



EIC PATHFINDER OPEN

The TorPropel Project

Toroidal Propellers for Efficient and Sustainable Aviation

Concept · Objectives · Methodologies · Impact



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36-month project · Feb 2025 – Jan 2028 · 9 partners across 7 countries · Grant Agreement No. 101187800

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Toroidal geometry propellers for civil aviation

TorPropel develops and **scales up toroidal-geometry propellers** for light aviation, building on the award-winning small-scale design pioneered by MIT Lincoln Laboratory.

The closed-loop blade suppresses tip vortices, a significant source of propeller noise propulsion efficiency losses. TorPropel aims to take this concept from centimetre-scale quadcopters to full-size aircraft blades of up to **1.7 m diameter**.



Toroidal geometry

Looped blades that reduce tip vortices



Sustainable composites

Recyclable, repairable and reprocessible vitrimers



Advanced Manufacturing

Additively manufactured tools and Rapid Tow Shearing



Our long-term vision

A new era of short-distance air travel that is **quieter, cleaner and more efficient**, through an innovative propulsion solution that is applicable to **commuter aircraft, hybrid-electric platforms, eVTOLs and UAVs**.

Initial target market: Light Aircraft, Sport Aircraft and Electric/Hybrid-Electric Aircraft, as a pathway to General Aviation.

Economic, societal and environmental returns



Economic

- Clear route to civil aviation through the Light Sport & Light Aircraft market
- Low-cost 3-D-printed tooling enables agile, low-volume, airframe specific production
- Technoeconomic evaluation used to quantify cost savings through enhanced propulsion efficiency



Societal

- Quieter operation provides direct health benefits over cities and near airports
- Continuous structural monitoring improves aviation safety
- Early damage detection enables optimizing maintenance schedule



Environmental

- >95% material recovery via recyclable vitrimers
- RTS process significantly reduces material waste and lowers manufacturing energy use
- Repairability extends service life; full LCA quantifies footprint

High-risk effort, not an incremental step

Getting toroidal propellers to reach full aircraft size means solving four coupled challenges at once; there is no precedent at the target diameter and technical specifications envelope



Aerodynamics & noise

Optimise a complex 3-D geometry to improve thrust efficiency while reducing noise



Structural optimisation

Withstanding mechanical stresses during flight conditions, while reducing weight to improve efficiency



Manufacturability

Utilising the RTS method to lay continuous fibre, defect-free, along curved, looping paths



Safety & standards

Design considering EASA CS-P to ensure progress beyond TRL4, and embed in-service monitoring for improved safety



Why EIC Pathfinder? TorPropel is a radically new approach to propulsion technology, requiring a leap in engineering capability across materials, computational physics and algorithmic optimisation, manufacturing and safety by design.

Five technical objectives, covering the full technology chain



Optimise toroidal composite propellers

1

Enhanced aerodynamic efficiency and noise reduction via CFD and iterative geometry optimisation **by M20**



Develop vitrimer prepreg tapes

2

Carbon-fibre preregs tailored for Rapid Tow Shearing **by M25**



Establish the RTS manufacturing process

3

Fabricate toroidal propeller demonstrator with vitrimer tapes **by M28**



Integrate structural health monitoring

4

Embedded sensors for real-time condition assessment **by 28**



Minimise environmental impact

5

Framework for reparability and recyclability **by M36**

Success Evaluated through Six Key Performance Indicators

 **>25%**

Thrust efficiency

vs conventional propeller

 **>15%**

Energy / fuel efficiency

in operational conditions

 **>10%**

Weight reduction

of the propeller assembly

 **>15 dB**

Noise reduction

acoustic footprint vs baseline

 **>500 h**

Durability

operation without degradation

 **>95%**

Recyclability

material recovery rate

Nine partners, seven countries, a combined effort



University of Ioannina

Coordination & project management



Aristotle Univ. of Thessaloniki

CFD, aeroacoustics & design optimisation



Technical University of Munich

Structural optimisation & LSAM tooling



iCOMAT

Rapid Tow Shearing manufacturing



CIDETEC

Vitrimers system development



GMI Aero

Composite repair equipment & protocols



Evektor

End-user requirements, validation testing



Brunel Composites Centre

SHM system & Dissemination Manager



Limmat Scientific

Modelling & optimisation support



An integrated design-to-demonstration and validation pipeline

01



Multi-objective design

CFD (DES/LES),
aeroacoustics (FW-H),
aeroelastic modelling
and NSGA-II optimisation
over 45 design
parameters

02



Sustainable vitrimer composites

Vitrimer-based carbon-
fibre prepregs with
reversible chemistry for
intrinsic recyclability and
repair

03



RTS manufacturing

Rapid Tow Shearing for
defect-free fibre steering,
with large-scale 3-D-
printed (LSAM) tooling

04



Embedded SHM

Strain sensor network
enabling a real-time
digital-twin of propeller
health

05

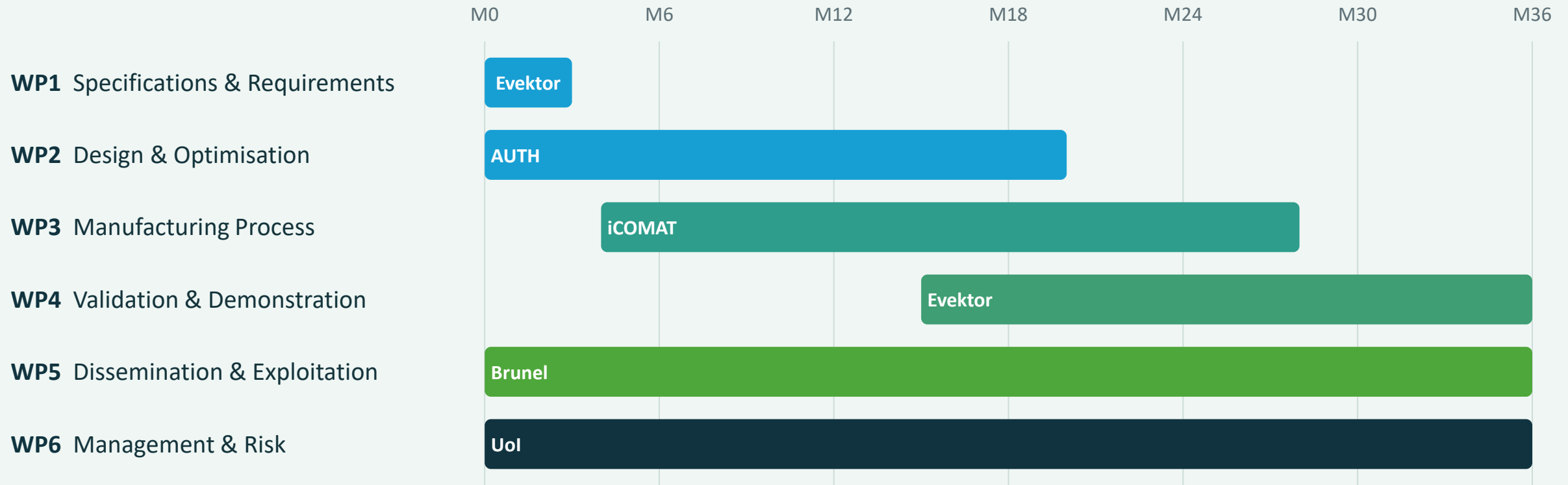


Validation & LCA

Ground-based TRL-4
testing on the Evektor
EPOS powertrain, plus
technoeconomic and life-
cycle assessment

Closed-loop optimisation: aerodynamic, acoustic, structural and weight objectives are traded off simultaneously, then carried into an RTS manufacturable geometry.

Six work packages over 36 months



€3.0M
total budget



360.5
person-months



4 + 2
technical + support WPs



7
milestones (Ms1–7)

WP1 — Propeller Specifications & Manufacturing Requirements



A 70-point requirement framework

Considerations on aerodynamics, structures, EASA CS-P regulations and manufacturing, which will serve the design rulebook for the consortium.



Baseline and platform selected

The composite propeller previously used on the Evektor EPOS electric powertrain enables a like-for-like toroidal-vs-conventional comparison.



Target market fixed

Light Sport & Light Aircraft as the entry segment, with General Aviation as the growth path.



Materials and RTS cell specified

Carbon-fibre reinforcements and vitrimer resin systems procured; Rapid Tow Shearing manufacturing-cell requirements defined.



Vitrimer tape preparation for the TorPropel project

70

requirements

EASA CS-P

design basis

Composite

propeller baseline

WP2 — Design & Optimisation of Toroidal Composite Propellers



A parametric design engine

45 geometric parameters and 100,000+ verified iterations generating a full .stl / .stp geometry in under one second.



Thrust and torque decoupled

Global (Morris) sensitivity analysis ranked the design space and exposed parameter interactions that decouple thrust from torque, facilitating a new design freedom.



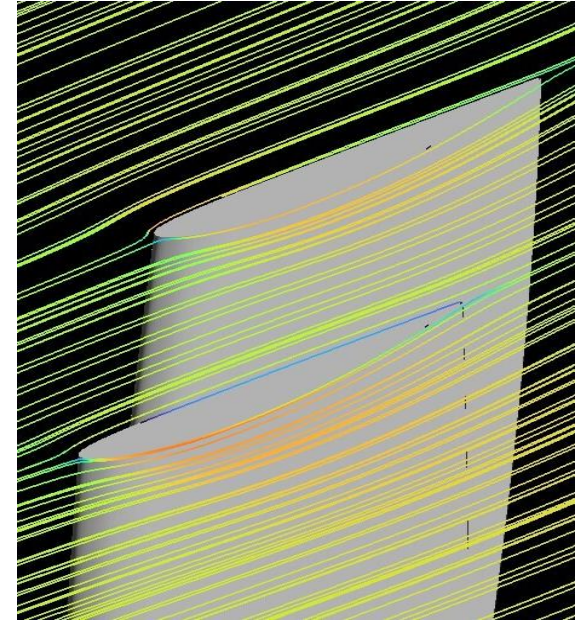
CFD workflow validated

An automated DES/LES workflow compares conventional and toroidal topologies and agrees well with experimental data.



Structural & acoustic models started

Composite-laminate optimisation (structural & aeroelastic) and the Ffowcs Williams-Hawkings (FW-H) aeroacoustic model are now under way.



Toroidal propeller design and the corresponding CFD flow field

45

parameters

100k+

iterations

< 1 s

per geometry

WP3 — Manufacturing Process Optimisation



Three vitrimer prepreg tape variations

TP-A, TP-A2 and TP-B carbon-fibre formulations developed and characterised; tack and Tg windows mapped for Rapid Tow Shearing.



First composite layers by RTS

Heated-press and forming trials with vitrimer tapes produced the first defect-free layers.



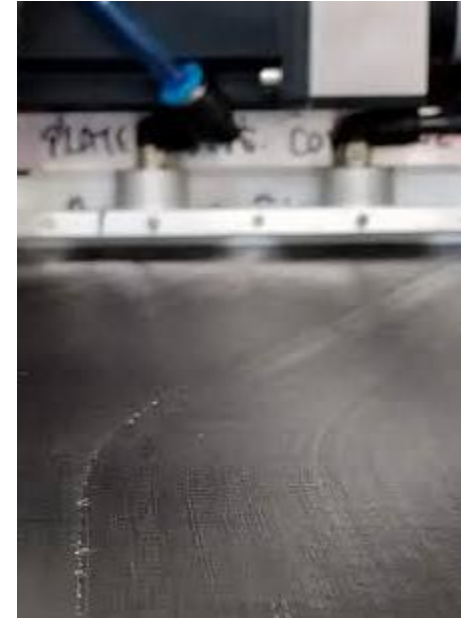
3D-printed tooling

A large-scale additively manufactured mould developed; print-direction and parameter studies converged on a precise, low-cost tool.



SHM network architecture defined

Sensor suite selected and data acquisition system developed for in-structure monitoring; preliminary testing and validation on vitrimer composite coupons



Large-scale additive manufacturing of the composite mould (left) and tape shearing with the iCOMAT RTS process (right)

3

vitrimer tapes

RTS

process optimisation

AM

3D printed tool

WP4 — Technology Validation & Demonstration



Test-bed started ahead of schedule

Preliminary design of the experimental test-bed and planning for the noise-measurement campaign



Acoustic measurement geometry

A microphone array at 45 degrees over 2–10 m arcs, front and rear, defines the propeller-noise survey.



Baseline noise characterisation

Wake and noise of the baseline, conventional propeller are being characterised to facilitate the toroidal-vs-conventional comparison.



Instrumentation & rig prepared

Sound-level metering, data acquisition and rig integration readied on the Evektor platform.



Open-air acoustic test set-up with the demonstrator platform

45°

mic array

2–10 m

arcs

baseline

acoustic performance

WP5 — Dissemination, Exploitation & Communication



Project identity launched

Website (torpropel.com), LinkedIn showcase, first newsletter and a full branding pack now in active use.



Growing international reach

22 LinkedIn posts in year 1 drew 18,650 impressions and 508 reactions, with an audience across Greece, the US, the UK, Spain, Germany and Czechia.



Presence in international events

Booth at JEC World and Aviation Week MRO, a TorPropel special session at ECCM22



Open science & clustering

All publications Open Access with a dedicated Zenodo community; active clustering with EU sister projects.



TorPropel project dissemination by CIDETEC at the ECP4 Conference (in the Lyon University Campus), 14/5/2025

18,650

impressions

ECCM22

Oslo session

100%

open access



WP6 — Project Management & Risk Mitigation



KPI-driven monitoring

All six technical KPIs tracked continuously against objectives and milestones.



Proactive risk management

A live risk register with mitigation actions maintained across every work package.



Open Data & FAIR Practices

A FAIR data-management plan with open datasets per task, and IP management aligned with EIC rules.



A (so far) well coordinated consortium

Nine partners across seven countries kept aligned, with no deviations affecting technical progress in year 1.

The management framework



Objectives & KPIs

6 indicators, 7 milestones



Risk register

proactive mitigation



Open data & IP

FAIR, EIC-aligned

6

KPIs tracked

FAIR

open data

9 / 7

partners / countries

TOWARDS QUIETER, CLEANER FLIGHT

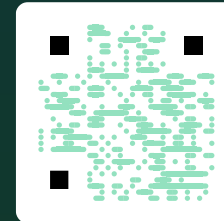
Reinventing the propeller for sustainable aviation

TorPropel unites optimisation, sustainable materials, robotic manufacturing and embedded monitoring to take the toroidal propeller from proof of concept to a demonstrable aircraft technology.

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