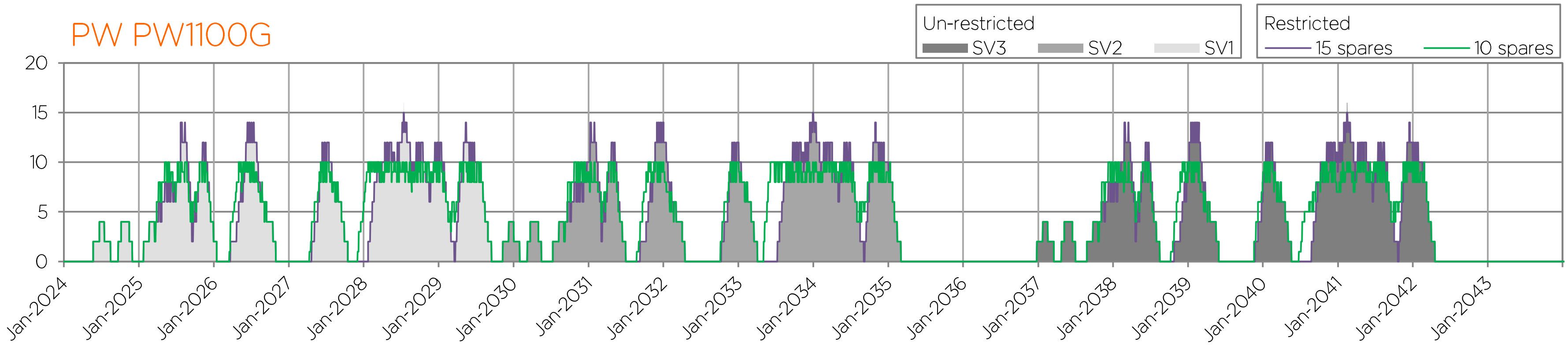
- EFPAC is the engine management software package that is currently used by easyJet to optimise its engine removal plan.
- A "NEO fleet" was created in EFPAC to simulate the engine shop visit profile for the next generation engines and evaluate the number of spare engines that will be required.
- The aircraft delivery profile was input as per the current fleet plan.
- Data obtained during the MSA process was input to EFPAC. This included the following assumptions:

- The next slide shows the resultant shop visit plans for each engine, for a 20 year period.
- A restriction in the number of available spare engines (15 and 10) has then been applied to measure the amount of stagger (lost life) that would need to be introduced into the programme to manage with this restricted number of spare engines

OPERATING COST COMPARISON
SHOP VISIT PLAN - SPARE ENGINES

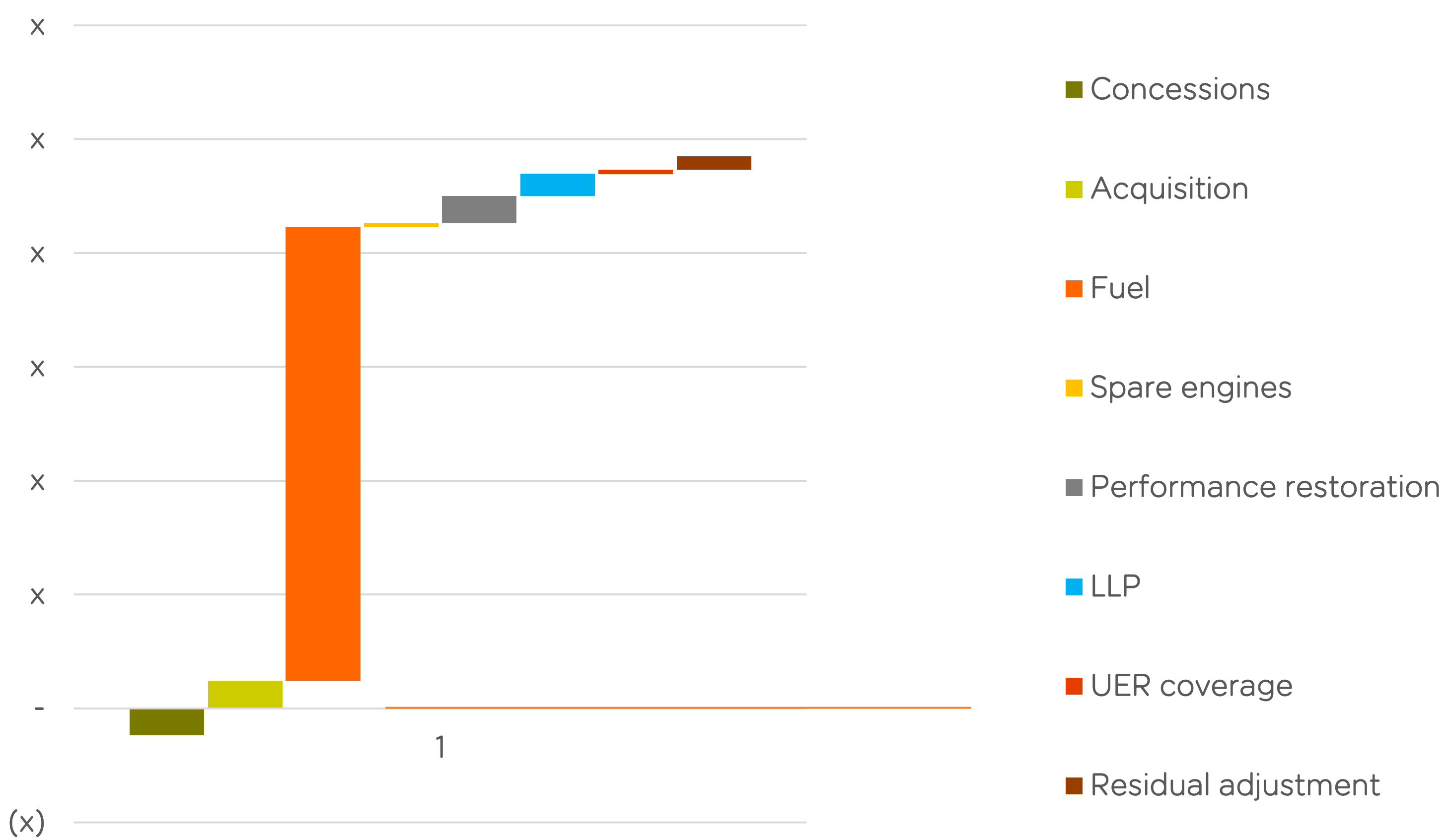
> Shop load forecast and staggering effect vs. number of spare engines:





Note: Above charts are for A320 thrust rating

LIFE CYCLE COST EVALUATION
NPV STACK SPLIT



> NPV stack dominated by fuel however difference between the 2 engines can be very small

> Difference between the 2 OEMs on the other NPV contributors can be very significant, best example being the concessions on the CEO fleet

AGENDA

- Our operation and the operating environment
- Efficiency drivers & Cost per seat reduction
- Project Eagle – Aircraft Selection
- Project Vulcan – Engine Selection
  - Technical evaluation
  - Lifecycle cost evaluation
  - Negotiation, Risk & mitigation
- Selection and entry into service

NEGOTIATION PROCESS
GUARANTEES & MSA

GUARANTEES

> The negotiation process does not only look at the deal economics but is also an opportunity to get the suppliers to provide a set of guarantees
> The goal for easyJet was to get this set of guarantees aligned with suppliers claims for their engine. For example, if the supplier claims its engine reliability will be as good as current engine generation, this should be reflected in TDR / UER guarantees
> Fuel burn guarantees were very closely looked at to ensure they will be administrable
> Guarantees will provide financial compensation to easyJet if the engine does not perform as expected and is also an incentive for the supplier to address issues promptly

MSA

> During the acquisition of the engine there is also an opportunity to negotiate a Maintenance Service Agreement (MSA), this is particularly important for this generation of engines because of the OEM approach to maintenance services
> An MSA is a way to transfer risk of engine maintenance costs from the airline to the OEM
> This is significant decision as the airline could be spending more money in maintenance than on the actual acquisition of the engine
> With none of the engine in service at the time of negotiation, the airline might try to build in flexibility over their decision after EIS

RISK

> A comprehensive risk review process was followed throughout Project Eagle and now Project Vulcan

> In all cases, we were evaluating:

- Large, established suppliers with already considerable order volumes
- Engines with robust development processes and considerable testing prior to easyJet's entry into service; backed by a substantial set of performance guarantees

> easyJet first NEO delivery will be in July 2017, with 50% of our deliveries over the next three years and the 100th NEO aircraft delivered by August 2014

> easyJet's first A320NEO delivery would be approx. line number 400 and the 25th delivery approx. line number 800

> The following slides detail the key risks and mitigations along with information on the current guarantees offered by the manufacturers

KEY RISKS ASSESSED AS HIGH OR CRITICAL

EXTRACTED FROM THE PROJECT VULCAN RISK REGISTER

RISK	RISK RESPONSE
Exposure to unproven new technology easyJet will be exposed to new technology which has not been fully tested or does not perform as expected.	Extensive testing by manufacturer/common certification requirements Phased Entry Into Service (EIS), easyJet is not the first operator Similar aircraft/engine – with different variants will enter service first Commercial warranties/guarantees will be sought to address any shortfalls in performance. Evaluating an MSA to 1st SV with an option to 2nd SV. Engine technology presentation from Cranfield at Jan PLC Board Test process (especially endurance testing) being evaluated/presented in the Technical report
Fuel Burn Performance Fuel burn performance at entry into service (EIS) does not match performance data submitted by manufacturers	Fuel burn and performance guarantees from the suppliers easyJet is not the first operator so fuel burn performance will be known prior to delivery
Reliability The engine develops an in-service condition that has an impact on multiple aircraft within easyJet's fleet, either through cost, poor reliability or the need to 'campaign' a modification	Specific system and batch guarantees Spare engine support guarantees Large installed base Established 'industry giant' suppliers
Engine Performance Performance of the engine degrades prematurely during service, affecting either fuel burn or unscheduled engine removal & shop visit timing (or both)	Both fuel burn degradation and shop visit costs/intervals will be the subject of specific guarantees
Engine maintenance costs Engine maintenance costs and parameters are higher than that used in modelling, adversely affecting financial performance	Best rate in the world guarantee requested Appropriate audit process: usage of external consultants to offer best practice/governance (workshop with Oliver Wyman held in Oct.) Comprehensive maintenance service agreement evaluation

Overall risk is assessed as being low.
All Risks can be effectively mitigated although severe engine technology failure, in-service support and product immaturity must be carefully managed by guarantees

GUARANTEES - OVERVIEW

> Guarantees typically have three elements
  - Form
    - Absolute: a straightforward warranty or performance level to be delivered on day one
    - Retention/period based: measured over a period of time, often to assure on product durability
    - Comparative: normally measured relative to a competitors product
  - Trigger
    - A ceiling / or floor beyond which a remedy is provided
  - Remedy
    - Describes the action taken if the trigger is breached
    - Often financial, and normally capped at a maximum value over the guarantee period

> Guarantees have been obtained as relevant in the following areas:
  - Product warranty (against failure), at airframe, engine and engine sub-system level
  - Long term performance (e.g. fuel burn)
  - In-service reliability (technical despatch reliability, unscheduled engine removal rates etc.)
  - Service and support levels

> All guarantees have been obtained on a 'fleet' and 'batch' i.e. a 20 aircraft sub-fleet basis to protect against the dilution of guarantees by the introduction of a large number of aircraft when smaller groups of non-performing/defective products arise

FUEL BURN GUARANTEES - ENGINE LEVEL

	DESCRIPTION	CFM LEAP-1A	P&W PW1100
Absolute fuel burn	A guarantee to ensure that delivered fuel burn is equal or better than data provided during the selection process		
Fuel burn at pass off	A guarantee to ensure consistency of engine performance within a tolerance of an agreed average, measured in the test cell. Drives the manufacturer to ensure standard assembly tolerances and forces performance to the highest level	TOP SECRET!	
Fuel Burn - comparative	Guarantee that the given supplier engine will be equivalent to/ be better than the competitors engine for fuel burn under standard conditions		
Fuel Burn degradation	Guarantee that the engine fuel burn will not increase more than (X)% due to long term deterioration		

The range of guarantees offered gives cover for the potential areas of exposure to easyJet; however work continues to ensure that the level of cover and the remedy is adequate to compensate for any shortfalls

AGENDA

- Our operation and the operating environment
- Efficiency drivers & Cost per seat reduction
- Project Eagle – Aircraft Selection
- Project Vulcan – Engine Selection
  - Technical evaluation
  - Lifecycle cost evaluation
  - Negotiation, Risk & mitigation
- Selection and entry into service

GEARING UP FOR EIS

LEAP-1A

> Delivery of the first easyJet A320 NEO with the LEAP-1A was on schedule in June 2017

> Within the last 12 months, all the following activities were completed in order to ensure a seamless Entry Into Service

- > A/C delivery schedule
- > Contracts
- > Operational data
- > Product Support Plan
- > Training
- > Flight Ops
- > Technical publications
- > New engine records
- > Spare parts Provisioning
- > Tooling
- > Spare engine support
- > On-Wing maintenance program
- > Engine Condition Monitoring
- > LRU vendors support
- > CFM Services solutions
- > On-Wing support
- > Budget preparation

NEO & A321

NEO

> Two NEOs, G-UZHA and G-UZHB, currently in operation with a total of 1400+ FH and 660+ FC flown so far.

> 99.09% TDR of LEAP-1A engines. Just some minor delays but no major operational disruption event so far.

> Noise and environmental benefits delivered.

> A/C meeting performance and fuel burn expectations. Fuel Consumption around 15% lower than A320 CEO.

> Solid foundation for next 2 aircraft on October, 20+ in 2018

> The current experience so far validates our selection process.

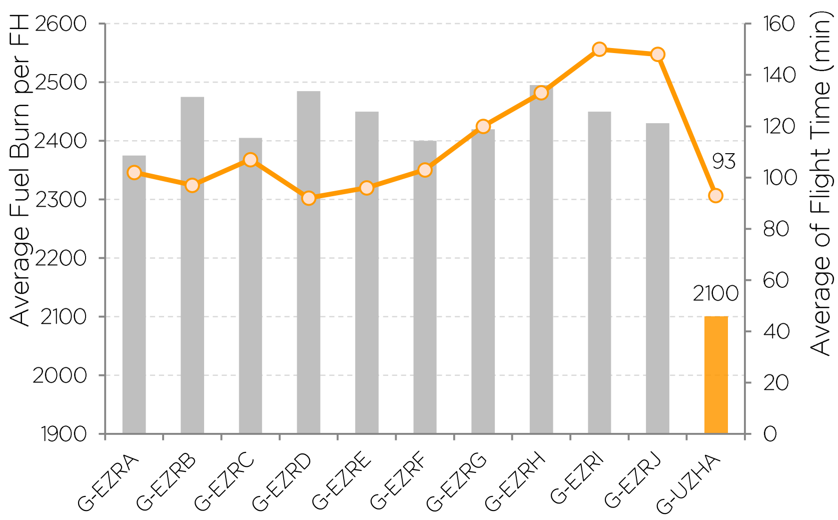
A321

> A321 NEO to be delivered mid 2018

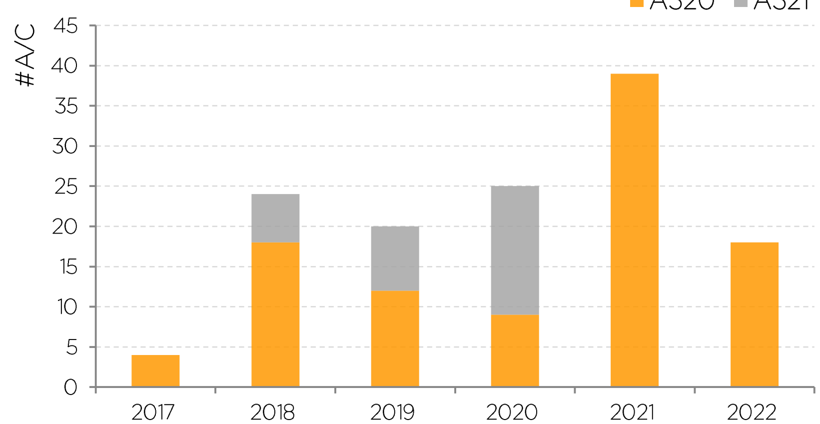
> 235 seat ACF aircraft

> EIS on target; spec confirmed

> NEO vs CEO FUEL BURN



> NEO DELIVERIES



SEXY PICTURES

CONCLUSIONS

- It's the technical issues that you can't predict that will cause the problems; therefore it's more about guarantees and mitigation
- Fuel is a big factor for changing aircraft but not such a big differentiator between engines
- Maintenance cost can be a big differentiator; 20% difference in LLPs is a lot more than 0.5% difference in fuel burn
- Price escalation is a big factor over a 20-year lifecycle
- We made the right choice!

Questions??