PORTFOLIO CASE STUDY 03 | UIR ACADEMIC CONCEPT

# Future Flight Lab: Eco-Efficient Aircraft Retrofit

A systems-engineering concept for upgrading existing aircraft through lightweight cabins, digital twins, predictive maintenance and propulsion-ready interfaces.

RETROFIT | DIGITAL TWIN | SAFETY | LIFECYCLE

**EVIDENCE STATUS**

The original school-project PPT is not available in the supplied files. This is an explicitly labeled concept reconstruction based on Aymane's stated future vision - not a claim of completed UIR calculations, prototypes or test results.

01 | STATUS

# What this academic concept does - and does not claim

## 01 Credible ambition

The purpose is to show how Aymane thinks as a systems engineer while preserving a clear boundary between a portfolio concept and verified academic work.

PROBLEM

### Existing fleets face trade-offs

Operators need lower lifecycle impact, competitive cost, safety, reliability and passenger comfort. Replacement alone is not always the only design path.

PROCESS

### Systems engineering

Define stakeholders and constraints, model a baseline, generate retrofit modules, evaluate trade-offs, control safety risk and validate through staged demonstrators.

SOLUTION

### Modular retrofit roadmap

A configurable package architecture: lightweight cabin, sensing and health monitoring, data platform, maintenance intelligence and propulsion-ready interfaces.

- **SOURCE-BACKED** — Visible in supplied notes
- **ENGINEERED** — Portfolio reconstruction
- **ILLUSTRATIVE** — Synthetic data or target

**ACADEMIC EVIDENCE BOUNDARY**

- Known: UIR graduate in 2025; stated ambition around eco-friendly aerospace, speed, safety, comfort and detail-led design.
- Reconstructed: project brief, requirements, architecture, trade study, FMEA, demonstrator and business model.
- Not supplied: original title, team, supervisor, aircraft baseline, calculations, CAD, simulation, prototype, test data and grade.

# Retrofit is a constrained systems problem

## DESIGN TENSION


## PROBLEM STATEMENT

How might an existing narrow-body aircraft be upgraded in modular steps to reduce energy, weight and lifecycle cost while protecting airworthiness, dispatch reliability and passenger experience?

## KEY CONSTRAINTS

- certification and configuration control
- structural and electrical interfaces
- mass, balance and installation downtime
- maintainability, supply chain and economics
- human factors and cybersecurity

## DESIGN PRINCIPLES

### MODULAR

Independent packages with controlled interfaces

### REVERSIBLE

Pilot changes that can be safely removed

### MEASURABLE

Baseline and verification defined first

### CERTIFIABLE

Evidence planned with the design

### MAINTAINABLE

Access, diagnostics and spares considered

### CIRCULAR

Repair, reuse and end-of-life pathways

# Translate ambition into testable needs

## STAKEHOLDER REQUIREMENT MAP

**OPERATOR**
dispatch reliability, downtime, ROI

**PASSENGER**
comfort, accessibility, connectivity

**CREW**
workload, usability, emergency operation

**MAINTENANCE**
access, diagnostics, parts, training

**REGULATOR**
compliance, evidence, configuration

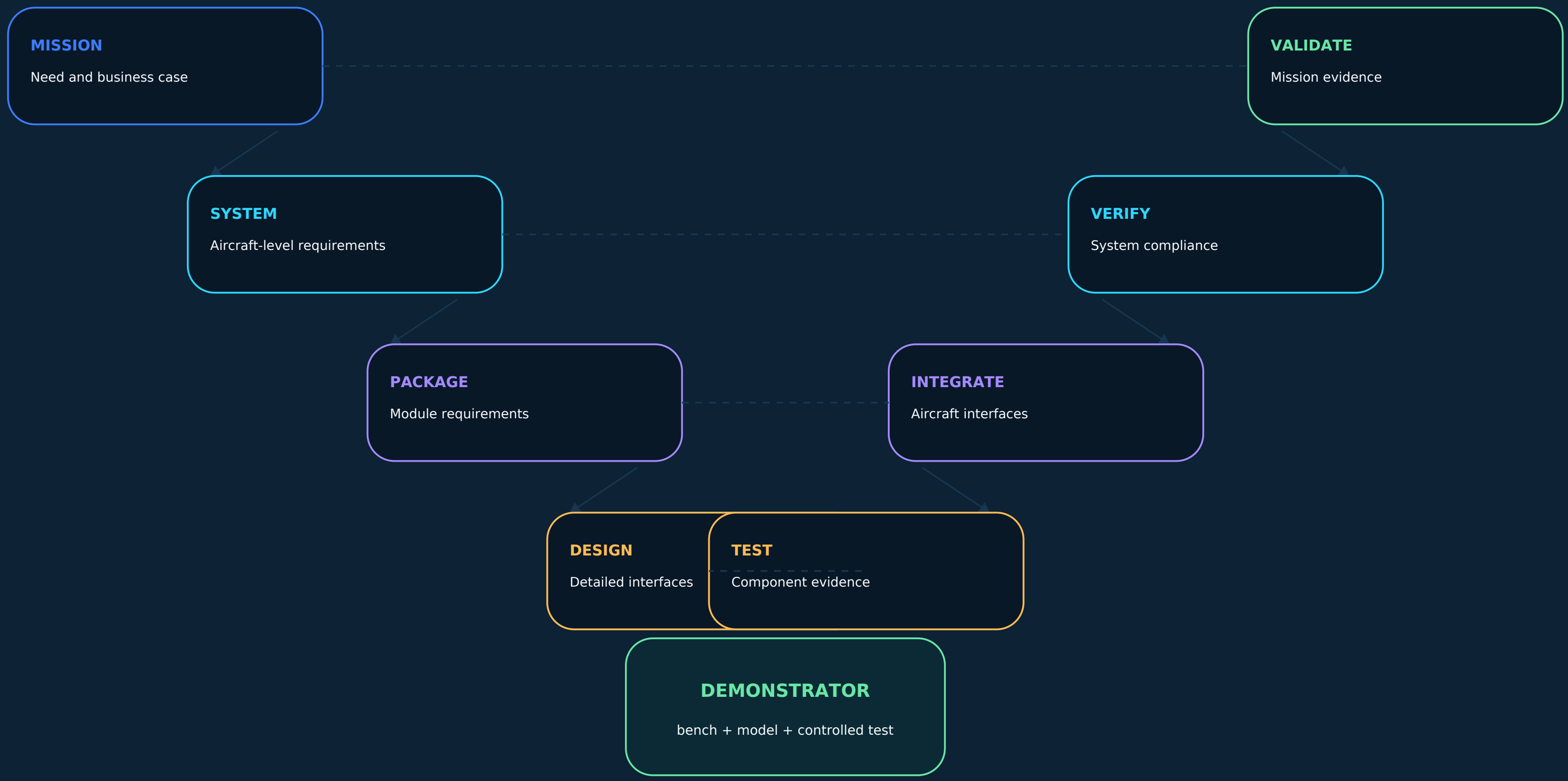
**ENVIRONMENT**
energy, material, lifecycle impact

## SAMPLE MEASURABLE REQUIREMENTS | CONCEPT

| | | |
|---|---|---|
| R-01 | **Mass** | Each package reports installed mass, center-of-gravity effect and margin. |
| R-02 | **Energy** | Cabin electrical demand is modeled by mission phase and operating mode. |
| R-03 | **Safety** | No single package may bypass required protection, warning or emergency function. |
| R-04 | **Maintain** | Line-replaceable elements have access, isolation and diagnostic provisions. |

# Use a V-model with evidence at every gate

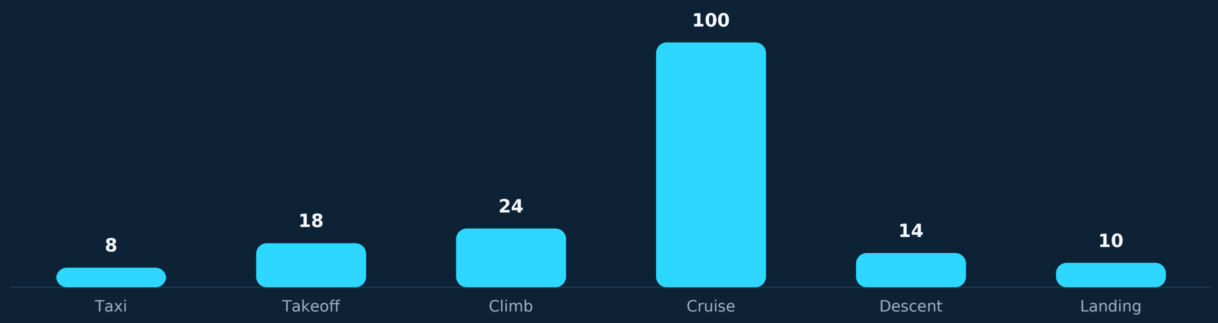
SYSTEMS ENGINEERING V-MODEL




Each requirement receives a verification method: analysis, inspection, test, demonstration or review of design. The trace matrix is part of the design, not an afterthought.

# Model the aircraft before proposing change

## NORMALIZED MISSION MODEL




*Synthetic portfolio data - replace with verified project records before publication.*

## MODEL BOUNDARIES

- aircraft configuration and mission
- payload, fuel/energy and reserves
- cabin electrical and thermal loads
- drag, mass and center of gravity
- maintenance and dispatch events
- material lifecycle and retrofit downtime

## FIRST-ORDER RELATIONSHIPS

**MASS**

Delta mass -> payload, fuel and CG impact

**DRAG**

Delta drag -> thrust and mission energy impact

**POWER**

Cabin load x mission time -> electrical energy

**RELIABILITY**

failure rate + repair time -> availability

**LIFECYCLE**

manufacture + operation + maintenance + end-of-life

No numerical aircraft claim is made here. The baseline must be rebuilt from the original project aircraft and verified source data.

06 | SOLUTION

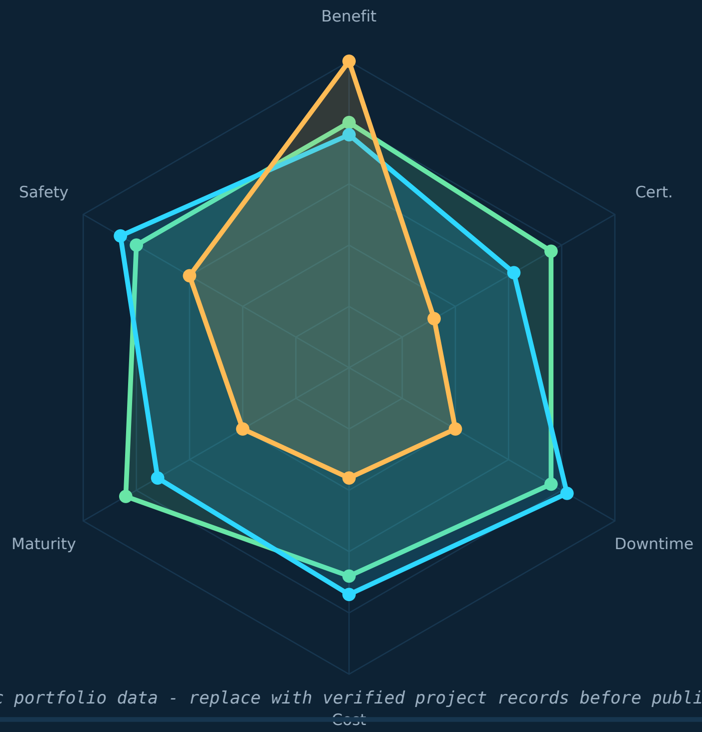
# A modular retrofit package architecture

FIVE UPGRADE MODULES


Package interfaces: structure, power, data, cooling, software, maintenance, human factors, certification and configuration control.

# Choose modules with transparent trade-offs

## WEIGHTED CONCEPT COMPARISON

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## DECISION MATRIX | ILLUSTRATIVE 1-5

| Module | Benefit | Risk | Maturity | Install | Priority |
|---|---|---|---|---|---|
| **Light cabin** | 4.1 | 2.1 | 4.2 | 3.8 | **P1** |
| **Smart loads** | 3.6 | 2.3 | 3.8 | 3.5 | **P1** |
| **Health monitor** | 4.0 | 2.4 | 3.6 | 4.0 | **P1** |
| **Data backbone** | 3.8 | 2.8 | 3.5 | 3.7 | **P2** |
| **Propulsion ready** | 5.0 | 4.4 | 2.0 | 2.0 | **P3** |

## SELECTION LOGIC

Start with modules that create measurable value, use mature interfaces and limit aircraft downtime. Keep high-benefit, high-certification-burden propulsion changes in a research track until architecture and evidence mature.

## SENSITIVITY CHECK

Repeat the ranking with different operator priorities: fuel price, aircraft age, route length, cabin downtime, financing, maintenance capability and certification route. A stable decision should not depend on one arbitrary weight set.

# Connect the physical aircraft to learning

## DIGITAL-TWIN REFERENCE ARCHITECTURE

**PHYSICAL ASSET** aircraft zones, cabin systems, selected condition signals

**EDGE + SECURITY** time synchronization, filtering, health checks, secure transfer

**DATA FOUNDATION** configuration, flight/ground context, maintenance and event lineage

**ENGINEERING MODELS** load, degradation, anomaly, energy and reliability models

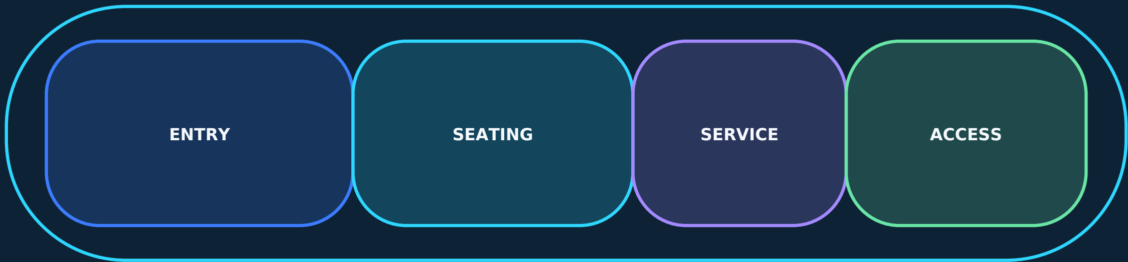
**DECISION SERVICES** maintenance recommendation, retrofit learning, fleet comparison

**GUARDRAILS** Configuration-aware data, access control, model versioning, uncertainty display, human authorization and a safe fallback state. The twin supports decisions; it does not create airworthiness approval.

09 | HUMAN FACTORS

# Improve comfort without adding uncontrolled complexity

## CABIN EXPERIENCE ZONES




Treat comfort as measurable system performance: acoustic environment, thermal uniformity, air quality, lighting, accessibility, storage usability, perceived space and service reliability.

## HUMAN-FACTORS TESTS

- task analysis for crew and maintenance
- reach, clearance and access checks
- failure and degraded-mode behavior
- cognitive load and alert hierarchy
- inclusive boarding and seat interaction
- cleaning, repair and turnaround trial

## COMFORT SCORECARD | CONCEPT

**Noise**
dBA by phase

**Thermal**
zone variation

**Air**
CO2 / particles

**Light**
lux / glare

**Access**
task time

**Reliability**
fault-free sectors

Targets require the original aircraft, route and customer brief.

# Design the certification evidence path early

## SAMPLE FMEA | ILLUSTRATIVE

| FUNCTION | FAILURE MODE | EFFECT | PREVENTION / DETECTION | EVIDENCE |
|---|---|---|---|---|
| **Zonal power** | uncommanded loss | comfort / function loss | isolation + safe state | bench + aircraft test |
| **Sensor node** | drift / bad data | wrong maintenance cue | self-test + plausibility | fault injection |
| **Data gateway** | unauthorized access | data / function risk | segmentation + auth | security assessment |
| **Cabin panel** | attachment failure | injury / damage | loads + retention | analysis + test |

## CERTIFICATION WORKSTREAM

- classify change and applicable requirements
- define compliance checklist and means
- control design, supplier and software evidence
- verify installation, instructions and configuration
- plan continued-airworthiness information

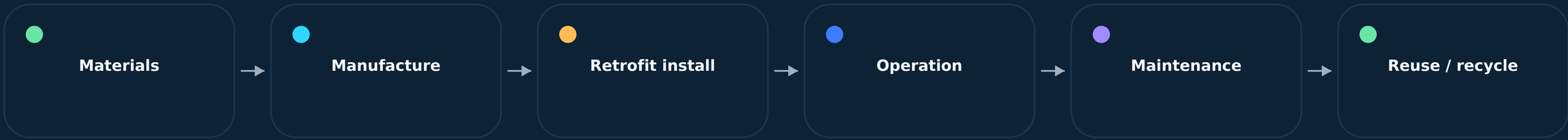
## NON-NEGOTIABLE

A portfolio concept cannot determine the certification route. The applicant, approved design organization and competent authority establish the applicable basis, means of compliance and approvals for the actual aircraft and change.

Safety arguments must be supported by controlled engineering evidence.

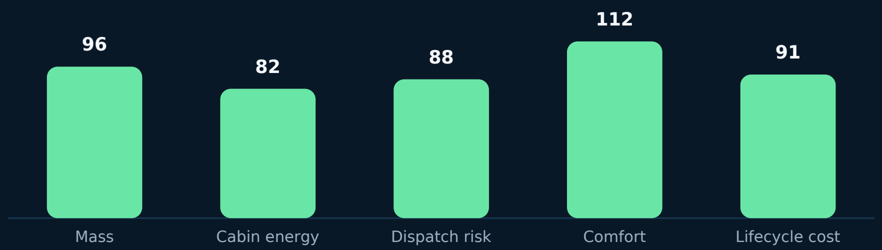
# Measure sustainability across the whole system

## LIFECYCLE BOUNDARY




A lower-energy component can still create a poor outcome if it adds mass, short life, difficult repair, long installation downtime or a weak end-of-life route. The model must expose trade-offs.

## NORMALIZED SCENARIO | BASELINE = 100

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## DECISION METRICS

- installed mass and mission-energy effect
- operational energy and consumables
- maintenance hours, spares and removal rate
- retrofit downtime and embodied materials
- repairability, reuse and end-of-life recovery

# Progress through safe demonstrators

## DEMONSTRATOR ROADMAP

**G0**
**Digital baseline**
requirements, model, assumptions

**G1**
**Component bench**
loads, energy, faults, durability

**G2**
**Cabin mock-up**
human factors, install, maintain

**G3**
**Ground rig**
integrated power, data, thermal

**G4**
**Aircraft ground**
approved installation checks

**G5**
**Flight evidence**
only within approved program

## GATE REVIEW QUESTIONS

**SAFE?**
Hazards controlled and fallback defined

**WORKS?**
Requirement met with repeatable evidence

**FITS?**
Interfaces, mass, power and access acceptable

**WORTH IT?**
Lifecycle value survives uncertainty

No flight test is proposed without the necessary organizational approvals, aircraft approvals, safety analysis, procedures and authorized personnel.

# Make the concept competitive and adoptable

## MODULAR VALUE MODEL

| CUSTOMER | OFFER | VALUE | PARTNERS | REVENUE |
|---|---|---|---|---|
| airlines, lessors, MROs, special missions | assessment, package design, integration, monitoring | lower loss, better comfort, longer useful life | OEM/STC, suppliers, MRO, data, research | engineering, package, integration, service |

Adoption depends on more than technical benefit. The business case must include aircraft downtime, certification cost, residual value, training, spares, financing, fleet commonality and uncertainty.

## STAGED OFFER

- 01 Fleet opportunity assessment
- 02 Digital baseline and trade study
- 03 Package engineering and evidence plan
- 04 Installation and acceptance support
- 05 In-service monitoring and improvement

## GO / NO-GO MODEL

Proceed only when expected lifecycle value remains positive across conservative assumptions and the technical, organizational and certification capabilities are available.

No pricing or ROI claim is made without an aircraft-specific baseline.

# What is needed to convert concept into verified case study

## ORIGINAL PROJECT EVIDENCE NEEDED

- Original PPT/PDF and exact project title
- Team members, supervisor, dates and individual role
- Aircraft or system baseline and requirements
- CAD, calculations, simulation and assumptions
- Prototype photographs and test configuration
- Measured results, limitations and lessons learned
- What can be published without restriction

## PORTFOLIO NARRATIVE

My ambition is to help take aerospace to the next level through eco-efficient engineering that protects speed, safety and comfort. I am interested in the difficult middle ground between a clean-sheet aircraft and the fleet already operating today.

This concept shows a disciplined route: requirements -> baseline -> trade study -> safety case -> staged demonstrator -> lifecycle evidence.

## PRIMARY REFERENCES


01 **EASA - Initial Airworthiness and Environmental Protection**
https://www.easa.europa.eu/en/document-library/easy-access-rules/easy-access-rules-initial-airworthiness-and-environmental

02 **EASA - Continuing Airworthiness**
https://www.easa.europa.eu/en/document-library/easy-access-rules/easy-access-rules-continuing-airworthiness

03 **NASA - G-III environmentally friendly aircraft concepts**
https://www.nasa.gov/aeronautics/g-iii/

04 **NASA - Hybrid engine system test (January 2026)**
https://www.nasa.gov/aeronautics/hybrid-engine-tested/


References frame the engineering context only; they do not validate this concept or imply affiliation.