BELGIUM CAMPUS iTversity	**Project Charter**	TAB
Programme: Aviation Safety		**Proj No:** AS
Project Title: AI-Enabled Pilot Fatigue Detection & Safety System with 3D-Printed Holding Case for Single-Prop Aircraft.		**Supervisor:** TBA

1 Research Programme

Project Definition:

Pilot fatigue remains a significant safety risk in general aviation, particularly for single-prop aircraft, where pilots operate with minimal automation and no co-pilot support. Fatigue can lead to slower reaction times, impaired decision-making, and increased risk of in-flight incidents.

This project aims to develop an AI-driven fatigue detection system, housed in a custom 3D-printed holding case, that will:

- Monitor pilot fatigue levels using facial recognition and biosensors.
- Analyse fatigue patterns with Machine Learning (ML) algorithms.
- Trigger real-time safety alerts via audio, haptic feedback, and visual indicators.
- Integrate with an IoT-based cloud system for fatigue trend analysis and predictive safety insights.
- Be enclosed in a lightweight, 3D-printed case for easy installation in aircraft cockpits.

Research Goals:

- Develop an AI-based fatigue detection module using computer vision and biosensors.
- Implement an IoT-enabled alert system to notify pilots and ground control.
- Use machine learning models to predict fatigue trends based on biometric and environmental factors.
- Design and manufacture a lightweight, 3D-printed case for secure and ergonomic installation in single-prop aircraft.

Methodology:

- **AI-Powered Pilot Fatigue Detection System**
  - Utilize computer vision (OpenCV, TensorFlow) to detect fatigue indicators:
  - Eye blink rate & prolonged closure.
  - Yawning detection.
  - Integrate wearable biosensors (heart rate & EEG monitors) for additional fatigue assessment.
  - Train ML models (Random Forest, CNNs) to analyse fatigue levels in real-time.

- **IoT-Based Safety & Alert System**
  - Deploy wireless IoT sensors for real-time biometric data collection.
  - Enable WiFi/Bluetooth connectivity to send alerts to:
  - Pilot (audio & haptic feedback alerts).
  - Ground control (remote monitoring of fatigue trends).

- **Automated Safety Responses**
  - Stage 1 Alert: Audio and visual warnings when mild fatigue is detected.
  - Stage 2 Alert: Haptic feedback (seat vibration) for moderate fatigue levels.
  - Stage 3 Alert: Engaging autopilot stabilization and transmitting emergency signals for severe fatigue cases.

- **4. 3D-Printed Holding Case Design**
  - Design a lightweight, durable, and heat-resistant enclosure for the fatigue detection module.
  - Optimize the case for secure cockpit mounting, ensuring ergonomic positioning for accurate monitoring.
  - Use 3D printing (PLA, ABS, or carbon fiber composites) for cost-effective manufacturing.

- **5. Data Analytics & Predictive Fatigue Monitoring**
  - Store pilot fatigue data in a cloud-based database.
  - Use AI to analyse long-term fatigue patterns and predict high-risk scenarios based on:
  - Pilot workload levels.
  - Cabin environmental conditions (temperature, oxygen levels, etc.).
  - Provide fatigue risk reports to aviation safety organizations.

Project Objectives:

Objective 1: Develop an AI-powered fatigue detection system for single-prop aircraft.

Objective 2: Implement an IoT-based safety alert system for real-time monitoring and intervention.

Objective 3: Design and manufacture a 3D-printed holding case for compact, secure installation.

Objective 4: Improve aviation safety by predicting and mitigating fatigue risks using AI-driven insights.

Project Scope

In-Scope:
- AI-based facial recognition & biosensor monitoring for fatigue detection.
- IoT-enabled alerts to pilots, ground control, and aircraft systems.
- Machine learning-based fatigue risk prediction and data analysis.
- 3D-printed holding case for system integration in the cockpit.

Out-of-Scope:
- Full automation of flight controls (focus is on fatigue monitoring and alerts).
- Medical diagnostics of fatigue-related conditions.
- Integration with commercial jet systems (focus is on single-prop aircraft).

Deliverables

1. AI-powered Pilot Fatigue Detection Module.
2. IoT-Based Safety & Alert System.
3. Machine Learning Dashboard for Predictive Fatigue Monitoring.
4. 3D-Printed Holding Case for cockpit installation.

Tools & Techniques
- OpenCV, TensorFlow, Keras for real-time fatigue detection.
- Arduino/Raspberry Pi + IoT sensors for biometric monitoring.
- WiFi/Bluetooth modules for wireless data transmission.
- Cloud-based analytics (AWS, Google Cloud, Firebase).
- Machine learning algorithms (CNNs, LSTMs, Random Forest) for fatigue trend predictions.
- 3D printing software (Fusion 360, SolidWorks) and materials (PLA, ABS, Carbon Fiber) for enclosure design.

References

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- https://www.captechu.edu/blog/how-ai-can-improve-aviation-safety
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