Zero Carbon Cabins

Ben Orson
Director, Orson Associates
Cabins Lead, FlyZero

FLY ZERO × Orson Associates

For further information on any of the topics covered in this presentation, please email us at hello@orsonassociates.com

Orson Associates

Contents

Orson Associates

FlyZero

Orson Associates

FlyZero

- Research project to realise zero carbon emission aviation by 2030
- £15m of UK Government funding
- Led by the ATI
- Investigating aircraft from regional to long range, fuelled by liquid hydrogen
- Output: 30+ research papers, 3x concept aircraft

Orson Associates

Cabins in FlyZero

- Role of the cabin
    - Ensure safety, comfort and operational requirements were met
    - Show that zero emission flight can be more desirable
- Key deliverables
    - Highly resolved designs for Concept aircraft
    - Collaboration with Cranfield University on the Sustainable Cabin Design positioning paper

Orson Associates

FlyZero Sustainable Cabin Design paper

- **www.ati.org.uk/flyzero-reports/**
- Summary of 10 months research with Cranfield University.
- Input from 12 partner organisations including Cathay Pacific, Etihad & Turkish Seating Industries (TSI).
- Summarises the ‘state-of-the-art’, identifies key issues, lays out specific recommendations and tangible technology proposals.

Orson Associates

Why cabins must prioritise sustainability

Orson Associates

The will of the market

76% of Gen Z say that climate change is one of their biggest concerns, **37% make it their number one concern**.

Pew Research Centre 2021.

70% agree that reducing aircraft emissions is the number one priority for the industry.

NATS Aviation Index 2020

36% would pay more for flight tickets to reduce the environmental impact of flying.

CAA UK Consumer Survey 2020.

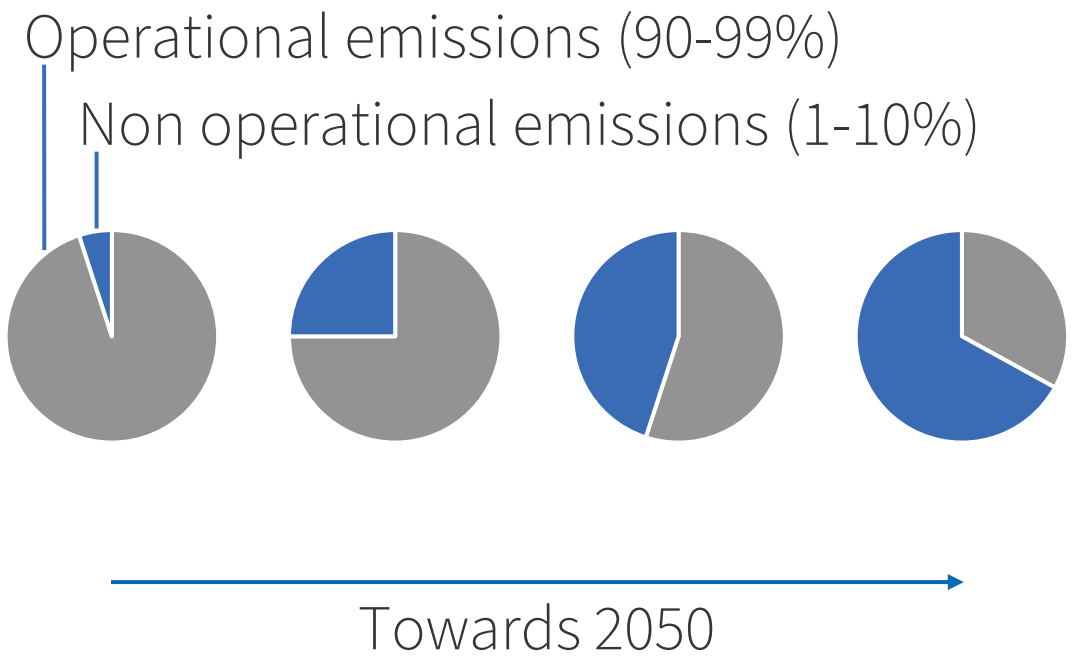
Orson Associates

Impact mechanisms

- How aviation impacts the environment:
  - **Operational** = tailpipe emissions
  - **Non-operational** = consumption of energy and materials due to manufacture and maintenance of aircraft + impact of disposal
- Historically, environmental considerations have focused on emissions only
- This balance will shift significantly in future as emissions tend to net zero

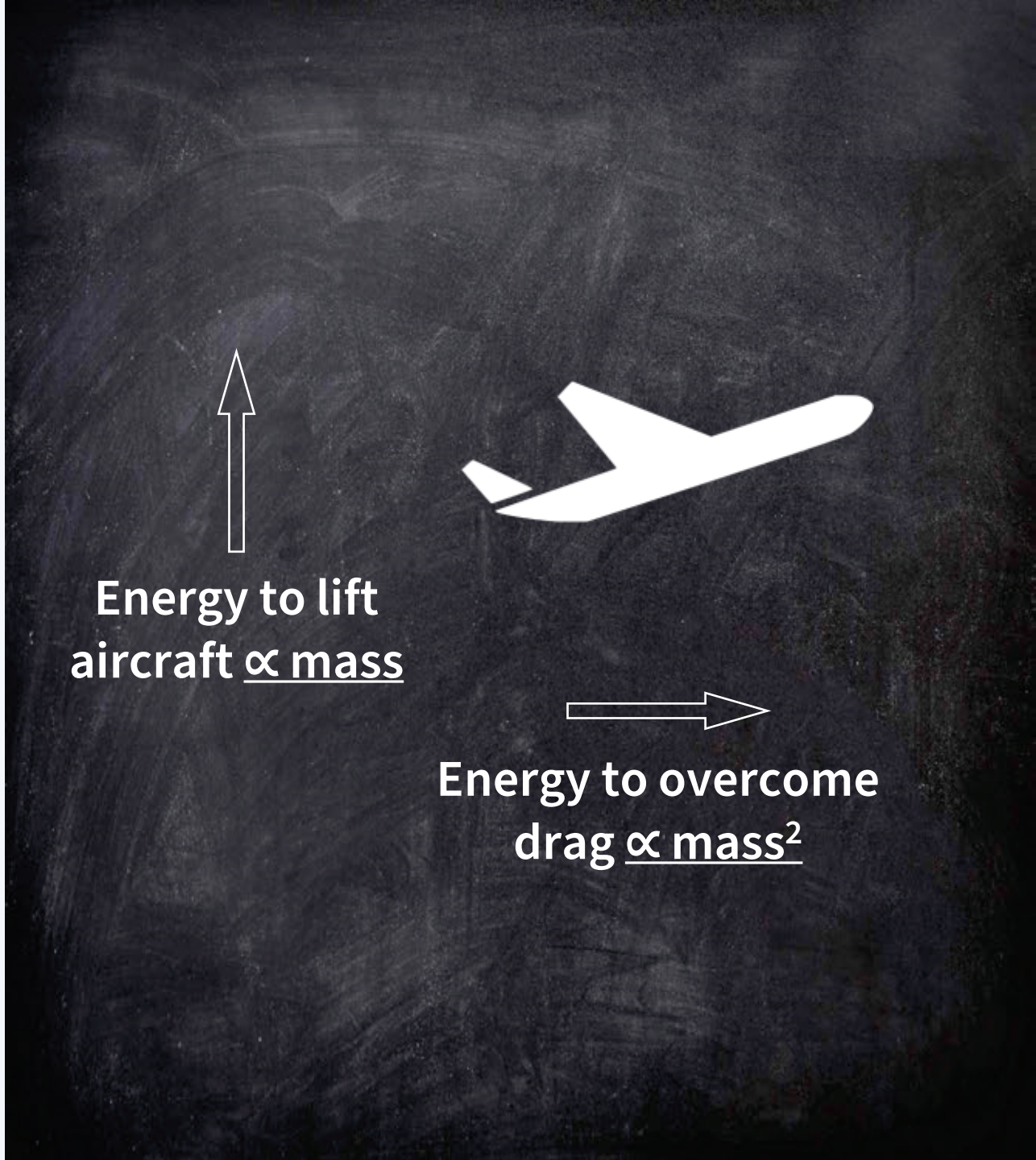
Orson Associates

Decarbonisation roadmap



Operational impact and the cabin

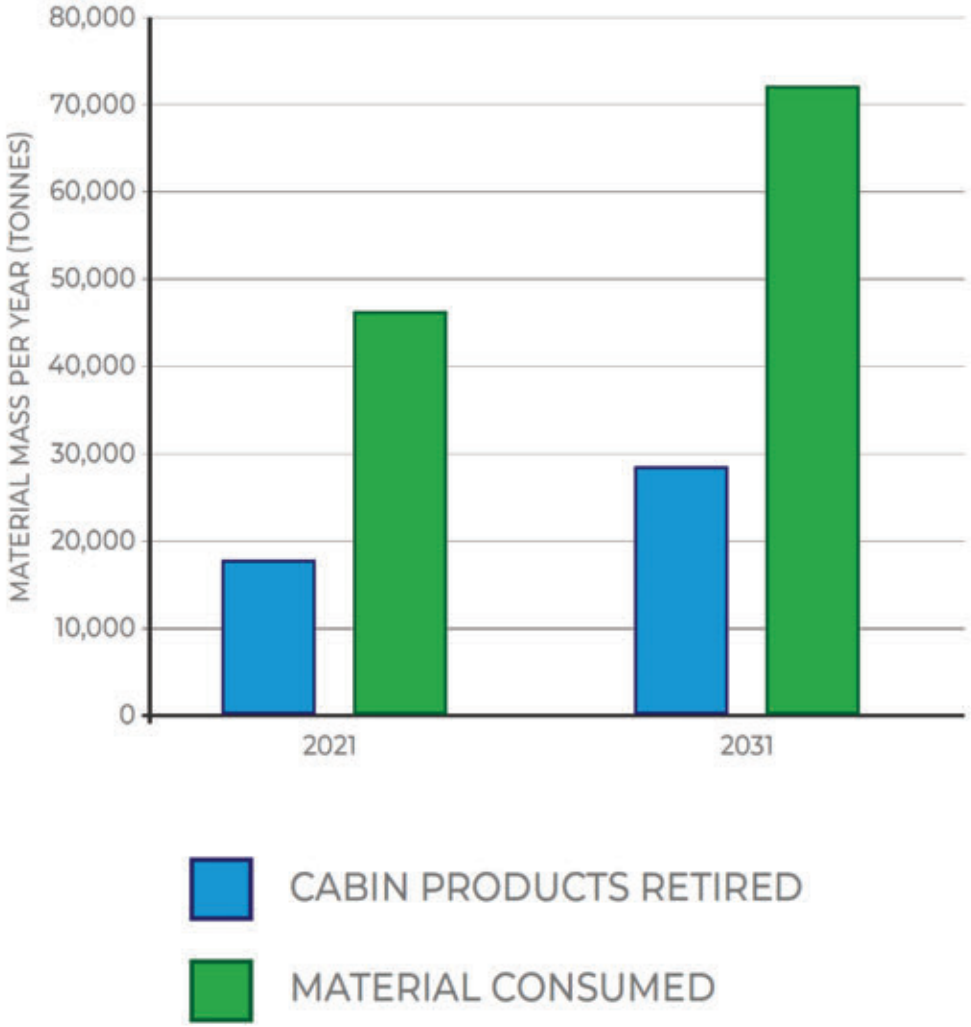
- Weight is fundamental to the energy required to fly
- Cabins weigh around 10% of the empty aircraft (OEW)
- Therefore, cabin weight has significant impact on fuel burn and emissions
- Cabin offers significant scope to reduce operational emissions through reducing weight



Orson Associates

Non-operational impact and the cabin

- Function of rate of creation/retirement of aircraft and the update rate of cabins
    - In 2018, 1764 commercial passenger jets were added to the global fleet
    - Over the past decade, 750 commercial aircraft per year have retired. FlyZero & Strathclyde University study indicates that post COVID-19, this will rise to 1,000 - 1,500 for the foreseeable future
    - Cabins are replaced 4 - 5 times during the life of the airframe (IATA)
- Non operational impact is addressed by increasing prevalence of circular product lifecycles

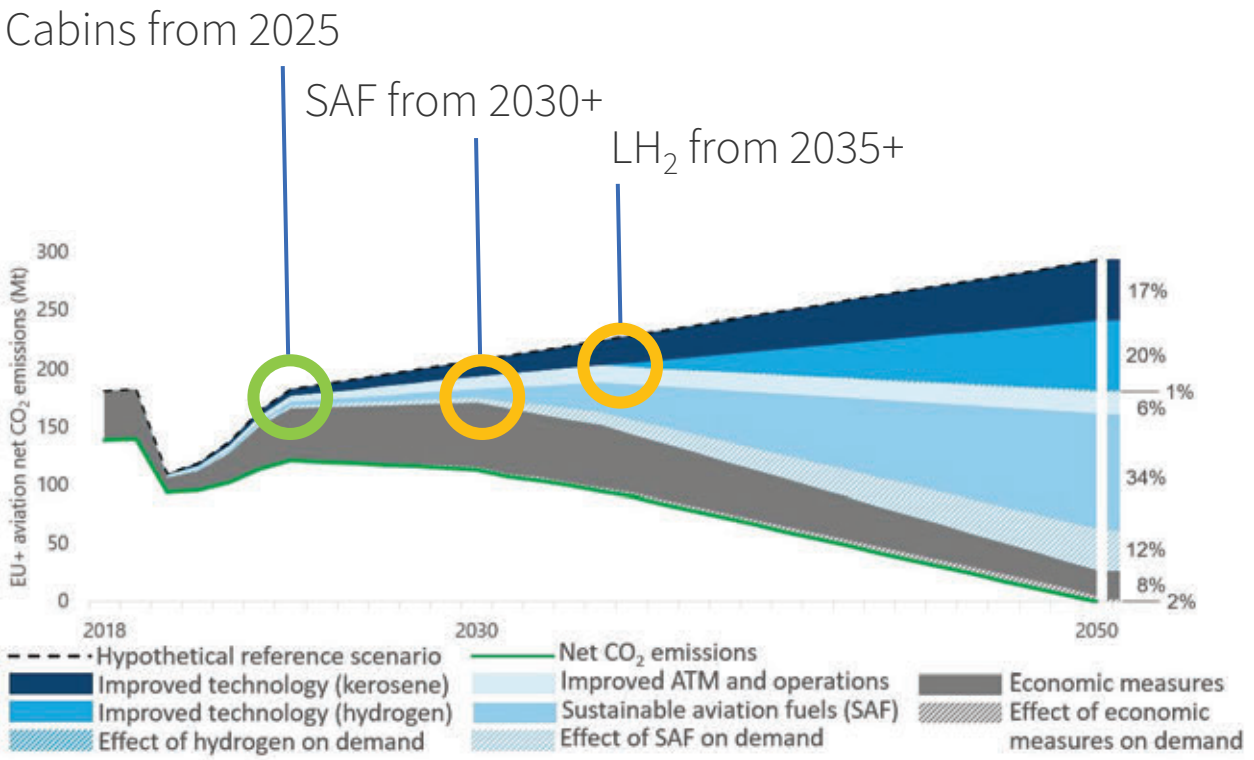


Orson Associates

Cabins can lead the way

- SAF and LH2 aircraft and infrastructure introduction will be gradual, over decades
- New cabin products can be introduced in 2-5 years and begin to deliver
- Line-fit and retrofit opportunities for fleet integration

Decarbonisation roadmap



Orson Associates

Cabins connect with customers

- Great way for airlines to communicate their sustainability leadership and encourage green behaviours
- $19bn market and sustainability is in demand

Orson Associates

Pathways to sustainability

Orson Associates

Light weight is paramount

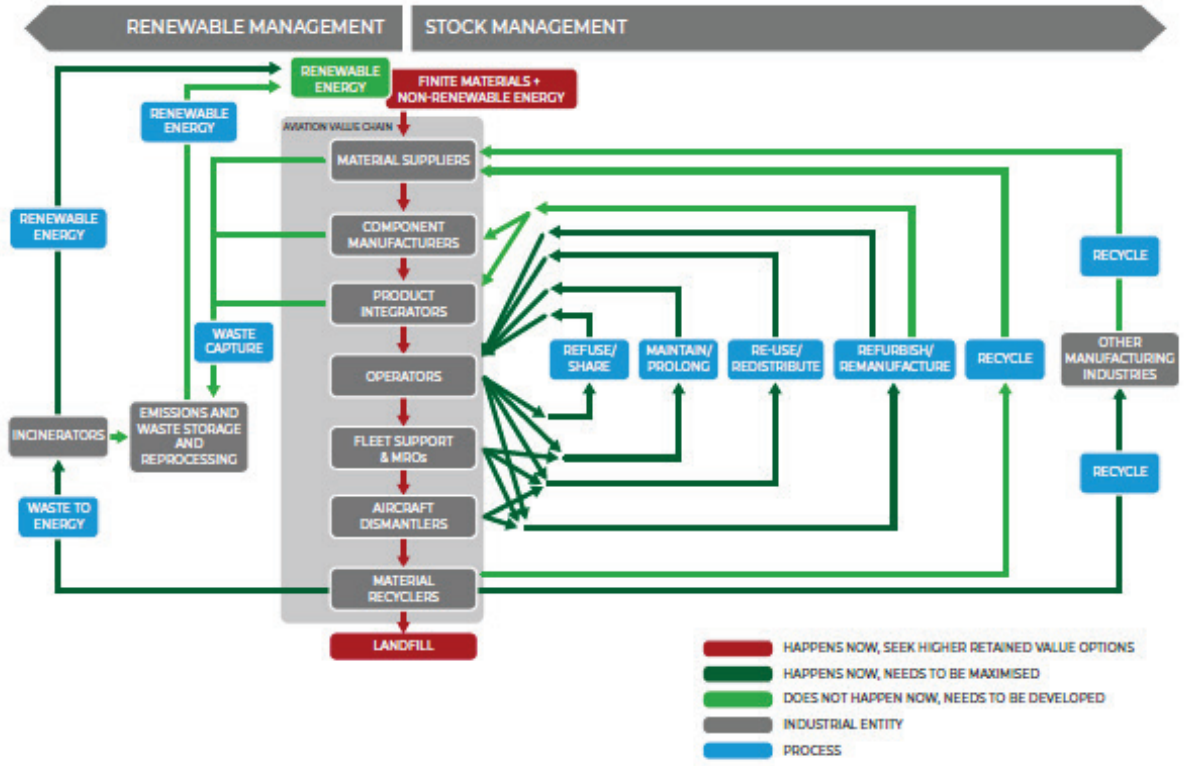
- In the near term, weight will be the most powerful lever to improve sustainability.
- We must continue to strive for weight reduction
- Any measure introduced should be weight neutral or better.

Orson Associates

Opportunities for circularity

Circularity disrupts linear value flow by returning materials, components, and products to higher value chain positions, minimising new material & energy consumption.

Cabin product lifecycles today



Orson Associates

Circularity opportunities

Example – Material marking and data sharing

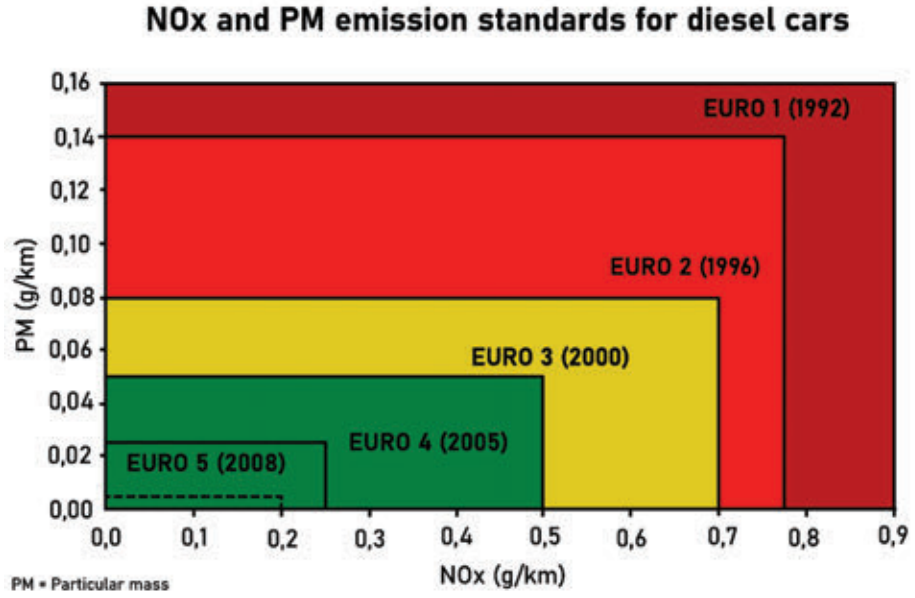
- End-of-life organisations find it challenging to identify materials recovered from dismantled cabins making recycling impractical
- Mark materials and keep databases of their chemistry

Orson Associates

Circularity opportunities

Example 1 – Staged introduction of recycled aluminium

- Manageable steps towards 100% recycled cabin Aluminium and Plastics
- Enables establishing the supply chain by reducing risk
- Ensures progress is made across the board



Orson Associates

Circularity opportunities

Example 3 – Furniture as a Service

- Follows model established in many other industries
- Airlines can look forward to regular product improvements
- OEMs benefit from long term relationships with customers
- Products must be designed to consider long service and multi-owner use so encouraging durability, remanufacturing, design for easy reconfiguration, etc.

Orson Associates

Materials based problem analysis

- FlyZero analysis of a complete cabin using industry standard LCA tools (SimaPro 9 + Ecoinvent 3) identified the most problematic materials.

Orson Associates

Materials based problem analysis

- FlyZero analysis of a complete cabin using industry standard LCA tools (SimaPro 9 + Ecoinvent 3) identified the most problematic materials.
- Testing for Impact, Prevalence and Density provided a ranking of negatively impactful cabin materials.

Top 10 problematic materials

Rank	Material	Component	Issues
1	Inconel	Fasteners	High energy demand, density, raw materials, toxicity
2	High-strength steel	Fasteners and brackets, emergency location transmitters	High density
3	Liquid crystal display (LCD)	IFE displays; cabin management system (CMS) crew interfaces	High weight / m², complexity makes disassembly challenging, precious metal content, electrical and electronic equipment (EEE), short lifespan relative to other items
4	Copper	EEE, wiring and connectors	High density, difficult to separate from the complex assemblies used on-board
5	Carbon fibre reinforced plastics (CFRP)	Seat back structure, air ducts	High energy demand, difficult recyclability, toxic dust
6	Stainless steel	Fasteners and bracketry, seat belts, lavatories, galleys (various items e.g., high-pressure water piping), cabin fire bottles	High density
7	Polyethylene terephthalate (PET)	Seat belts, insulation blankets, cabin transparencies and furnishings, air ducts, emergency equipment	Toxic manufacturing and EOL (unless recycled), energy demand, carbon intense (oil), releases microplastics
8	Perfluoroalkoxy alkanes (PFA)	Waste system (lavatory), galleys	Toxic and persistent production and disposal waste, EOL energy
9	Polyvinylidene fluoride (PVDF)	Passenger seating components, cabin linings and window frames, cabin monuments, cabin trolleys	Carbon intense (oil), harmful and toxic production and EOL inputs and emissions; global warming potential (GWP) impacts
10	Nylon / Polyamide (PA)	Seat belts, cabin floor carpets, seat track covers, cabin dividers and decorations, emergency equipment	Carbon intense (oil), manufacturing and EOL energy demand and emissions, indefinitely persistent

Materials based problem analysis

- FlyZero analysis of a complete cabin using industry standard LCA tools (SimaPro 9 + Ecoinvent 3) identified the most problematic materials.
- Testing for Impact, Prevalence and Density provided a ranking of negatively impactful cabin materials.
- Pairing materials to components through a holistic assessment (sustainability, cost, production constraints, etc.) enables prioritising products for development.

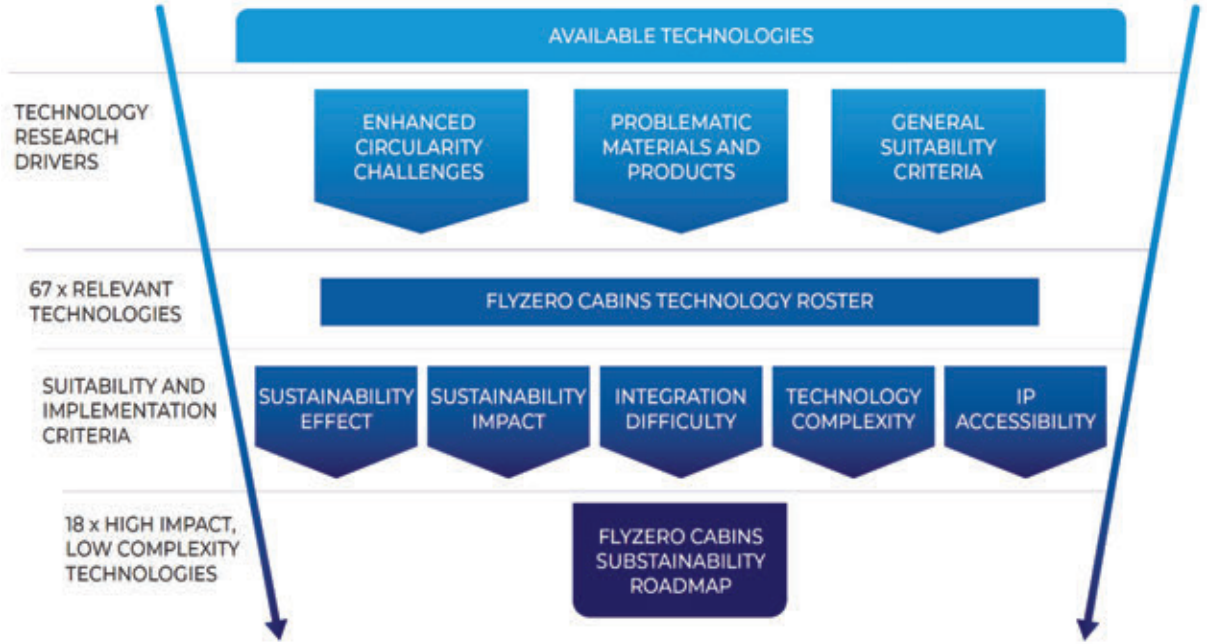
Orson Associates

Problematic components

Cabin item	Problematic component	Development goal
Seats	CFRP back structure	Replacement of the material or more sustainable life cycle
	Aluminium primary structure	Reduction of virgin aluminium presence in cabin
	Seat covers	Wool sustainability enhancement or replacement
	Seat cushions	Replacement for melamine and PU Foams
Fasteners and brackets	Inconel and steels	Lighter weight alternatives such as bonding
Cabin furnishings	Aramid core composite panels	Sustainable recycling options or more sustainable material alternatives
Air ducts	PET	More sustainable material alternatives
	PP	More sustainable material alternatives
Electrical and electronic equipment	Copper wiring	Lighter weight alternatives or make redundant (e.g. wireless technologies)
	IFE displays	Lighter weight alternatives or make redundant (e.g. enable bring your own device models)

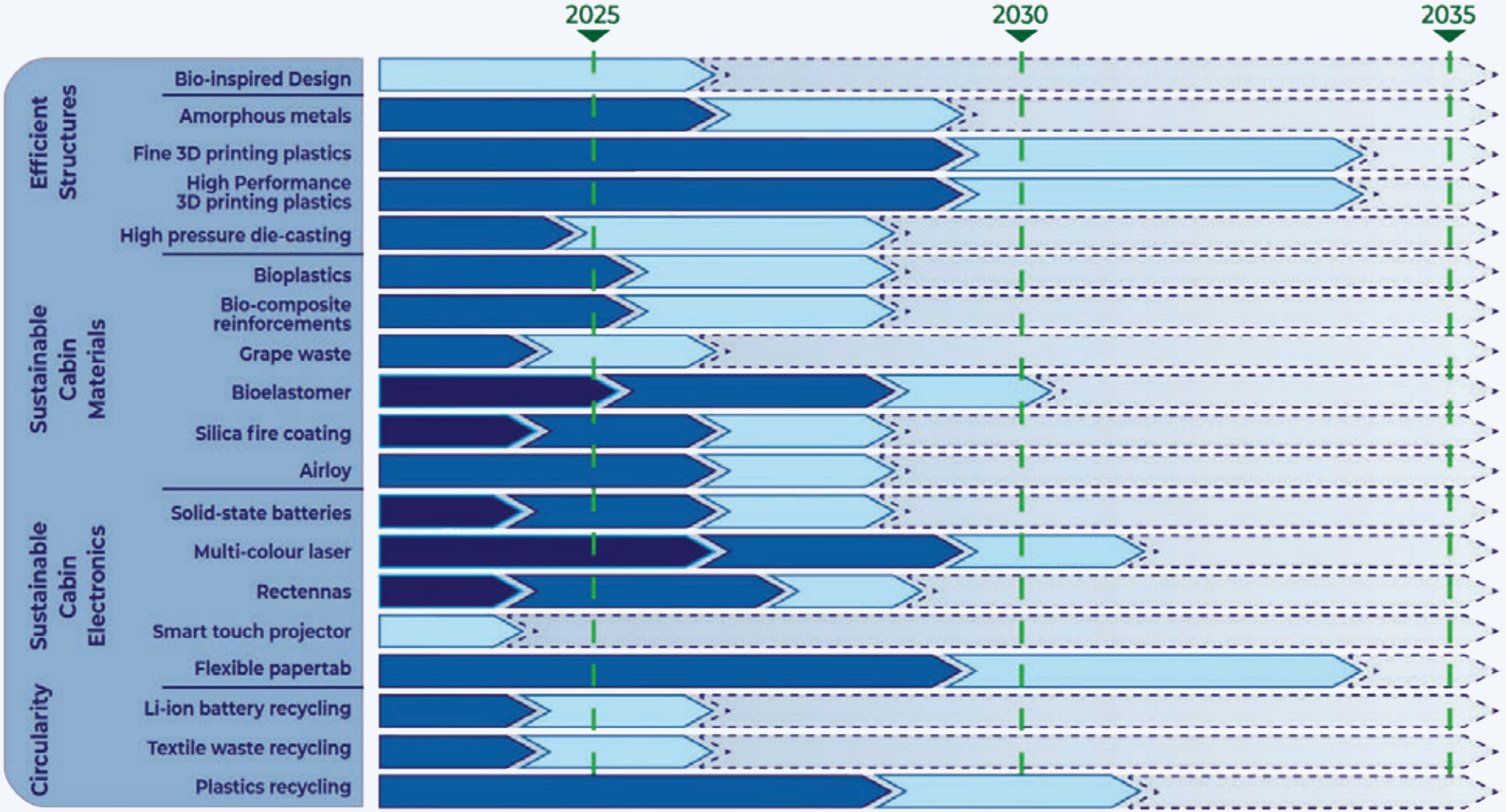
Technology opportunities

- 800 technologies checked against requirement
- 67 graded and down-selected for near term potential
- 18 high-impact x low-complexity priorities in the roadmap



Orson Associates

Technology opportunities



Orson Associates

Technology opportunity

- Bionic design: topology optimisation and generative approaches
- Rapidly developing field: materials (fine powders), processes, applications.
- 10-20% weight reduction for structural parts
- Near zero waste production

Orson Associates

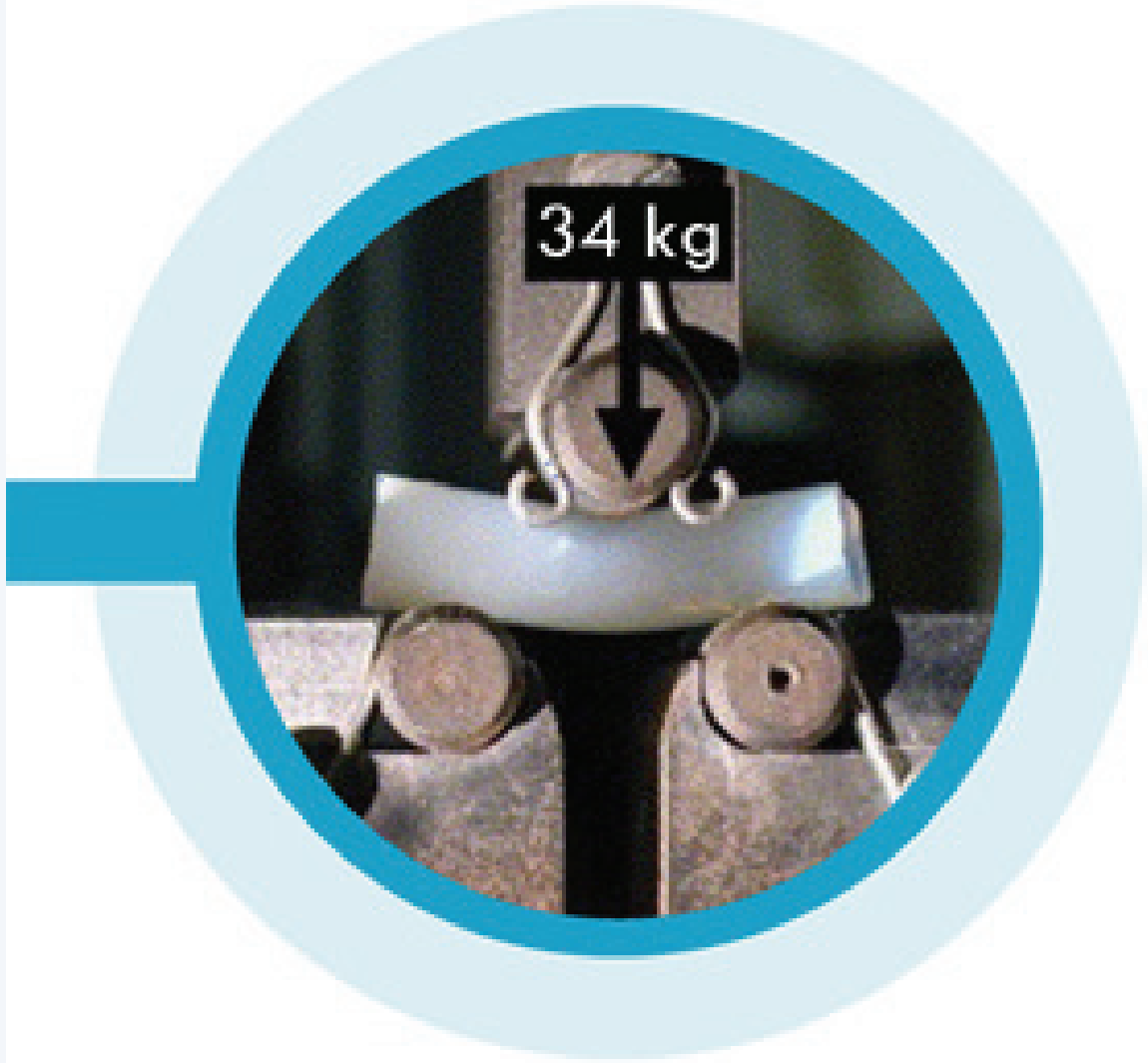
Technology opportunity 2

- Bio composites: resins and reinforcements
- Lightweight benefits of composites without the negative impacts of synthetics

Orson Associates

Technology opportunity 3

- Airloy
- Engineering materials combining strength of plastics with the lightweight and insulating properties of Aerogels
- Potential as thin, high performance cabin insulators
- Potential core material replacement for sandwich panels
- 5% cabin weight reduction



Orson Associates

Wrap up

Orson Associates

Summary

- **Cabins can make a big difference** to aviation's emissions, material consumption and waste problems.
- Cabins must **become lighter, increase circularity in product lifecycles and reduce use of harmful materials.**
- Design is key – **80% of a product's impact is determined in the design phase.**
- **Material and technology R&D is essential** to drive continuous progress.
- Sustainability performance is increasingly effective in providing a **sales and marketing advantage.**

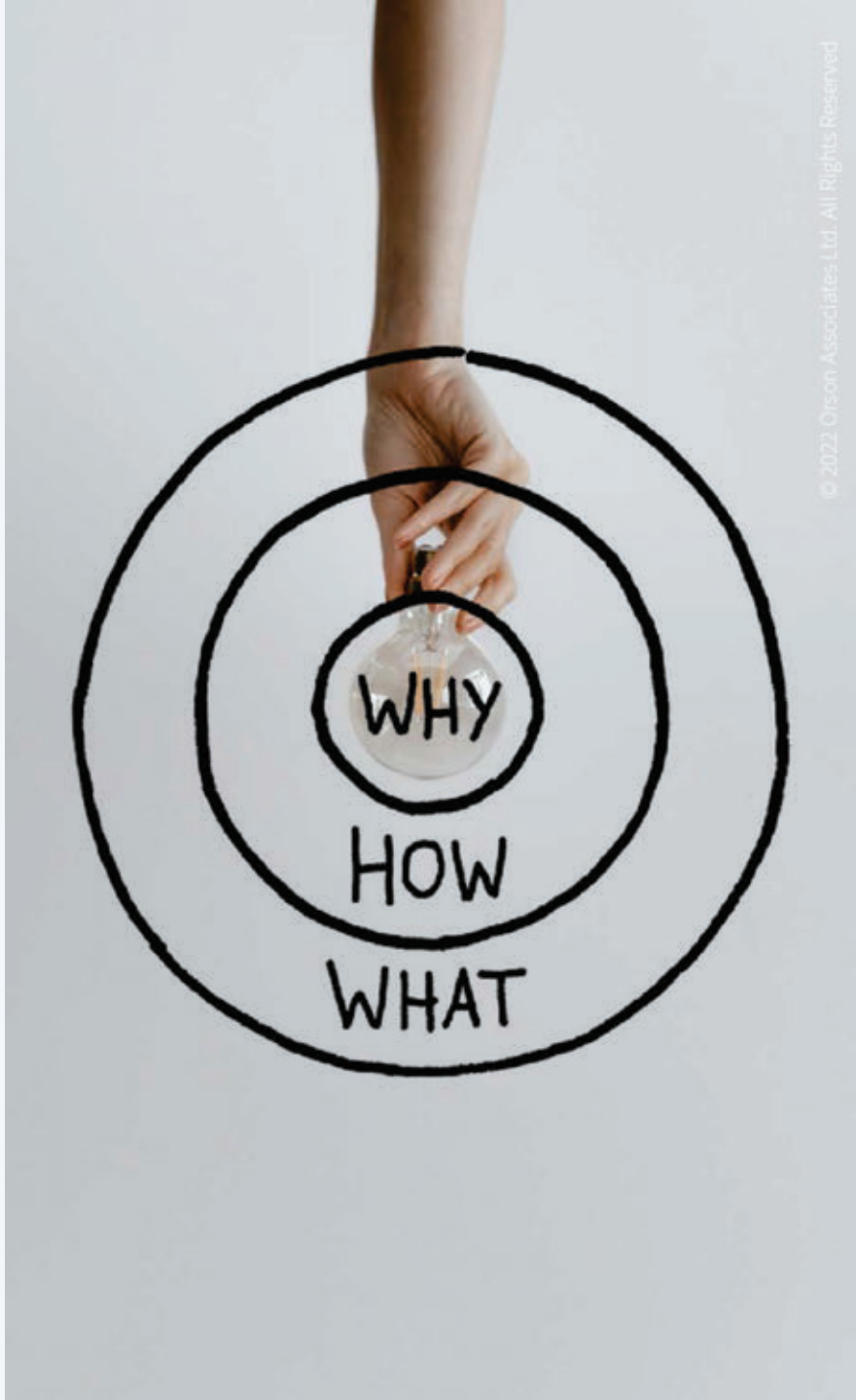
Plan of action

Sustainable impact builds on purpose. **Starting with ‘WHY’** over ‘WHAT’ facilitates commitment and alignment.

- **Why?** - The value chain urges industry to act
  - Listen to society and customers
  - Attract and retain talent

- **How?** - Collaboration unlocks impact.
  - Inter and intra sector collaboration to unlock opportunity
  - Transparency makes challenges and impact visible

- **What?** - Building an ecosystem.
  - From eco-efficiency to systems building
  - Governance through actionable KPIs and industry standards.



Orson Associates

Think Global, Act Local

No individual or organisation will effect great change alone.

We all have a responsibility and must all use the influence we have to change aviation for the better.

Orson Associates

Zero Carbon Cabins

www.ati.org.uk/flyzero-reports/
hello@orsonassociates.com
www.orsonassociates.com

Ben Orson
Founder, Orson Associates
FlyZero Cabins Lead

FLY ZERO × Orson Associates