https://doi.org/10.5281/zenodo/4674302

The role of technology in the future aircraft cabin

Dr Thomas Budd & Dr Craig Lawson FRAeS

Cranfield University

8 April 2021, via Zoom
RAeS / Hamburg Aerospace Lecture Series

www.cranfield.ac.uk

Deutsche Gesellschaft für Luft- und Raumfahrt Lilienthal-Oberth e.V. Bezirksgruppe Hamburg | Royal Aeronautical Society Hamburg Branch e.V. | ZAL | VDI Hamburger Bezirksverein Arbeitskreis Luft- und Raumfahrt | HAW Hamburg

Hamburg Aerospace Lecture Series

Hamburger Luft- und Raumfahrtvorträge

RAeS Hamburg in cooperation with the DGLR, HAW, VDI, & ZAL invites you to a lecture

The Role of Technology in the Future Aircraft Cabin

Dr **Thomas Budd**, Lecturer in Airport Planning and Management &
Dr **Craig Lawson**, FRAeS, Senior Lecturer in Airframe Systems Design,
both at Cranfield University

Lecture followed by discussion
No registration required !
Online Zoom lecture

Date: **Thursday, 8 April 2021, 18:00 (CEST)**
Online: http://purl.org/ProfScholz/zoom/2021-04-08

Philippine Airlines business class Airbus A330-300 in tri-class configuration (Carlo Salgado, CC BY-SA , http://bit.ly/3srpnfN)

Focussing on **passenger satisfaction** and remaining responsive to shifts in passenger preferences and requirements is key to the **design of future cabins**. Awareness of the environmental impacts of aviation and the need to mitigate these effects through enhancements to operations and aircraft design has arguably never been greater. The nature of these challenges has been made even more complex by the ongoing disruption caused by **COVID-19**.

New technologies are likely to play a key role in helping overcome these barriers, and we are already seeing exciting innovations in areas including in-flight passenger **wellbeing, sustainability** and **personalisation**.

This presentation examines the role of **emerging technology in the future aircraft cabin**, examining onboard needs and requirements from a passenger's perspective to better understand the capabilities and potential applications of various current and future aircraft cabin technologies. **Cranfield University is inviting debate** on the pros and cons of the resulting intelligent cabin proposals.

HAW/DGLR	Prof. Dr.-Ing. Dieter Scholz	Tel.: (040) 42875-8825	info@ProfScholz.de
RAeS	Richard Sanderson	Tel.: (04167) 92012	events@raes-hamburg.de
VDI	Dr.-Ing. Uwe Blöcker	Tel.: (0151) 12338411	uwe.bloecker@t-online.de

Hamburg Aerospace Lecture Series — DGLR, HAW Hamburg, RAeS, VDI, ZAL

DGLR Bezirksgruppe Hamburg https://hamburg.dglr.de
RAeS Hamburg Branch https://www.raes-hamburg.de
ZAL TechCenter https://www.zal.aero
VDI Hamburg, Arbeitskreis L&R https://www.vdi.de

Hamburg Aerospace Lecture Series (AeroLectures): Jointly organized by DGLR, RAeS, ZAL, VDI and HAW Hamburg (aviation seminar). Information about current events is provided by means of an e-mail distribution list. Current lecture program, archived lecture documents from past events, entry in e-mail distribution list. All services via http://AeroLectures.de.

Cranfield's global research airport offers a unique environment for **transformational research** into the aerospace sector. As one of the few universities in the world with our own airport, we are at the forefront of aerospace technology, working to address the challenges of **digital aviation** and rethink the airports, airlines, airspace management and aircraft of the future.

The Passenger Experience Laboratory

At scale airport terminal environment

User trials

Innovative design and co-creation

Identification, testing and validation of airport technologies

The Passenger Experience Laboratory

Aircraft Cabin Technologies Integration Facility

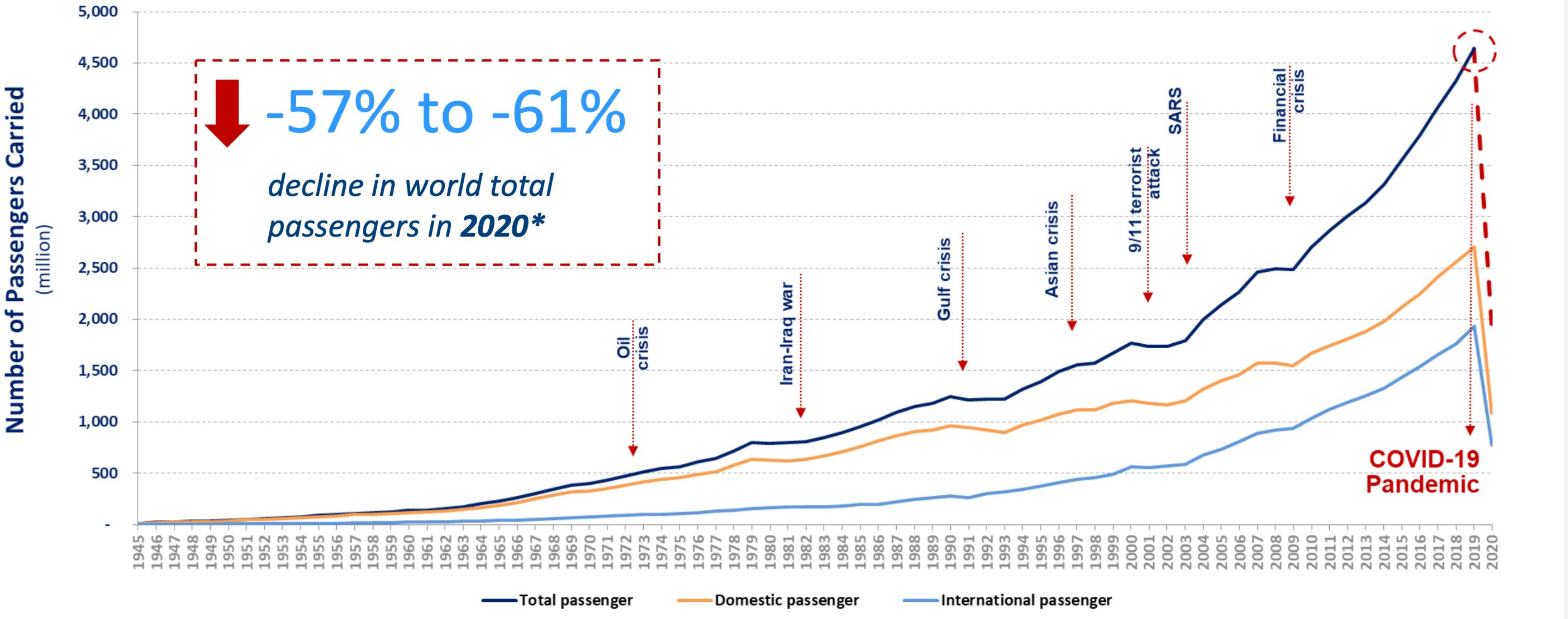
Cabin Development Capabilities

Identify & Realise viable cabin R&D streams

Verify & Validate cabin technology

COVID-19: an unprecedented shock for aviation

World Passenger traffic evolution – 1945-2020



Source: ICAO Air Transport Reporting Form A and A-S plus ICAO estimates*

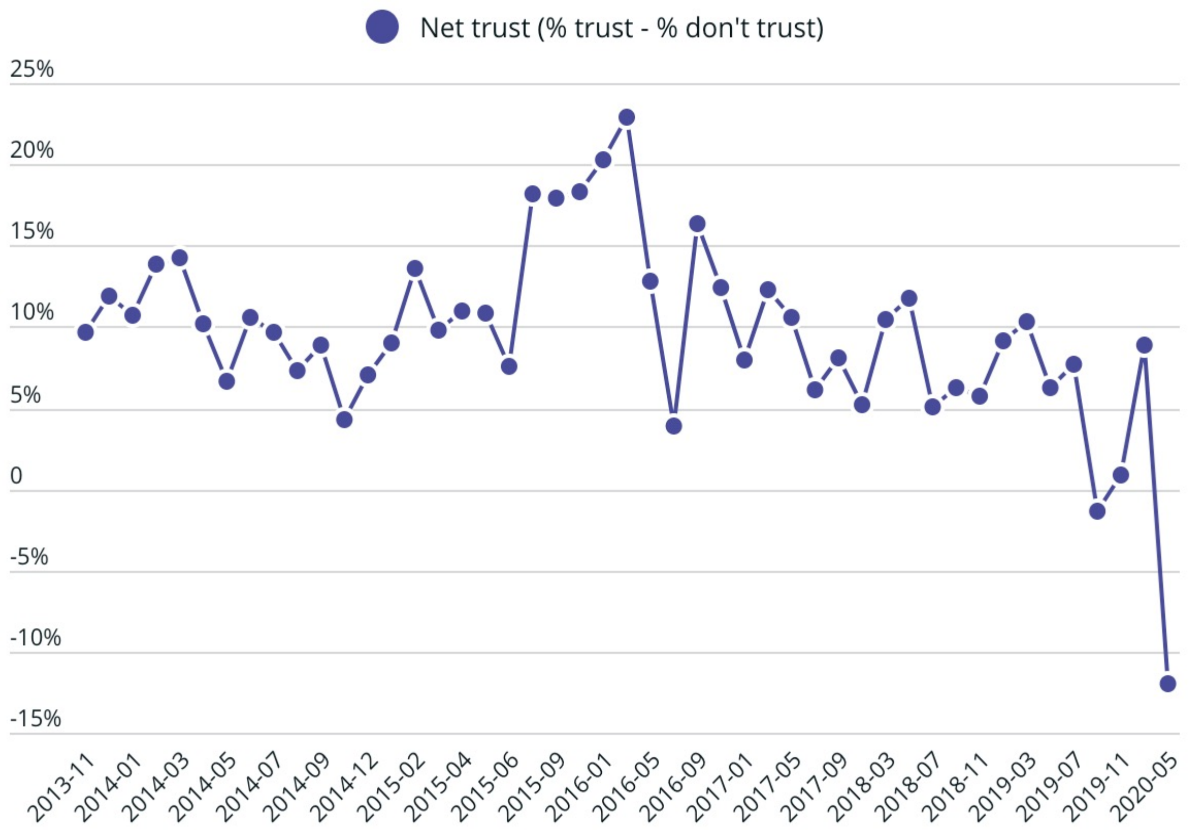
Restoring passenger confidence is key

‘Bio-safety’

Rebooking, compensation, insurance

Quarantine, testing requirements

UK Consumer Trust in Travel Industry



Source: Which? Consumer Insight Tracker, Online Poll weighted to be nationally representative (UK), approx. 2,000 respondents per wave

Some cause for optimism, but concerns remain

84% of people would not travel if there is a chance of quarantine

84% passengers 'somewhat concerned' or 'very concerned' about contracting the virus while travelling

81% say they would be more likely to fly once they are vaccinated

57% would wait two months or less before flying again

Top concerns

65% Sitting next to infected person
59% Being in a crowded bus/train
42% Using restroom/toilet facilities

Source: IATA, 2020/21. Air Traveler Response to COVID-19

Passenger experience in a new era of air travel

COVID-19 presents an opportunity to reassess and redefine the future air passenger experience for a new era of air travel

Seamless

Safe

Sustainable

Images: Storyblocks

…but what does that mean in terms of future aircraft cabin technology?

Evolution, then revolution?

Source: IATA

2021-2035

Traditional tube-and-wing configurations with turbofan engines

2035 onwards

Radical designs, blended wing bodies, strut-based wings, hybrid and pure electric, hydrogen propulsion

Key technology trends


Bio-safety


Connectivity & Personalisation


Wellbeing & accessibility


Sustainability

An expectation of bio-safety

Touchless surfaces (gesture and motion control)

'Bring your own device'

Visible interventions

Image: Storyblocks

Cleaning and disinfection

Active

‘Enhanced’ sanitation

Treatment with UV-C light

Passive

Antimicrobial films and adhesives (retrofitted or incorporated in the manufacturing process)

Images: Ryanair and Corsair Media Centre

The ‘always-on’ passenger, connected and informed

Image: Storyblocks

Digital expectations driven by desire for:

- Interpersonal connections
- Convenience
- Self-expression

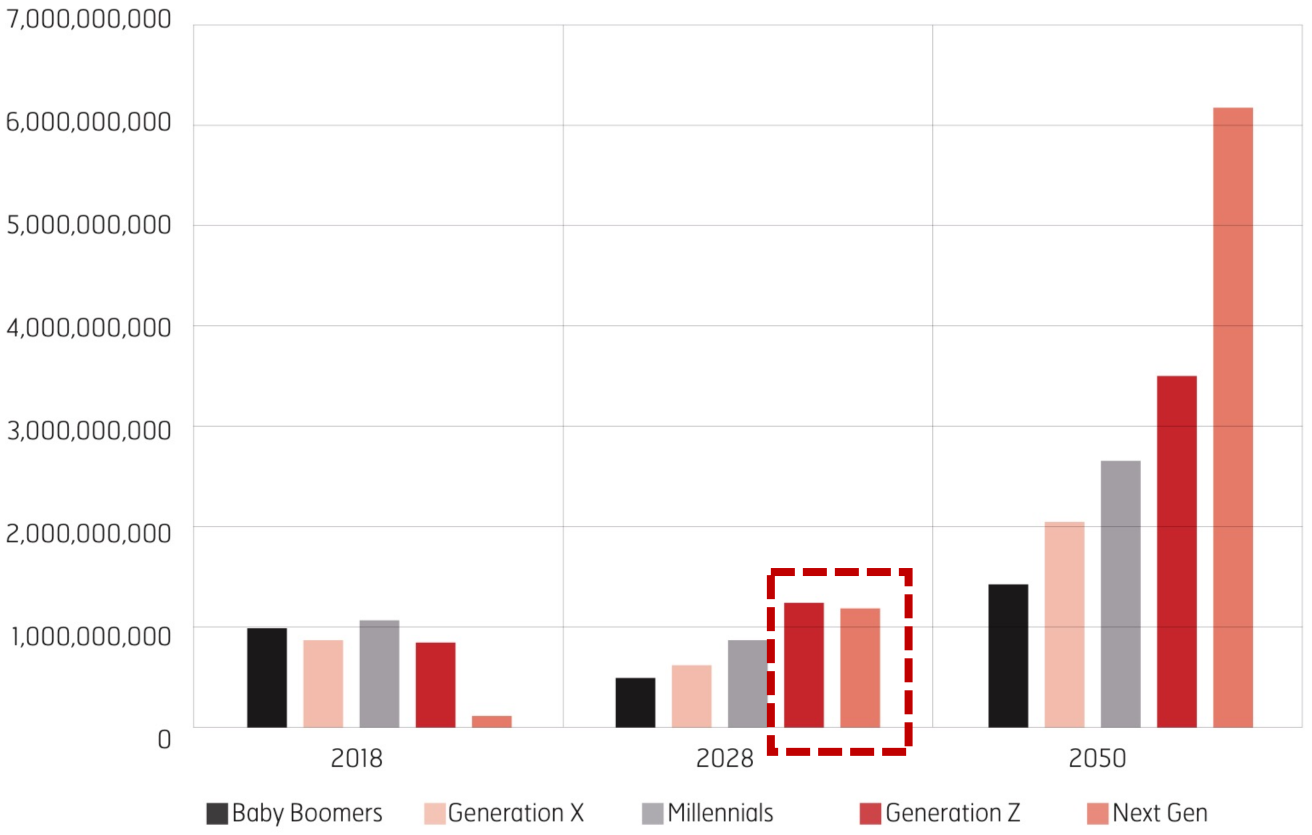
Real-time information & booking

- flight status, baggage tracking, onward travel

Personalised and contextual e-commerce

Driven by changing passenger demographics

Passenger Forecasts by Generation types globally to 2050



	Global Passenger Forecasts by Cohorts		
	2018	**2028**	**2050**
Next Gen	43,000,000	1,196,000,000	6,163,598,421
Generation Z	946,000,000	1,248,000,000	3,520,000,000
Millennials	1,075,000,000	884,000,000	2,400,000,000
Generation X	860,000,000	780,000,000	2,080,000,000
Baby Boomers	989,000,000	728,000,000	1,440,000,000
Total	**4,300,000,000**	**5,200,000,000**	**16,000,000,000**

Source: IATA, Knomea and LSE Research, cited in Inmarsat 'Sky High Economics, 2018

A focus on wellbeing and accessibility

Physical wellbeing (body motion, lighting, noise, vibration, air pressure and humidity)

Mental wellbeing (fear, distress)

Monitoring and sustainment

Inclusive design

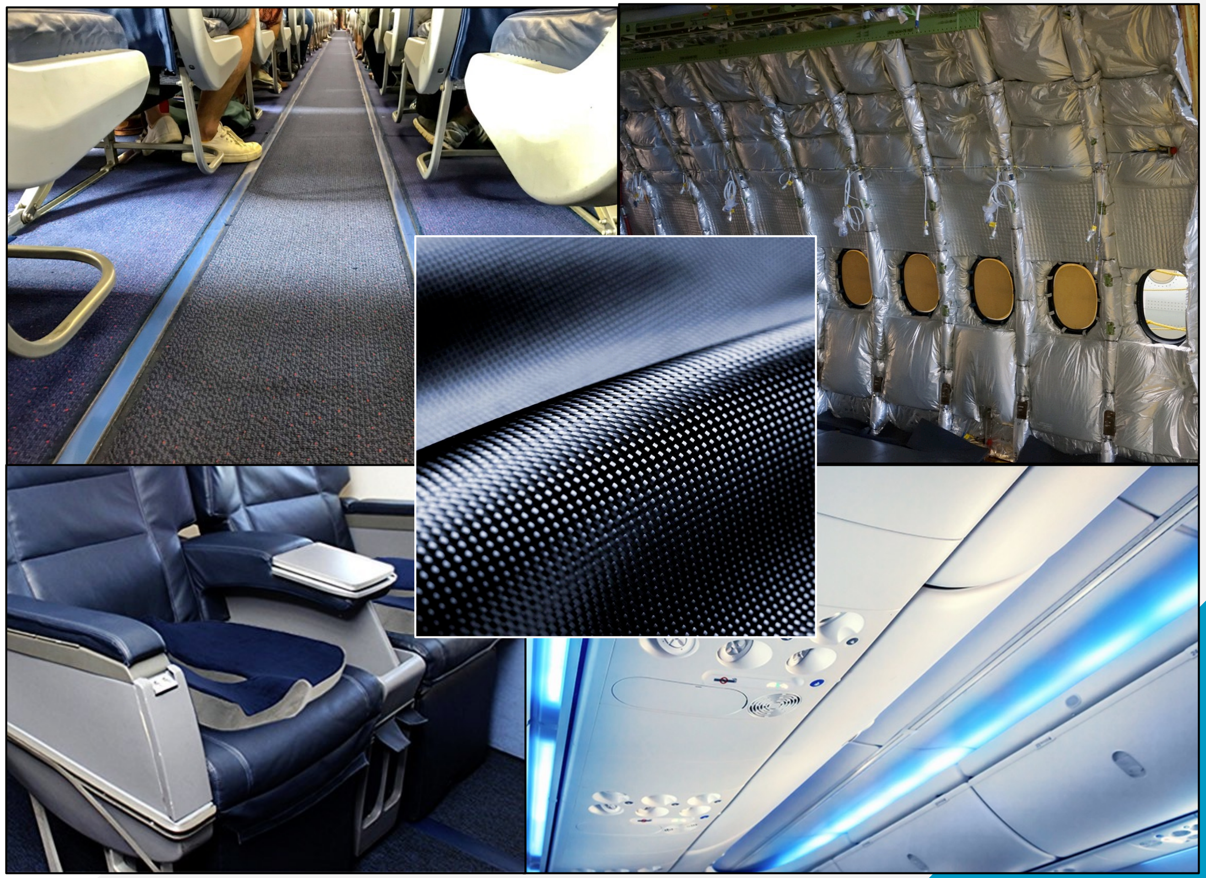
Image: Apex Experience Magazine, April/May 2019

Sustainability as the foundation

Light and efficient structures

Circular economic principles

Environmental information

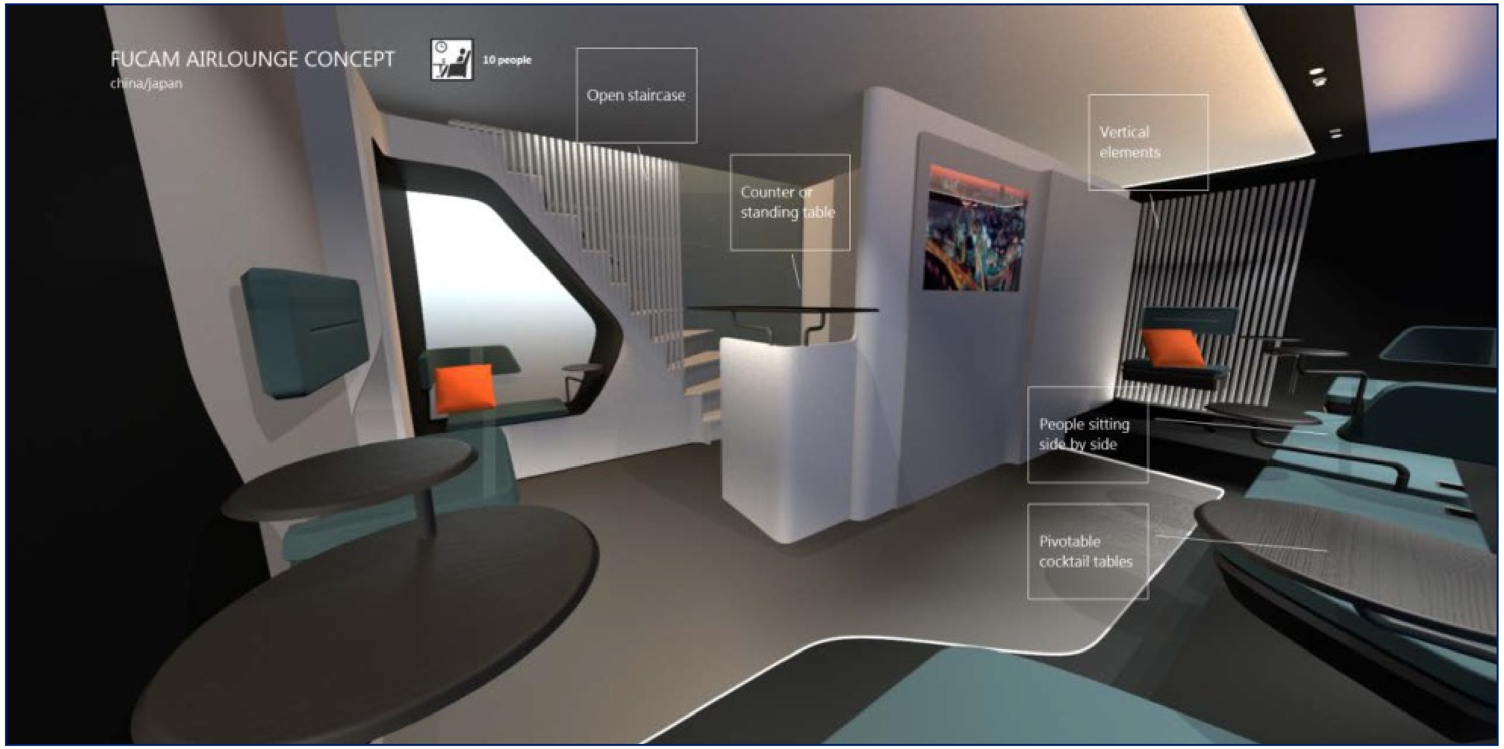


Cabin Interiors Research Activities

Collaborative academia / industry research to accelerate TRL progression and enhance passenger experience through technology integration

- Theoretical Research
- Technology Adaptation
- Laboratory Prototypes
- VR/AR Models
- Dimensional Mock-ups
- Functional Prototypes
- On-Board Installations
- Routes to Market

FUCAM Project: Bottom Cabin Lounge Area, Spatial Visualisation



FUCAM: FUture Cabin for the Asian Market

The Challenge:

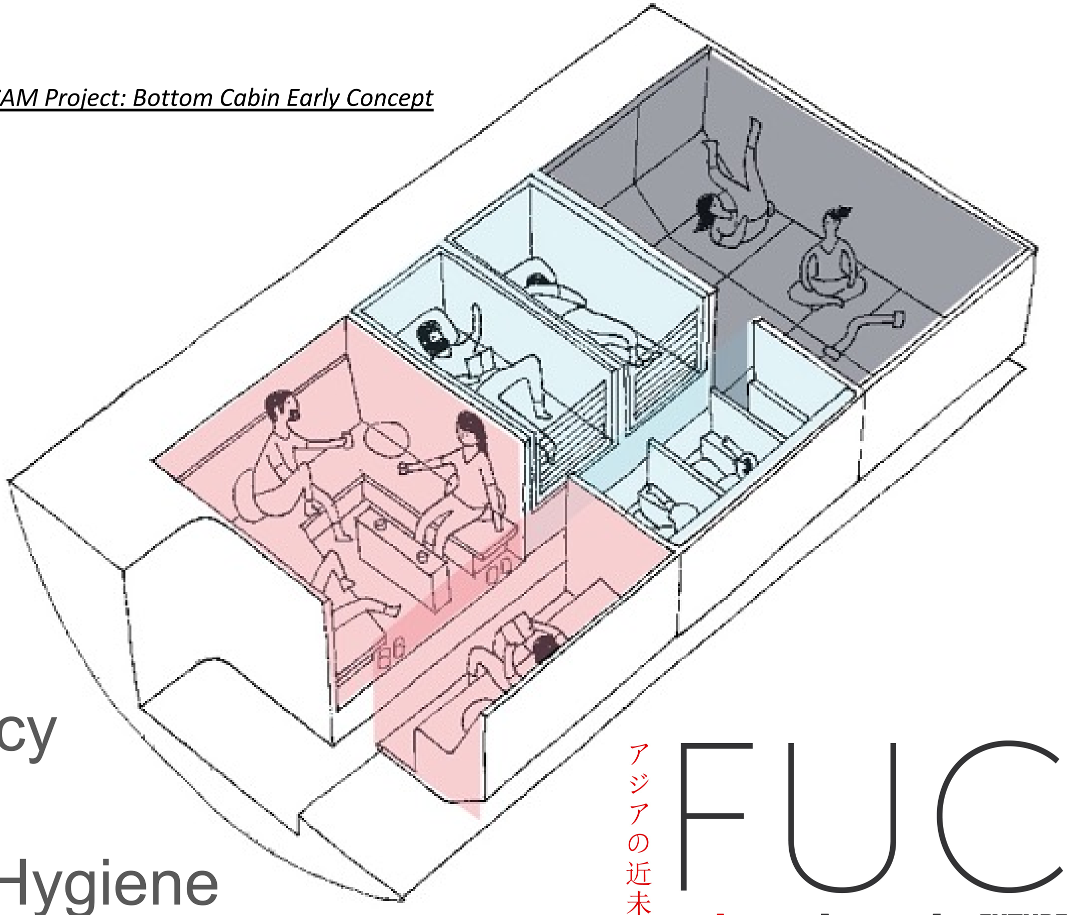
- To develop a conceptual cabin interior design dedicated to the Asian markets from 2025

- Horizon 2020 collaborative project €1.8m
- 8 Partners co-ordinated by Airbus 2016-19

アジアの近未来キャビン
FUCAM
FUTURE CABIN FOR THE ASIAN MARKET

FUCAM activities and areas of focus

FUCAM Project: Bottom Cabin Early Concept



Viable Solutions Brainstorming:

- Possible Cabin Configurations
- Functional application scenarios
- Implementation assessment

Different Regional Customer Needs (EU/JP):

- **Seat:** Physical Space / Personal Privacy
- **Interaction:** Individualism / Collectivism
- **Lavatory:** Functional Simplicity / Effective Hygiene
- **Functions:** Comfortable Resting / Extended Activities

アジアの近未来キャビン
FUCAM
FUTURE CABIN FOR THE ASIAN MARKET

FUCAM Enabling Technology (CU)

Cabin Technology Library:

- A database of **potential** cabin technology
- Methodologically reviewed & selected
- **Cabin TRL 1-3** (existing cabin tech excluded)
- Focus on technologies, not specific solutions
- 1000s reviewed, ~400 recorded
- Push and Pull modes

Records include:

- Time horizon
- Cost outlook
- Basic description
- Justification for cabin application

Technology Name:	**Printed Lighting**
Source (Link, Ref.):	http://www.lightsheets.net/home.html ; http://www.crugi.com/printed-light.html
Developed By: Various	*Country of origin:* USA

Description:

A novel technology involves spraying electroluminescent ink onto various surfaces, which may even be touched by hand. The light-emitting material consists of a phosphorescent compound that has been processed at a nano-molecular level and emits light when exposed to weak electrical current. Produces pleasant light at the intensity directly related to the strength of supplied current.

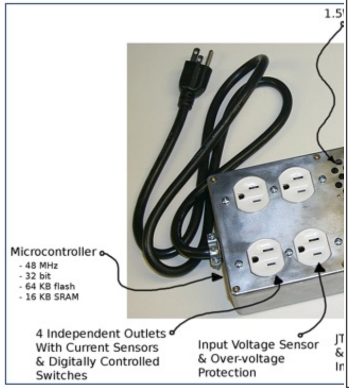
Example application of printed light in a public building.

Readiness Level: *See TRL Criteria*	TRL 4-6 (Lab Phase)	**Justification:** Offers extremely light weight and volume of installed lighting, unprecedented freedom for visual design, and the delivery of light where current solutions cannot reach.
Time Horizon: *Approximate*	5 - 9 years	**Barriers:** The risks of applying large areas of electrically-conductive material within cabin need to be studied and mitigated (some work already done by vendors); needs to be qualified for aerospace use.
Cost Outlook: *Approximate*	Low	

Technology Name:	**Distributed Acoustic Conve**
Source (Link, Ref.):	https://resenv.media.mit.edu/plug/
Developed By:	*Massachusetts Institute of Technology*

Description:

The system, originally developed for the special service c
reduce the annoyance to working colleagues, delivers ac
noise altering and cancelling. This is achieved through list
in a particular location where a conversation takes place, a
to mask the spoken content and reduce the overall volume
parts of the office. The system relies on a network of speak
room, and a software module that defines active sound ma



A small (palm-sized) module delivering the described functionality.

Readiness Level: *See TRL Criteria*	TRL 4-6 (Lab Phase)	**Justification:** Allows creating "local" conference areas at passenger seats through enclosing their confidential discussions within aural volumes, without the help of physical separators or the need for dedicated conference rooms.
Time Horizon: *Approximate*	5 - 9 years	**Barriers:** Currently developed and tested within the lab for a standard office environment within the building. Not initially considered for use within aircraft cabin – area for further development.
Cost Outlook: *Approximate*	Low	

FUCAM Enabling Technology (CU)

Data Framework - Cabin Breakdown Structure:

- A Top-Level breakdown of cabin components
- Unrelated to any particular OEM product
- Used for aircraft-level impact assessment
- Facilitates the allocation of new technology for cabin integration

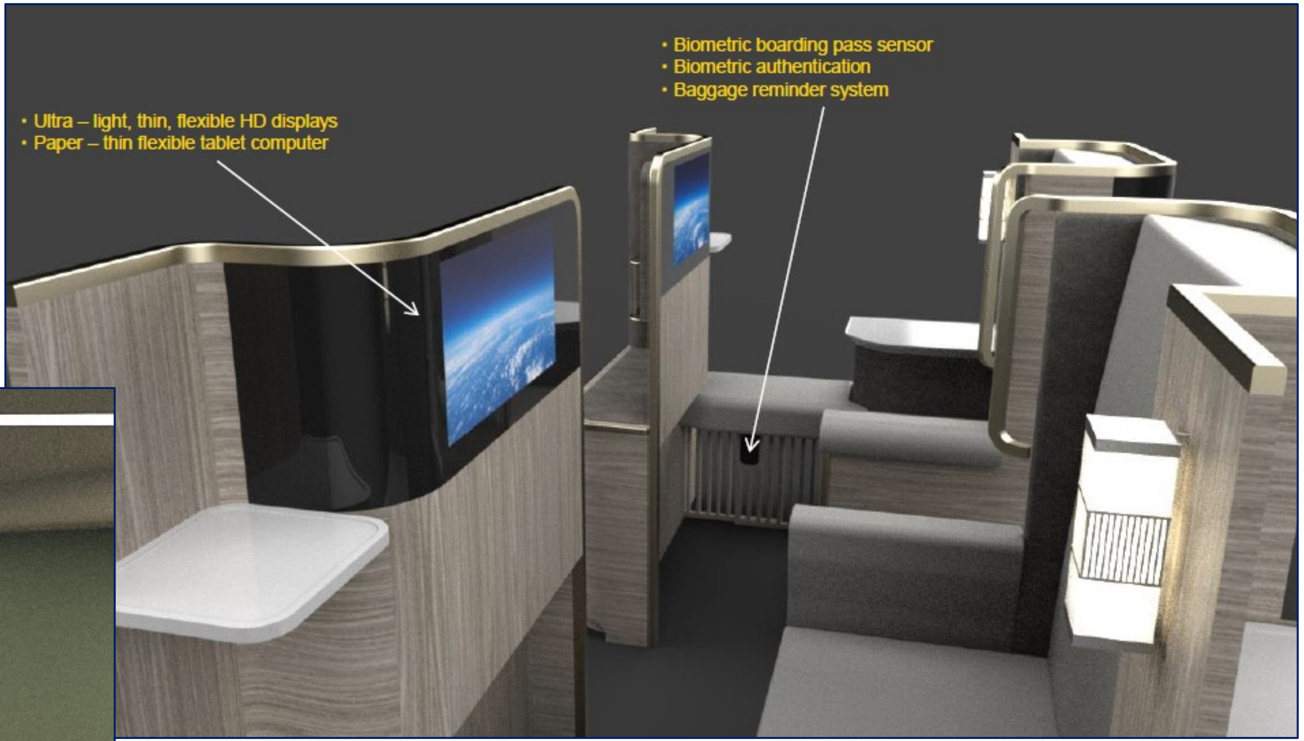
Structure:

- 9 Top-Level Categories
- 30 Sub-Categories

Domain	Cat. #	CBS Category Designation	Topic Ref.	Topic Name
1. Cabin Core & In-Flight Entertainment System Elements	01	Cabin Management System	A	Control Panels / User Interface / Input
			B	Processing Units & Control Modules
			C	System Interfaces & Data Connectors
			D	Servers & Mass Memory Systems
	02	Connectivity (Data Transfer)	A	On-Board - Wired
			B	On-Board - Wireless
	03	Satellite Communication Services	A	Satellite Radio
			B	Satellite TV
			C	Satellite Communication (External)
	04	User Interfaces / PSU	A	Device & Data Ports
			B	Buttons & Switches
			C	Control Panels
	05	Cabin Monitoring & Security	A	Video Monitoring
			B	Audio Monitoring
			C	Chemical Sensors
			D	Movement/Motion Monitoring
			E	Other Security Equipment
	06	Cabin Communication	A	Crew Intercom
			B	Passenger Address
			C	Signs, Indicators & Plackards
	07	Playback / Output (CMS & IFE)	A	Display / Visualisation Systems
			B	Audio Systems
			C	Printers & Other Physical Outputs
	08	Information Solutions	A	Flight Information
			B	Passenger Tools
2. Cabin Electrical Systems	01	Cabin Power Systems	A	Power Network Architectures
			B	Power Generation
			C	Power Distribution
			D	Power Storage
			E	Charging Plugs & Sockets
			F	Safety Means
	02	Galley	A	Beverage Preparation
			B	Food Chilling Equipment
			C	Food Warming Equipment
			D	Food Storage & Dispensing
			E	Waste Storage & Processing
3. Environmental Control	01	Cabin Lighting	A	Light Sources
			B	Lighting Architecture & Controls
	02	Cabin Air	A	Air Ventilation
			B	Air Conditioning
			C	Air Distribution
	03	Cabin Aural Envirnment	A	Noise Suppression
	04	Oxygen Systems	A	Passenger Oxygen
			B	Cabin Crew Oxygen
	05	Smoke & Fire Systems	A	Smoke Detection
			B	Smoke Containment
			C	Fire Extinguishing Systems
			D	Fire Prevention Means

FUCAM lower concept cabin (Airbus)

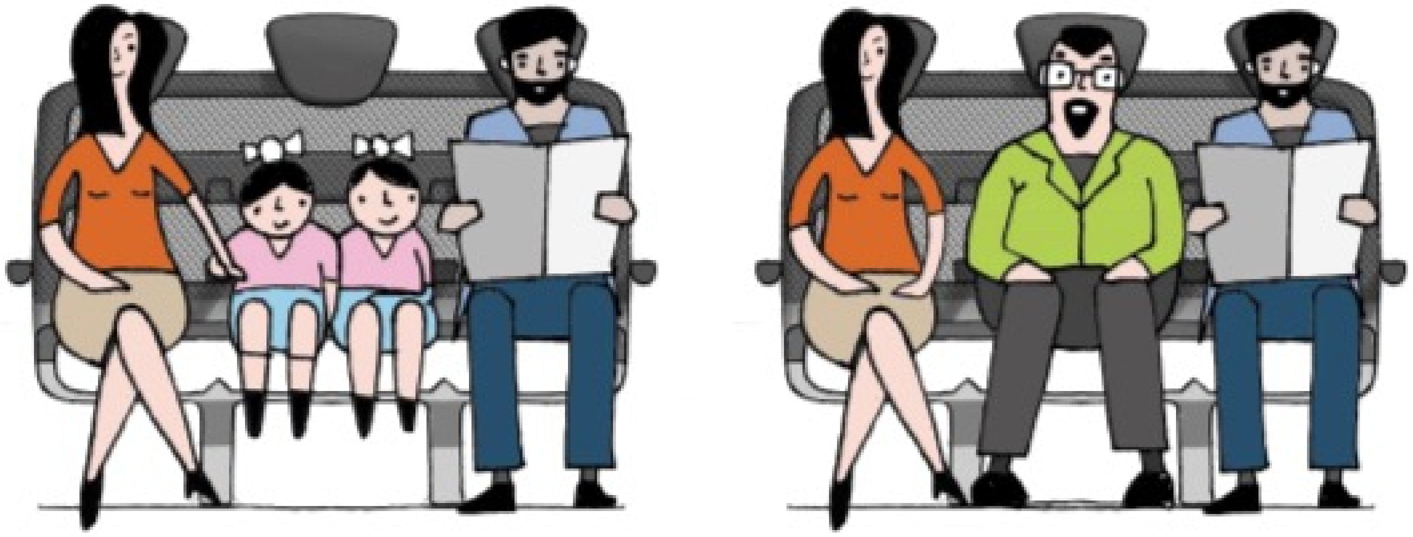
- **Partner:** bottom cabin interior design
- **Cranfield:** technology application scenarios



FUCAM Project: Bottom Cabin Relaxation Area, Spatial Visualisation

FUCAM super-economy seat (Mormedi)

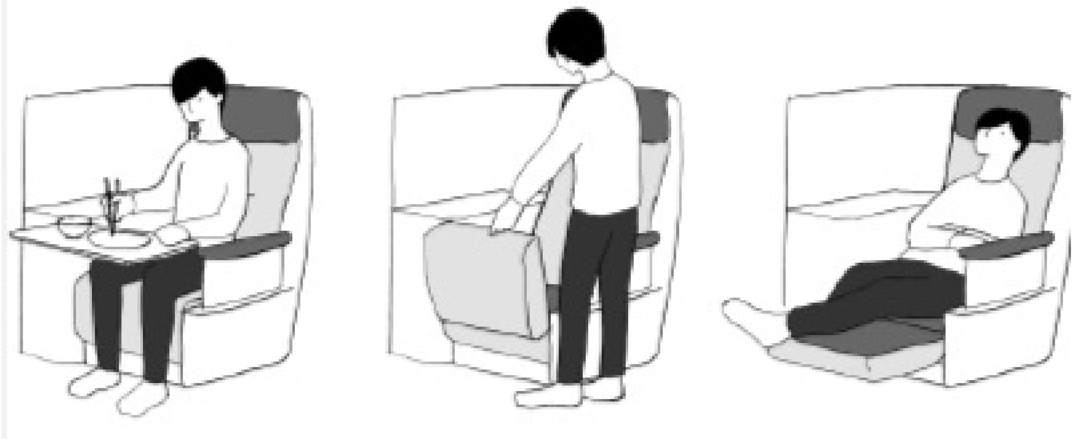
- High density flexible bench seat concept
- Mormedi's FUCAM seat was awarded Excellent Product Design recognition in the 2020 German Design Awards: Aviation, Maritime, Rail category



FUCAM Project: Super eco seat concept by Mormedi, enabling technology by Cranfield University
https://www.mormedi.com/en/german-design-award-super-eco-seat/

FUCAM Za-isu Seat (Jamco)

- Za-isu traditional Japanese seating chair
- New premium class opportunities
- Interchangeable hard/soft seat cushions
- Accessible hand luggage
- Patented table and seat features



FUCAM Project: Super eco seat concept by Mormedi, enabling technology by Cranfield University

https://www.jamco.co.jp/en/news/ir_news/COPY-COPY-COPY-ir_news-1615776096950769597/main/0/link/79th%20Term%20Business%20Report.pdf

ATI Future Cabin Opportunities

Aerospace Technology Institute

- Creates UK technology strategy
- Funds R&D through UK Department for Business, Energy & Industrial Strategy

- UK Cabin Interiors - £2bn
- Tech strategy report 2019 by ‘Achieving the Difference’ and Cranfield University

INSIGHT

Brought to you by AEROSPACE TECHNOLOGY INSTITUTE

Introduction

The UK has an estimated turnover exceeding £2bn in the cabin interiors market. Given the breakneck progress of technology in other areas of aircraft design and manufacture, and the need to reduce the environmental impact of aviation, the cabin interiors market is ripe for innovation. In this INSIGHT, the ATI sets out the rationale and opportunity for more innovation in cabin interiors based on market assessment, economic potential and the UK’s strong position.

The analysis identifies five technology themes that show great promise for growth and alignment with UK capabilities; it then describes 32 specific high-potential technologies that sit below these themes. This INSIGHT initiates a clear plan to catalyse innovation in UK cabin interiors. The ATI will engage throughout the supply chain to support the formation of collaborations and technology projects, and drive disruptive innovation through new and existing mechanisms.

https://www.thedifference.co.uk/

https://www.ati.org.uk/media/zdkpeumi/insight_14-the-uk-cabin-opportunity.pdf

ATI Future Cabin Opportunities

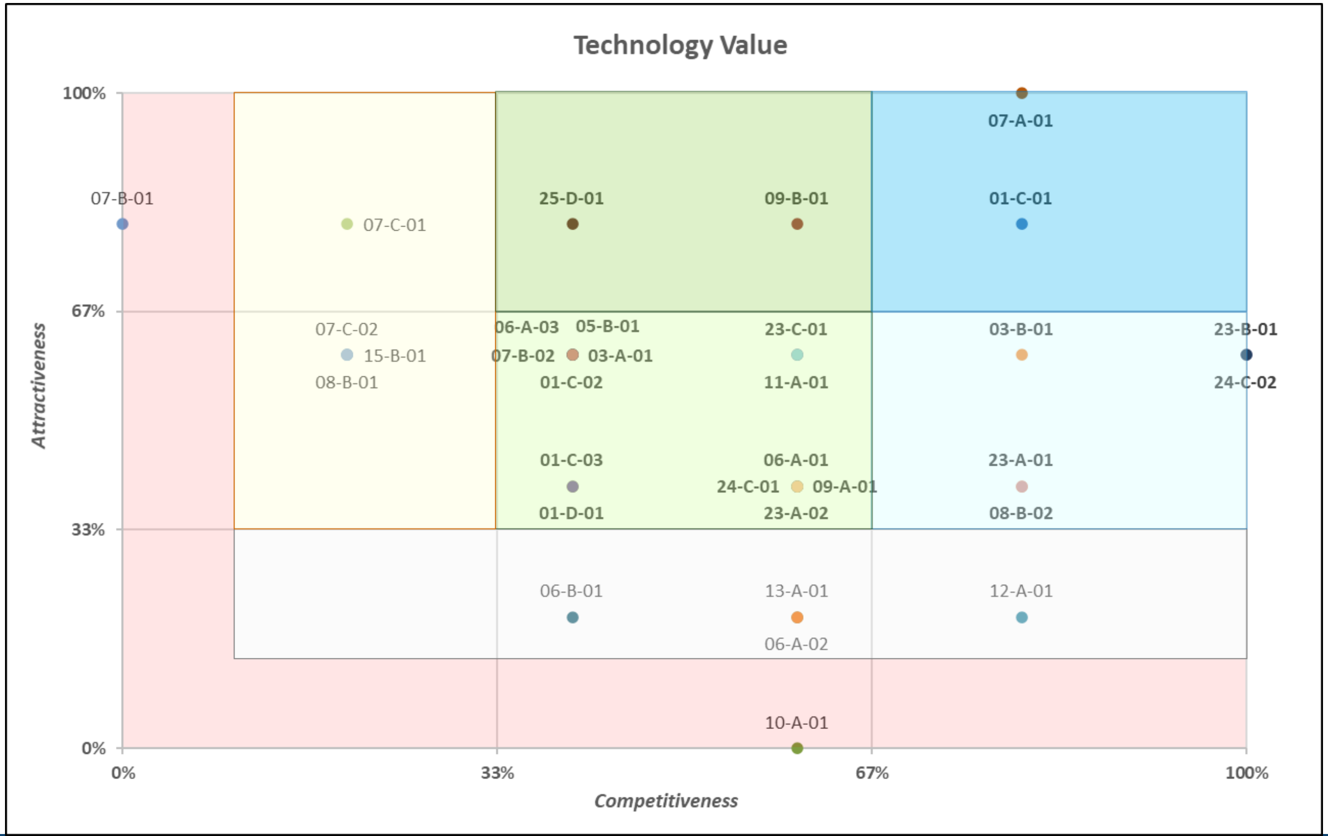
Technology Prioritization by GE/McKinsey Matrix

Passenger Cabin Prospects:

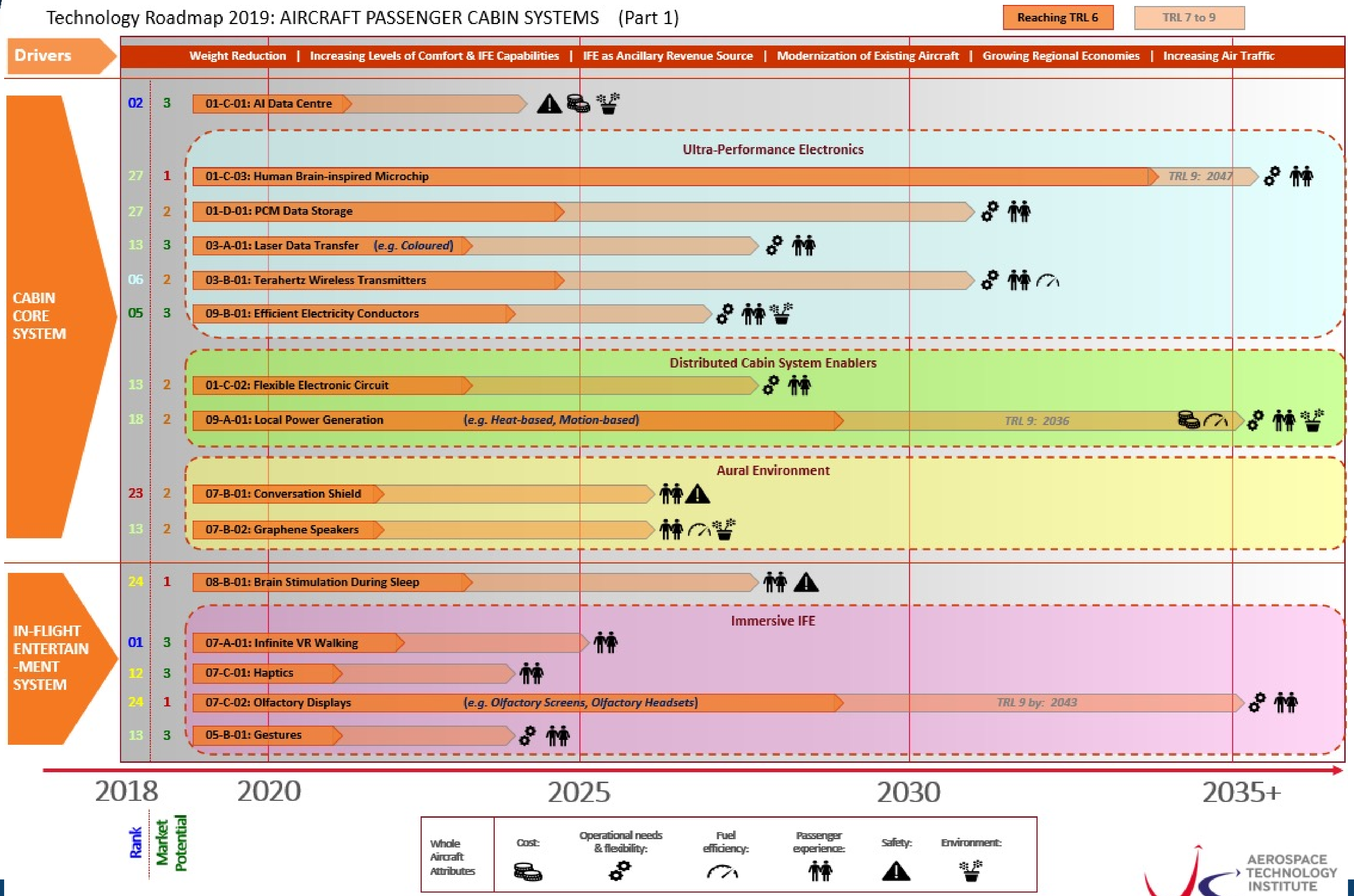
- Full Cabin Equipment Breakdown
- Identification of Potential Solutions

Assessment of Relevant Technology:

- Cabin Application Assessment
- Technology Value Ranking
- Detailed Roadmaps



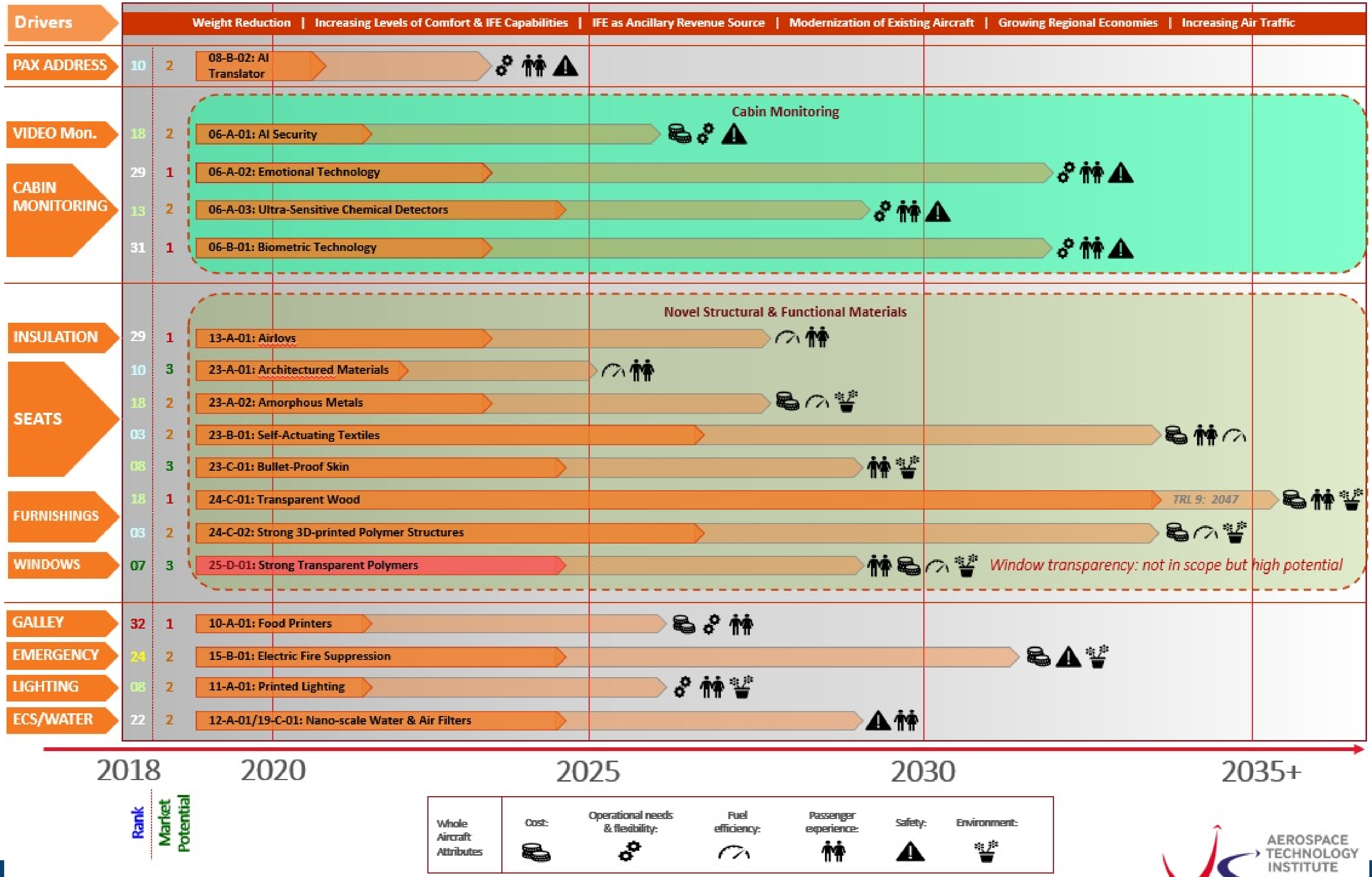
ATI Study Output



ATI Study Output

Technology Roadmap 2019: AIRCRAFT PASSENGER CABIN SYSTEMS (Part 2)

Reaching TRL 6 | TRL 7 to 9



Future Cabin Design Method (PhD Project)

Multi-faceted motivation:

- Offer unprecedented levels of PAX satisfaction
- Ensure tangible Carrier revenue growth
- Meet OEM stakeholder values & needs

  → Strategic dominance for all involved

Bespoke Methodology:

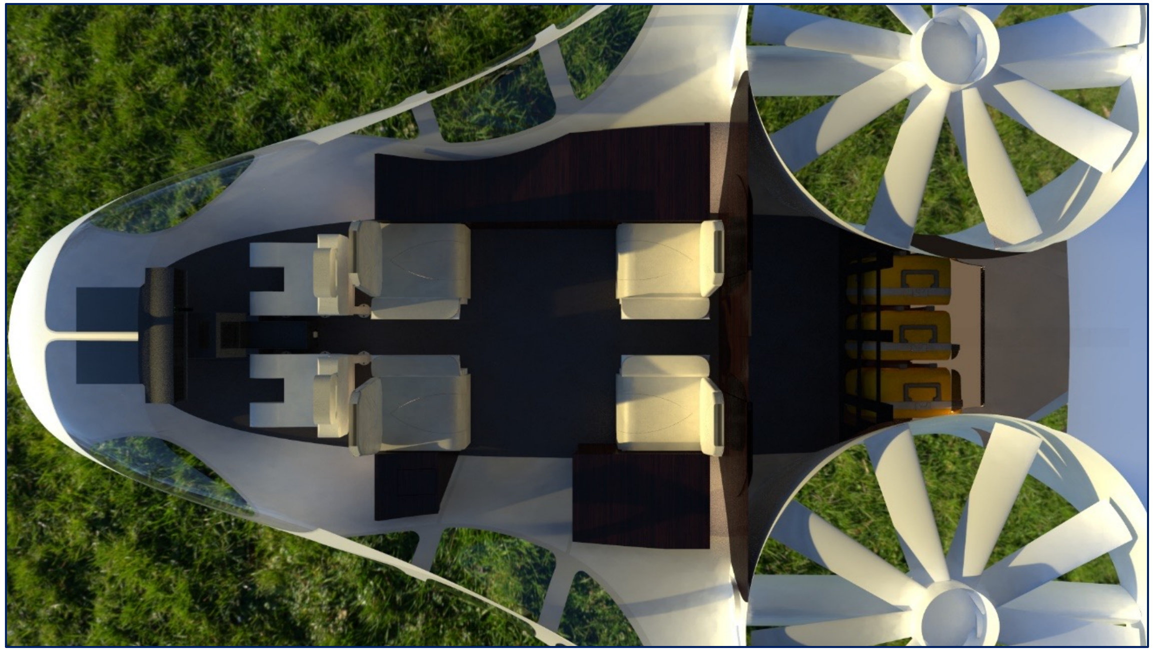
- Demonstrating MCDA for Cabin Design
- Building upon the latest approaches
- Simplicity / industrial applicability

Item	Type	4.4-1: Super-Skin	4.4-4: Hydration Sensor	4.7-4: Graphene Speakers	4.13: Olfactory Technology	4.18-1: Audio Brain Stimulation	4.18-2: Anti-Jetlag Goggles	Unit
ii. Total Profit per Flight (Cruise Time) - Before Payback								
Cruise Time Profit, per-Passenger:								
- Short Range:		-€ 0.02	€ 0.09	€ 0.06	-€ 0.03	€ 0.00	€ 0.15	EUR / PAX
- Intermediate Range 1:		-€ 0.09	€ 0.63	€ 0.27	€ 0.19	€ 0.02	€ 1.02	EUR / PAX
- Intermediate Range 2:		-€ 0.20	€ 1.35	€ 0.56	€ 0.47	€ 0.04	€ 2.19	EUR / PAX
- Long Range:		-€ 0.34	€ 2.24	€ 0.97	€ 0.65	€ 0.07	€ 3.64	EUR / PAX
Cruise Time Profit, whole Cabin (all PAX):								
- Short Range:		-€ 5	€ 27	€ 17	-€ 10	€ 0.9	€ 45	EUR
- Intermediate Range 1:		-€ 29	€ 192	€ 83	€ 57	€ 6	€ 312	EUR
- Intermediate Range 2:		-€ 61	€ 413	€ 172	€ 143	€ 13	€ 669	EUR
- Long Range:		-€ 103	€ 684	€ 297	€ 198	€ 22	€ 1,112	EUR
iii. Total Profit per Flight (Cruise Time) - After Payback								
Cruise Time Profit, per-Passenger:								
- Short Range:		-€ 0.01	€ 0.09	€ 0.06	-€ 0.02	€ 0.00	€ 0.16	EUR / PAX
- Intermediate Range 1:		-€ 0.07	€ 0.64	€ 0.30	€ 0.29	€ 0.02	€ 1.11	EUR / PAX
- Intermediate Range 2:		-€ 0.15	€ 1.37	€ 0.63	€ 0.69	€ 0.05	€ 2.38	EUR / PAX
- Long Range:		-€ 0.25	€ 2.27	€ 1.08	€ 1.02	€ 0.08	€ 3.96	EUR / PAX
Cruise Time Profit, whole Cabin (all PAX):								
- Short Range:		-€ 4	€ 27	€ 19	-€ 5	€ 1	€ 49	EUR
- Intermediate Range 1:		-€ 22	€ 195	€ 93	€ 89	€ 7	€ 340	EUR
- Intermediate Range 2:		-€ 45	€ 419	€ 193	€ 211	€ 16	€ 728	EUR
- Long Range:		-€ 77	€ 695	€ 332	€ 311	€ 26	€ 1,211	EUR
iv. Profits per year								
Pre-payback Yearly Profit		€ 0	€ 609	€ 293	€ 81	€ 20	€ 995	EUR / Seat
		€ 0	€ 186,503	€ 89,510	€ 24,882	€ 6,100	€ 304,442	EUR
Post-payback Yearly Profit		€ 0	€ 619	€ 324	€ 596	€ 64	€ 1,086	EUR / Seat
		€ 0	€ 189,354	€ 99,247	€ 56,725	€ 7,129	€ 332,293	EUR

Bizjet Cabin Concept

VTOL Hybrid-Electric Business Jet:

- Industry-funded Group Design Project
- Joint CS-23 & CS-27 Certification
- Dedicated MSc candidate for Cabin Design Development & Integration



E-Starling Cabin Concept by a Cranfield MSc student

E-Starling by SAMAD Aerospace https://www.samadaerospace.com/estarling/

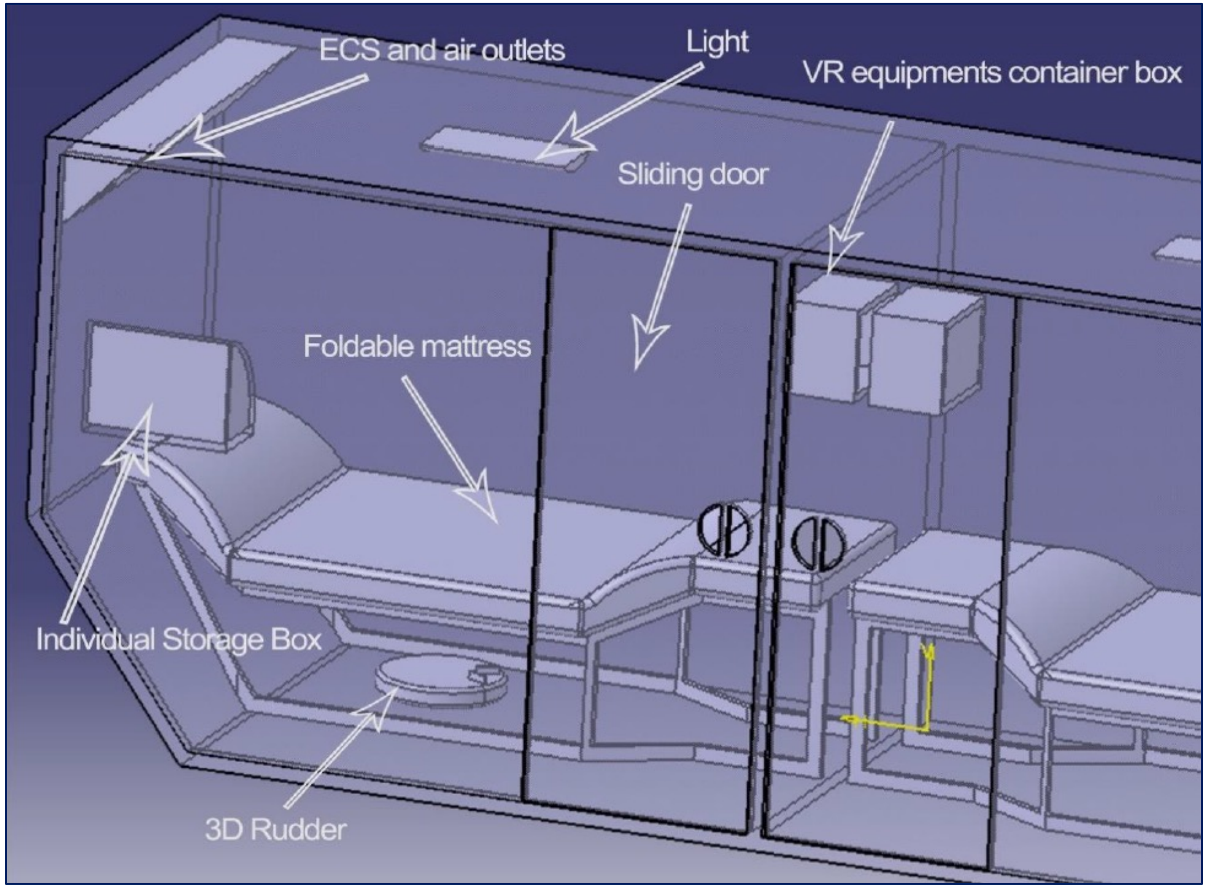
Tasks Performed:

- Cabin Concept Development
- Detailed CAD: structures, systems, maintenance
- Certification Compliance & Safety assessment

Lower Cabin IFE Module

Passenger value:

- Entertainment
- Seclusion & Privacy
- Resting & Relaxation



Container-based Bottom Cabin Entertainment Module Concept by a Cranfield MSc student

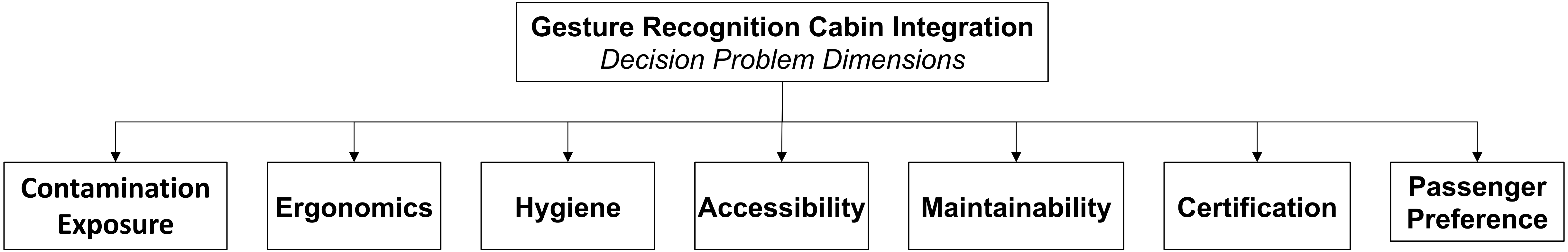
Stakeholder value:

- Significant ancillary revenue potential
- Modularity (container-based)
- Maintainability (easy access)
- Easy implementation (no significant structural re-design)

Biosafe Tech Integration

Cabin Biosafety:

- Individual MSc Research Project
- Considers a variety of means for tackling COVID-19 spread in cabin
- Technology Assessment to establish suitable implementation options



Biosafe Tech Integration

Biosafety Technologies considered:

- Gesture-Recognition Technology
- Touchless Cabin Interfaces
- Active Disinfection
- Passive Sanitisation
- Bio-Resistant Polymers
- Air & Water Treatment/Filtration

Cabin-wide Biosafe Gesture Recognition System Concept by a Cranfield AVD MSc student

Thank you for your attention!

Seamless Journey and the Passenger Experience Laboratory, DARTeC

Dr Thomas Budd and Dr Craig Lawson

DARTeC, Cranfield University

t.m.budd@cranfield.ac.uk

c.p.lawson@cranfield.ac.uk

Thanks to Roman Kirenskis for providing significant slide material