JetX®
Engineering

X-PLORER 1 EC

Pushing the boundaries in aerospace education and research through inspiring partnerships.

EC STANDS FOR EXTENDED CAPABILITIES. **AND WE HAVE DONE JUST THAT.**

The second engine of the X-Plorer family builds upon the design of its award-winning predecessor. Find out more about all the changes and improvements we've made over the 9-month redesigning and manufacturing journey.

CONTENTS

Hello! We have put together this document to give you some background information on our work and team. The X-Plorer 1 EC is the second jet engine model that we have designed and manufactured. We would like to highlight some of the biggest improvements that we've worked on; from the assembly procedure to electronics.

X-PLORER 2 & KRONOS TEAMS

2017/18

In 2018 we restructured our team to better serve our current portfolio. It is now specialty-driven, allowing each member to focus on their area of preference.

ABOUT US

JetX was founded in 2014 to provide a richer education experience to those interested in the aerospace sector whilst still in university. Even today, it is one of the most innovative and business-like student projects, offering learning opportunities in areas such as propulsion, computational modelling, 3D printing, materials testing, electronics, embedded systems, software design, marketing and more. As of early 2018, we have engaged over 90 engineering students from a broad range of backgrounds and years of study in our projects. In 2017 our first ever engine model, the X-Plorer 1, received praise from industry leaders and media from the additive manufacturing community. We love sharing our passion for engineering with a broad range of audiences and hope to continue inspiring young engineers across the UK and beyond.

PAST PROJECTS

CURRENT PROJECTS

X-PLORER 1

Design

All components are designed by our team, going through computational analyses and optimisation for 3D printing and assembly

3D Print

Excluding fasteners, fittings and electronics, all other components are 3D printed with various types of filament

Test

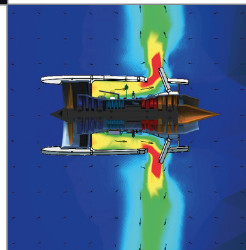
Using compressed air, we can simulate a range of testing conditions while monitoring static performance

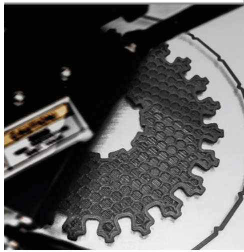
264

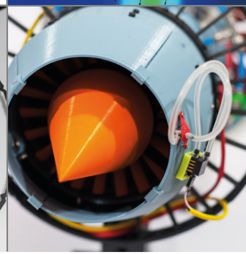
3D printed parts

8.1 kg

Gross weight







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Sensors

Project of
the Year 2017

WINNER
of the
Solidworks Jury Prize

in the Dassault Systèmes
competition

3D Hubs
Student Grant 2017

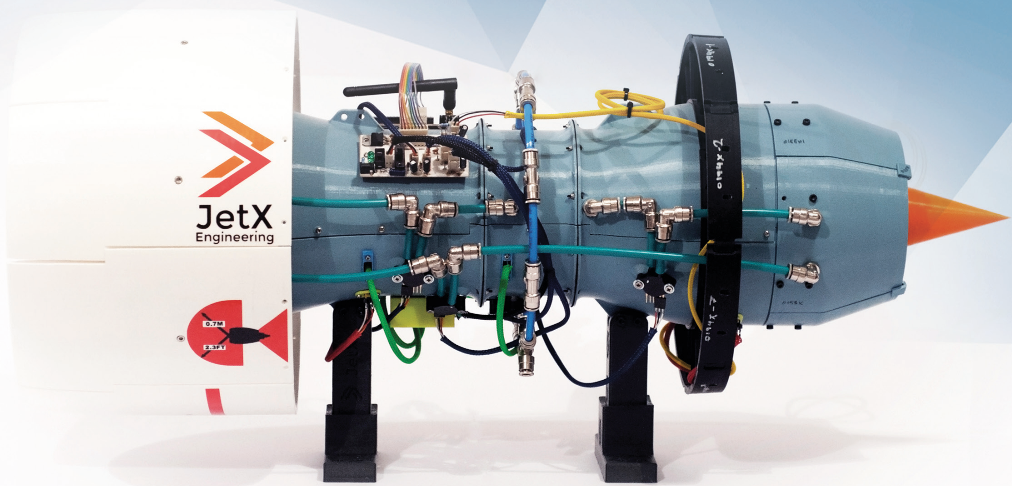
SHORTLISTED
project in the
'Engineering'

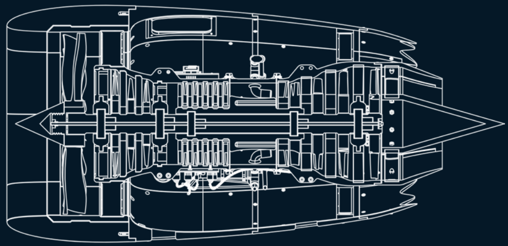
category of the 3D Hubs
competition

Project of
the Year 2017

9th
most voted from the public
out of 214 entries

in the Dassault Systèmes
competition





X-Plorer 1 EC

REDESIGN BEGAN JANUARY 2018
3D PRINTING BEGAN APRIL 2018
FIRST RUN AUGUST 2018
DELIVERED OCTOBER 2018

- **1432** components in final assembly
- **55** unique sub-assemblies
- **269** 3D printed parts
- **1000+** man hours for part prep, assembly & testing

The same X-Plorer 1 core with more small improvements than the eye can see.

Keeping all the good stuff...

Apart from keeping the same core design, we have also kept and refined the best manufacturing practices. For example, the use of heat-pressed inserts was proven to be very effective for the previous nacelle and was rolled out across other sub-assemblies for the EC.

...and innovating along the way.

Improving the efficiency of certain components and making disassembly and maintenance easier were two of our main goals. A largely redesigned electronics and monitoring system makes operation easier than ever before.

3D PRINTING STATS

3D Printing is our main manufacturing method, providing a cost-effective and fairly forgiving way of prototyping. Since the beginning of our operations, we have spent over 5500 hours 3D printing parts, including trial prints, final parts and revisions!

2588 hours

of 3D printing for the X-Plorer 1 EC for all parts including spares

670 parts

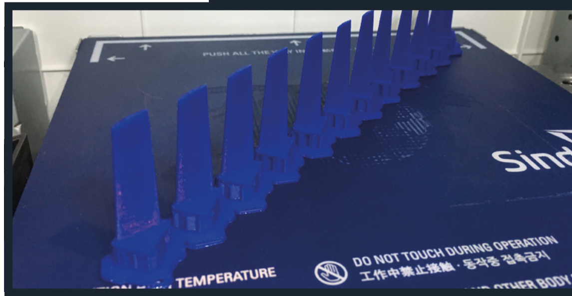
for the X-Plorer 1 EC including spares

That equates to

3.8 km

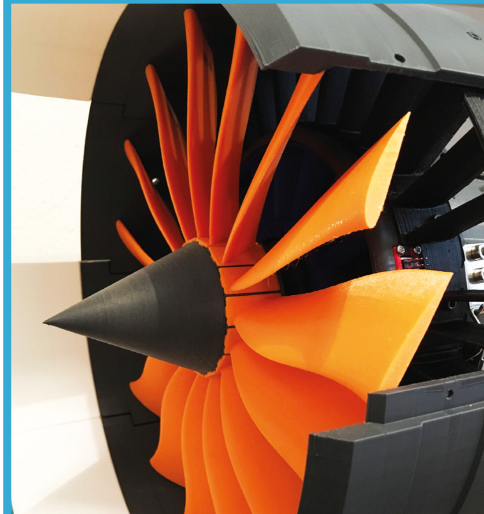
of filament

which is 900m more than the minimum runway length for an A380 take-off



FAN BLADES

Our first generation fan blades followed a very strict design process dictated by the fundamental principles of aerofoil design. As a result, they looked more like the fan blades one would encounter in the early engines of the 60s and 70s. The clear room for improvement was exploited last year by the compressor team which delivered the second generation of fan blades used in the EC.



OUR SOLUTION

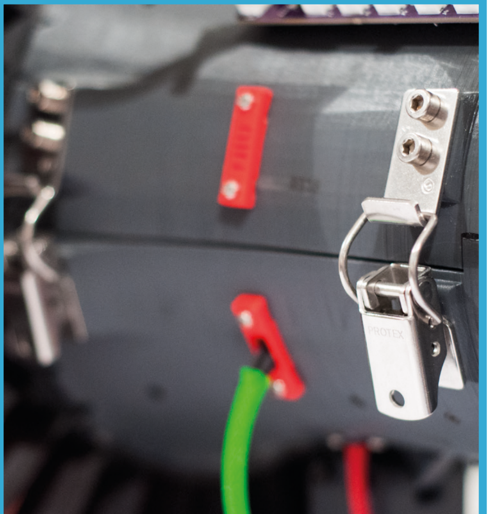
A new design was proposed to reduce drag and the overall perturbation of the flow. This used NACA5510 as the starting point with modifications to the pitch and twist angles, before being computationally evaluated. The resulting blade from this study offered an increase in mass flow rate from 1.7 kg/s to 2.3 kg/s as well as a 30.8% increase in the maximum theoretical thrust.

SPECS

Pitch Angle 25 degrees
Theoretical Max Speed 5000 rpm
Optimum Number of Blades 18
Actual Number of Blades 15

18%
more efficient air displacement

30.8%
increase in max theoretical thrust



With the support of

PROTEX® ISO: 9001:2015 · Tappex

EASE OF ASSEMBLY

Assembling the X-Plorer 1 highlighted a number of weaknesses in the attachment method, particularly of the two casing halves. This made partial disassembly challenging to the extent that substitution of components was not practical. As experimenting with different components is one of the main goals of our projects, this had to be addressed as soon as possible.

OUR SOLUTION

Offering a practical and affordable solution to this problem was broken into three parts. We eliminated the use of M2 nuts, as the embedded sockets were failing frequently, and expanded the use of heat-pressed threaded inserts across the engine. Additionally, we carried out trials using toggle latches which were hugely successful in simplifying the attachment and release procedure. Finally, the redesign of the EMS involved grouping sensors on each casing half, reducing the number of connections that have to be undone each time.

LATCHES

Type Light duty spring
Material Stainless steel
Max Working Load 18 kg
Sets Used for Core 6

INSERTS

Product Range Microbarb ®
Material Brass
Application Temp 220-250 °C
Total Number in Use 233

PRESSURE SENSORS

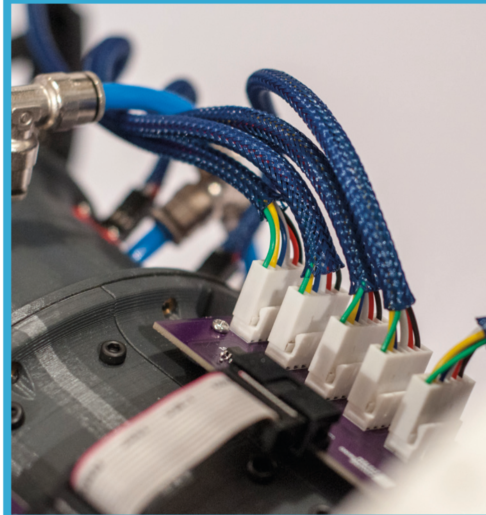
The first version of our Engine Monitoring System (EMS) was a great step in providing an integrated and complete solution for our testing needs. However, the first iteration suffered from inefficient integration and lack of information surrounding the testing conditions led to incorrect sensor specification. No useful data was ever obtained for pressure levels, as the actual range fell within the sensors' noise range. The search for more suitable sensors was coupled with improving the packaging solution.

OUR SOLUTION

The new pressure monitoring subsystem introduces MEMS components in the EMS for the first time. Using sensors with a suitably low pressure range was thought to be potentially limiting, which led to a higher pressure sensor installed alongside the low-pressure ones, giving us greater flexibility and range.

SPECS

Low Pressure Range 26-126 kPa
High Pressure Range 0-5 bar
Low Pressure Sensor Size 2x2x0.8mm



2x
fewer secondary components

6
total number of pressure sensors

PART MARKING

Logging and traceability have always been taken into consideration. Since we got our first 3D printer, we established a serial numbering system that keeps tracks of several prototyping parameters; from the material to the printing speed and any post-processing carried out. Out of the 1190+ parts we have ever produced, only 533 are actually on an engine at one time. However, the ink from pen markings often leaked along the layers and faded, making it very difficult to identify the serial number.

OUR SOLUTION

A low-cost laser marking procedure has been implemented and was used for a large proportion of the EC parts. A layer of powder, consisting of graphite and clay, is locally applied prior to marking and is later washed off. It is a time-consuming process but produces markings with significantly improved quality and durability.

SPECS

Laser Power 1500 mW
Wavelength 405 nm
Processing Time 2-7 minutes

60%+
of parts on EC were laser marked

0.6 mm
max marking depth

With the support of

TECHNOMATIC Group IKE

Cole-Parmer

FREE AIR DELIVERY

Going forward, we are looking to push our engines to their limits and collect a wide range of data at higher speeds. Assuming access to a compressor with high Free Air Delivery (FAD) is provided, it was necessary to modify the Pneumatics Control Unit (PCU) to be capable of handling such flow rates. In the process, we also reviewed some of the components in the first PCU, whilst taking design limitations on the engine side into account.

OUR SOLUTION

The main design limitation concerned the use of tubing with 4mm ID on the propulsion chamber. On one side, this is a bottleneck for high flow rates under relatively low pressures and on the other hand, using tubing with 6mm ID would be impractical due to the minimum bend radius. The use of a single control valve, a twin 4mm ID tube from the PCU to the engine and the provision for 2 280LPM flow meters allow us to release up to 500LPM!

SPECS

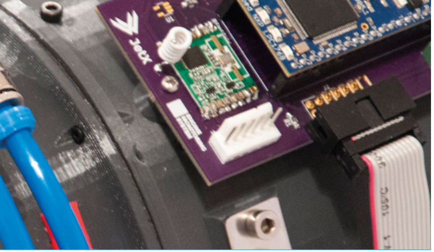
Max Flow Rate 500 LPM
Max Operating Pressure 6.9 bar
Pressure Relief Inlet, main line & bypass line

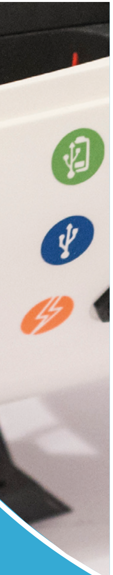
> “The EC does not only have a real potential as a tool in academic research, but we're also honoured that it marks the start of our collaboration with the University of Sheffield.”

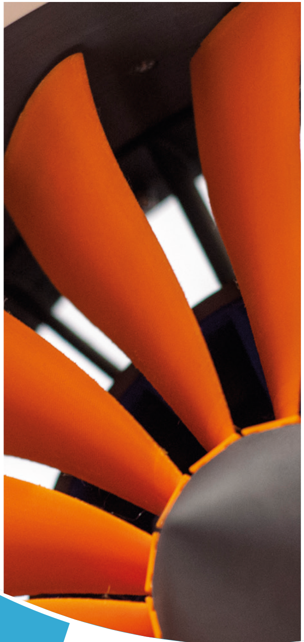
GREAT COMPONENTS

From all over the world

Over the last few years, we established numerous relationships with leading manufacturers and suppliers of products required for our projects. We are extremely grateful for the help and valuable contributions.







The EC is supported by

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ANSYS

TECHNOMATIC Group IKE

Form Futura

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WCL

X-PLORER 1 EC

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