11%

89%

Nowlan and Heap, United Airlines study, 1978

11%	**89%**
items showed age-related failure	failed randomly

Intervals alone cannot predict failure

Source: Nowlan, F.S. & Heap, H.F., Reliability-Centered Maintenance, United Airlines for the Office of the Assistant Secretary of Defense, 1978 (AD-A066579), Exhibit 2.13 — United Airlines 1968 dataset. Later Swedish (1973) and U.S. Navy (1982) studies found similar patterns with different splits.

ARTIFICIAL INTELLIGENCE
FOR PREDICTIVE MAINTENANCE & AVIATION SAFETY

FLIGHT SAFETY THROUGH NEXT LEVEL ENGINEERING

OBJECTIVE

To appraise about **Artificial Intelligence** in **Predictive Maintenance** for augmenting **Aviation Safety**

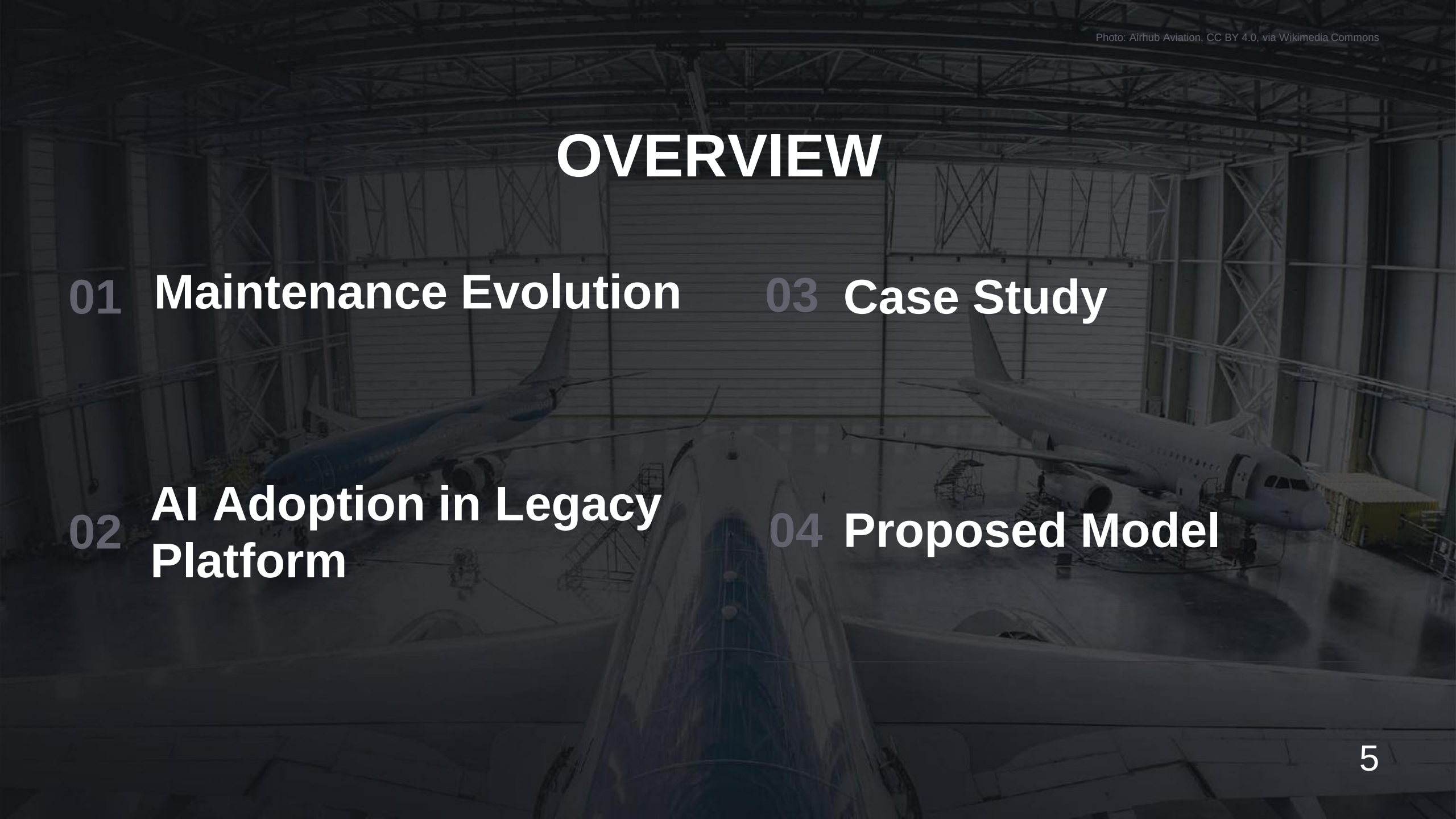


Photo: Airhub Aviation, CC BY 4.0, via Wikimedia Commons

OVERVIEW

01 Maintenance Evolution

02 AI Adoption in Legacy Platform

03 Case Study

04 Proposed Model

FROM LEGACY COCKPITS TO 5th GENERATION



Analogue

Gauges read by a human.
Nothing recorded.

→



Instrumented

Continuous recording.
Terabytes per flight.

MAINTENANCE EVOLUTION



REACTIVE



PREVENTIVE



PREDICTIVE

SAFETY CHAIN IN AVIATION

- Flight-envelope protection
- Runway incursion alerting
- Ground collision aversion
- AI-driven weather analytics
- Hazard analysis and avoidance
- Effective maintenance



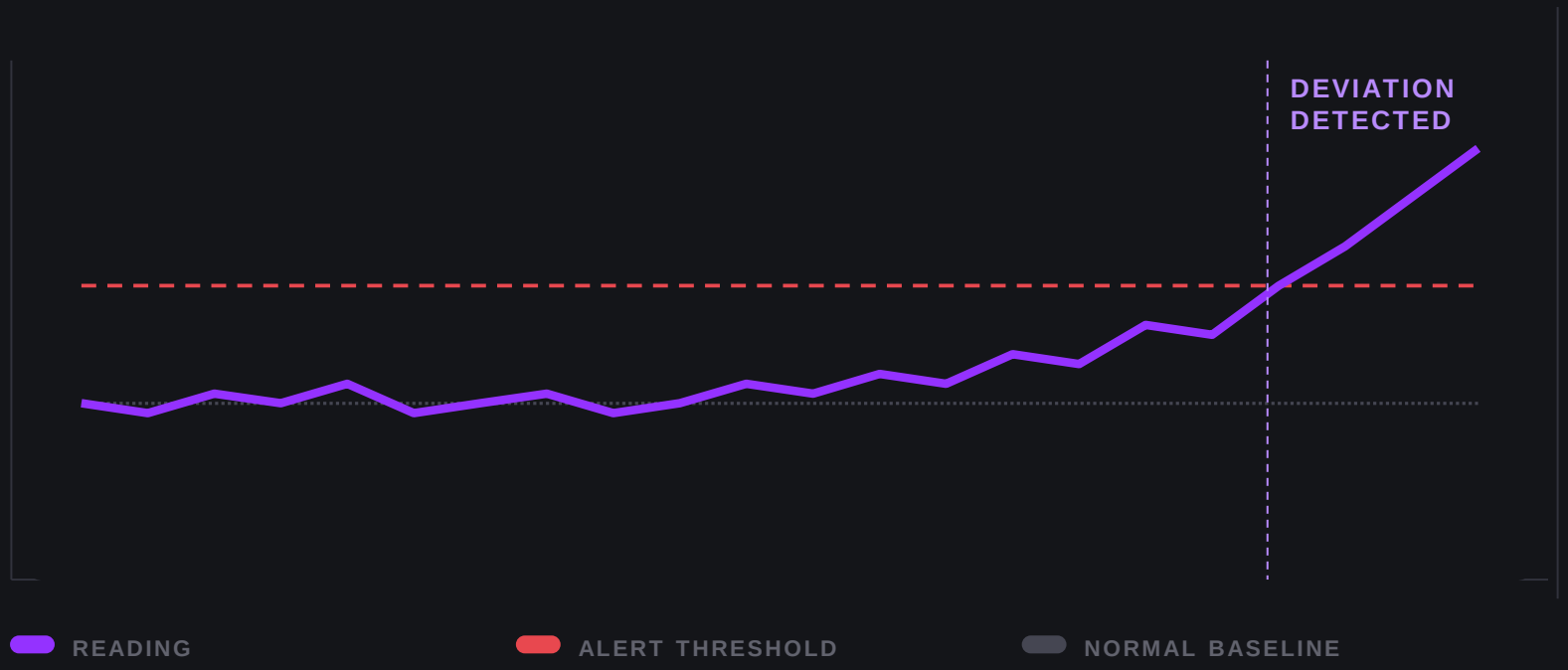
WHY AI?

- TERABYTES of DATA
- ONE ANALYST
- A FLYING SENSOR NETWORK MONITORING

ENGINES	HYDRAULICS	AVIONICS	STRUCTURES	ENVIRONMENTAL SYSTEMS
				


AI TECHNOLOGY FRAMEWORK

MACHINE LEARNING



Continuous monitoring

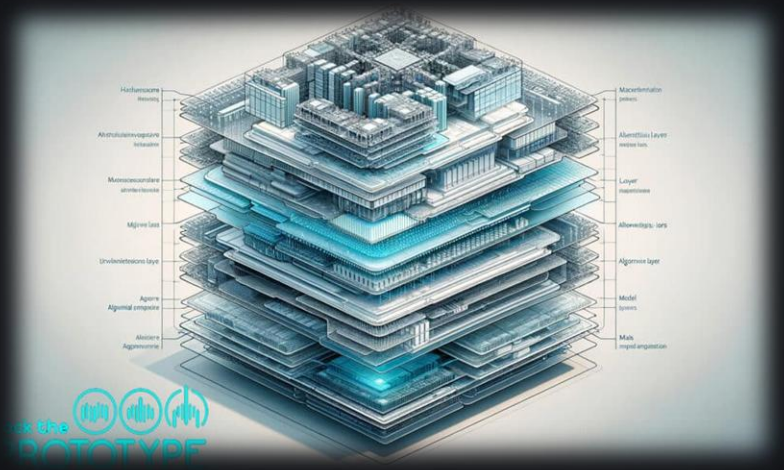
Statistical deviation

Subtle trend shifts

DEEP LEARNING

Vibration signatures

Acoustic emissions



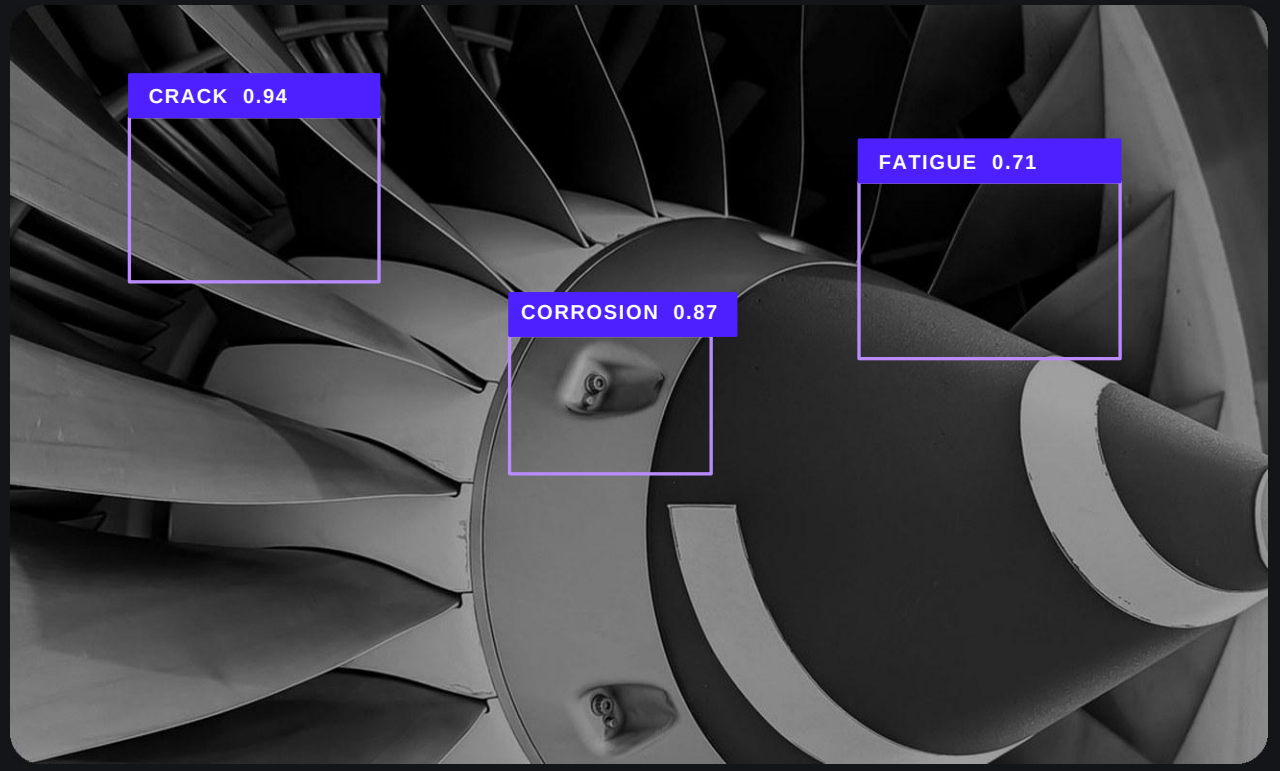
Multi-dimensional sensor streams

Thermal gradients

Detecting Patterns Invisible to Human Eyes

COMPUTER VISION





From Visual Inspection to AI-Powered Defect Detection

NATURAL LANGUAGE PROCESSING



NLP →

- COMPONENT
- FAULT TERM
- PART LINK
- RECURRENCE
- EMERGING PATTERN
- HIDDEN RISK

DIGITAL TWINS

Virtual Replicas for Degradation & Fatigue Modelling



Sensor Data

Flight Cycles

Maintenance History

Wear, Fatigue Crack Propagation

System Degradation

AI TECHNOLOGY FRAMEWORK

- Create singular maintenance and safety framework
- Support the engineer’s decision

LEGACY AIRCRAFT ADOPTION

SQUARDRON



DEPOT



TECHNICIANS



ARCHIVE



RECORD SECTION




Every flight tells a story....



CASE STUDY

REACTIVE
VS
AI DRIVEN PREDICTIVE MAINTENANCE

Hypothetical scenario. Aircraft, figures and AI output are illustrative.

EIGHT WEEKS OF DATA

Date	Aircraft	Flight Hours	Pilot Observation	Vibration(mm/s) (Limit <4)	EGT(°C) (Limit<20)
15 Jan	A-101	1250	Slight vibration	2.1	+5
22 Jan	A-103	1180	Normal	1.8	0
29 Jan	A-101	1275	Normal	2.3	+8
05 Feb	A-102	1320	Slight noise	2.0	+3
12 Feb	A-101	1300	EGT slightly high	2.8	+12
19 Feb	A-103	1210	Normal	1.7	0
26 Feb	A-101	1325	Vibration again	3.4	+18
05 Mar	A-102	1350	Normal	2.1	+2
12 Mar	A-101	1350	**Engine Failed**	—	—

All data is hypothetical and for illustrative purposes only.

REACTIVE MAINTENANCE ANALYSIS

	Without AI
Detection	After Failure
Cost	Full engine overhaul
Aircraft Downtime	Significant
In flight	Emergency

THE HIDDEN PATTERN

Date	Aircraft	Flight Hours	Pilot Observation	Vibration(mm/s) (Limit <4)	EGT(°C) (Limit <20)
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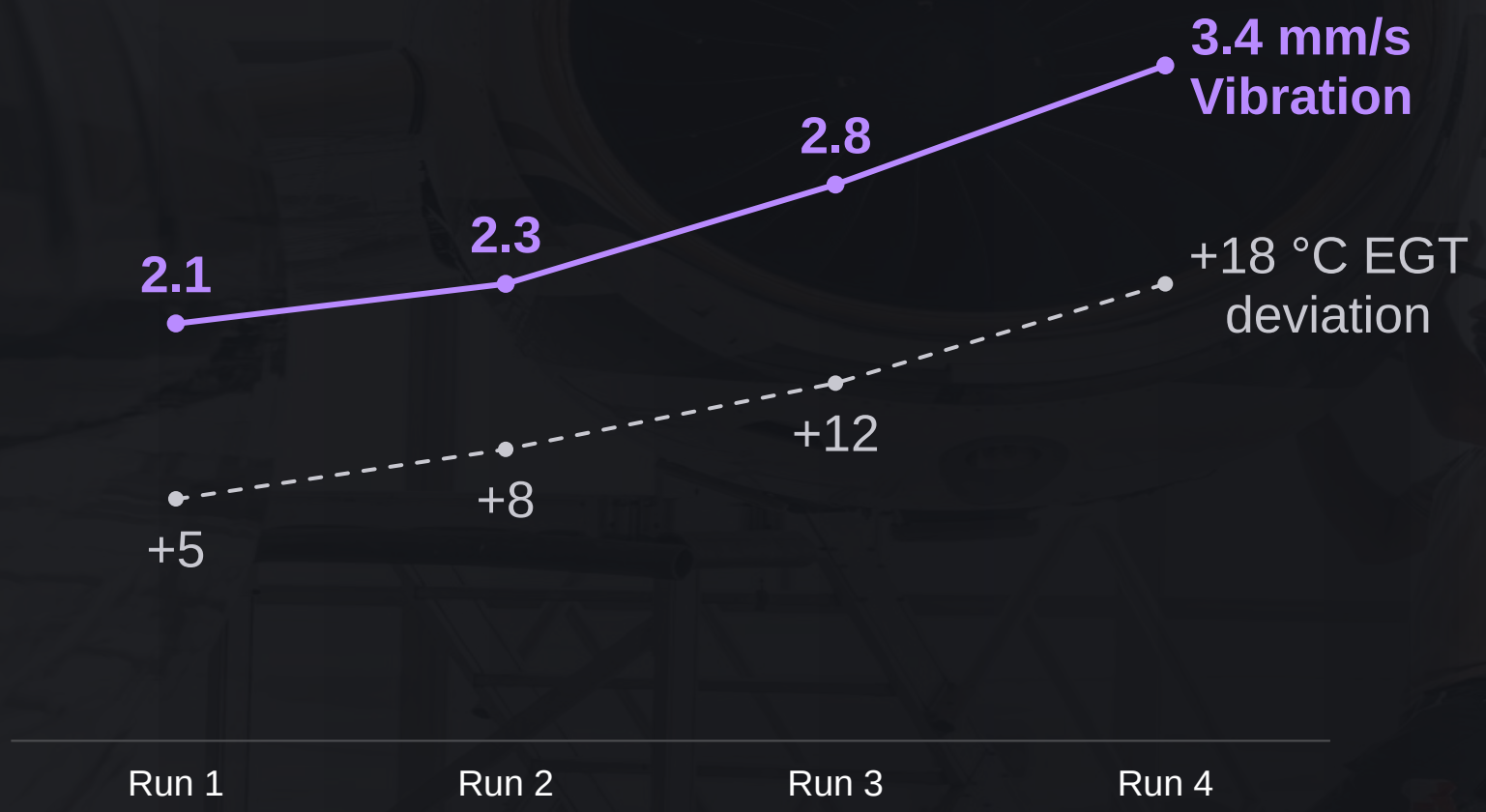
COMPARISON ACROSS THREE AIRCRAFT

Aircraft	Vibration Trend	EGT Trend	Report Frequency	AI Assessment
A-101	**Increasing (2.1 → 3.4)**	**Increasing (+5 → +18)**	**Accelerating**	**High Risk**
A-102	Stable	Stable	Low	Low Risk
A-103	Stable	Stable	None	Normal

The AI sees what individual records cannot show

A-101 OVER FOUR GROUND RUNS

Vibration (mm/s) and EGT deviation (°C)



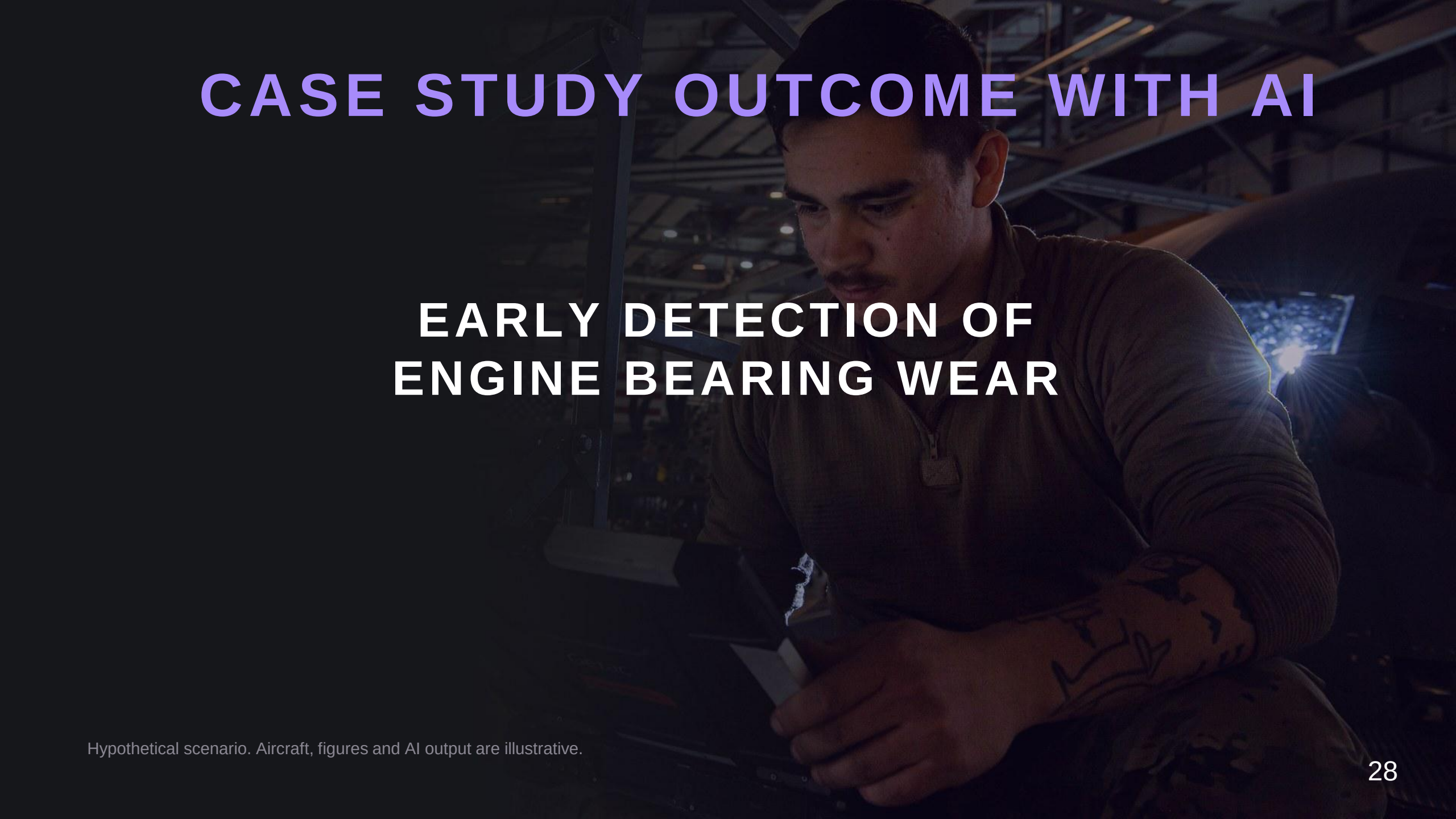
Vibration
2.1 to 3.4 mm/s

EGT deviation
+5 to +18 °C

AI DRIVEN PREDICTIVE MAINTENANCE

	Without AI	**With AI**
Detection	After Failure	**Before Failure**
Cost	Full engine overhaul	**Bearing replacement**
Aircraft Downtime	Significant	**Minimal**
In flight	Emergency	**No event**

CASE STUDY OUTCOME WITH AI



EARLY DETECTION OF ENGINE BEARING WEAR

Hypothetical scenario. Aircraft, figures and AI output are illustrative.

KEY TAKEAWAY

Not a new algorithm

Better use of the data we already hold, With AI in charge



Sources: F-35 Joint Program Office / U.S. DoD releases on the ALIS-to-ODIN transition, 2020–2022; U.S. Naval Air Systems Command contract announcements, 2026.

Insight Accelerator



Source: Boeing Global Services product description. Vendor-published capability description; no independently verified operator performance figures are claimed here.

PREDICTIVE MAINTENANCE IN PRACTICE

DELTA AIR LINES

MAINTENANCE CANCELLATIONS

5,600+ → **55**

2010 2018

>95%



Delta credits its predictive maintenance programme on the **A320** and **A330** fleet

Sources: Delta Air Lines, reliability programme presentation to IATA; Delta TechOps / Airbus Skywise programme reporting, 2018–2019. Figures as reported by the operator.

THE INDUSTRY IS MOVING TO AI IN MAINTENANCE

ADOPTION SIGNALS

12,000 aircraft on Airbus Skywise

83% of airlines use AI in operations

1 in 2 MRO firms plan to invest in AI

AI IN AVIATION MARKET

- **22.6% a year to 2030**
- led by predictive maintenance



Investment is flowing into AI-driven predictive maintenance

Sources: MarketsandMarkets, AI in Aviation Market 2025–2030 (commercial forecast); SITA, Air Transport IT Insights 2025; Airbus, Skywise (April 2026); Oliver Wyman, MRO Survey 2026.



A GROUNDED AIRCRAFT IS THE CONSEQUENCE

WHAT CAN WE CHANGE?

Can AI help legacy fleets recognise developing faults earlier?

SWOT ANALYSIS FOR LEGACY PLATFORM



Strengths

Weaknesses

Opportunities

Threats

ADOPTING AI DRIVEN PREDICTIVE MAINTENANCE

	HELPFUL	HARMFUL
	Strengths	**Weaknesses**
INTERNAL	**S1** – Experienced engineers **S2** – Established safety frameworks **S3** – Value from existing data	**W1** – Fragmented, part-paper records **W2** – Little sensing on older aircraft **W3** – Limited digital infrastructure
	Opportunities	**Threats**
EXTERNAL	**O1** – Developing AI Technology **O2** – Academia and OEM collaboration **O3** – Existing Examples	**T1** – Cyber attack on data or models **T2** – Automation bias, over-trust **T3** – False alarms, missed faults

FROM SWOT TO ACTION

SO

START WITH WHAT WE ALREADY HAVE

Existing maintenance records to prove concept

WO

MAKE THE DATA USEFUL

Digitise records; build skills with partners

ST

KEEP HUMAN IN CONTROL

Model warns, engineers decide

WT

PROOF BEFORE SCALE

False alarms, missed faults

THE PROPOSED MODEL

PROPOSED MODEL

1st Phase **Foundation**	1	Dataset
	2	Model Development
2nd Phase **Pilot Project**	3	Pilot Project
	4	Validate the Model
3rd Phase **Scale-up**	5	Fleet wise Implementation
	6	Institutional Capability

DATA AND MODEL PREPARATION

1ST PHASE · FOUNDATION



Digitize

Paper and digital records

Standardize

Part numbers, engine variants, spares

Connect

Time and events

Model

Set the baselines

Before the model predicts a problem, it must first understand the history

DESIGN A CONTROLLED PILOT PROJECT

2ND PHASE · PILOT PROJECT

EXISTING DATA

One dataset

One fleet or system

+

AI MODEL

Level 1 advisory AI model

+

EVALUATION

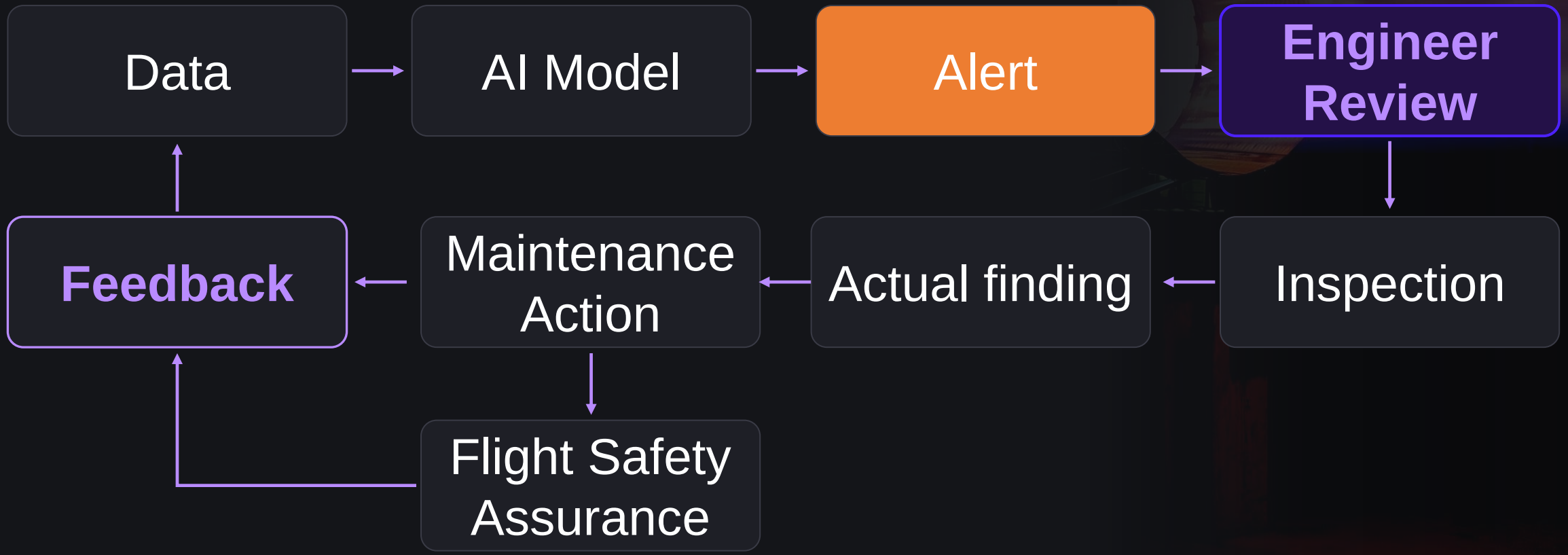
Primary capability evaluation

1st Trial of AI as Advisory Agent

A controlled environment to test the predictive model

PUT THE PREDICTION INTO THE WORKFLOW

2ND PHASE · PILOT PROJECT



FROM ONE PILOT TO A FLEET CAPABILITY

3RD PHASE · SCALE-UP

01
Pilot Project (1-2 Aircraft)

02
Limited Fleet

03
Multiple Fleets

04
Institutional Capability

REGULATORY FRAMEWORK

REGULATORY FRAMEWORK

Regulatory Direction	• FAA AI Roadmap (2024) • EASA AI Roadmap 2.0 (2023)
Rules in progress	EASA RMT.0742: Part-145 drafted
Applies today	Existing airworthiness rules and approved procedures
Authority	AI output is verified. Qualified personnel decide

CHALLENGES

CAN WE TRUST THE PREDICTION?

01 DATA

Is the information good enough?

02 SYSTEM

Can the system perform reliably?

03 HUMAN

Will people trust it appropriately?

04 SECURITY

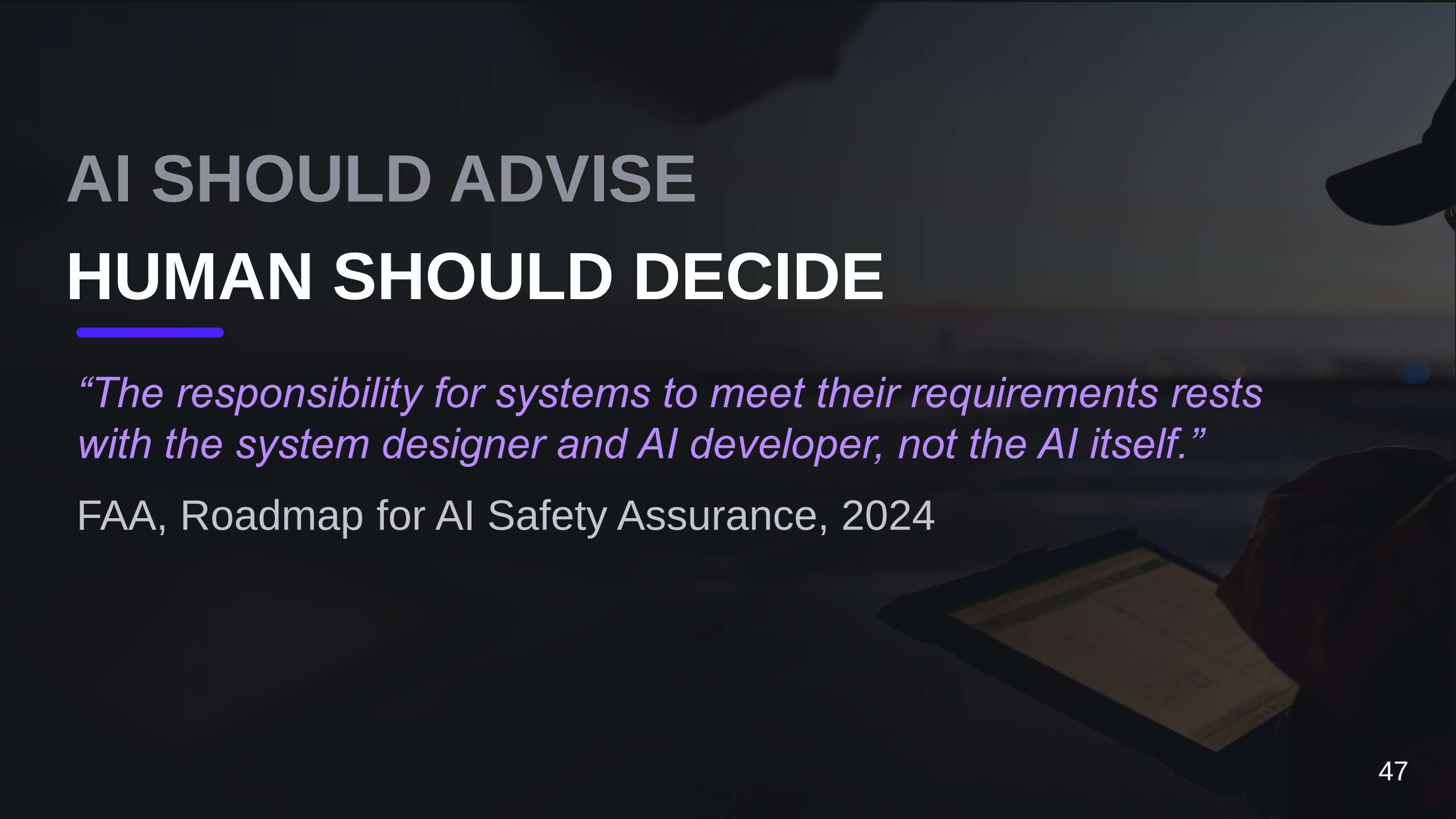
Can the data and model be protected?

05 EVIDENCE

Can we prove the prediction is right?

06 REGULATION

Can it be used within approved framework?



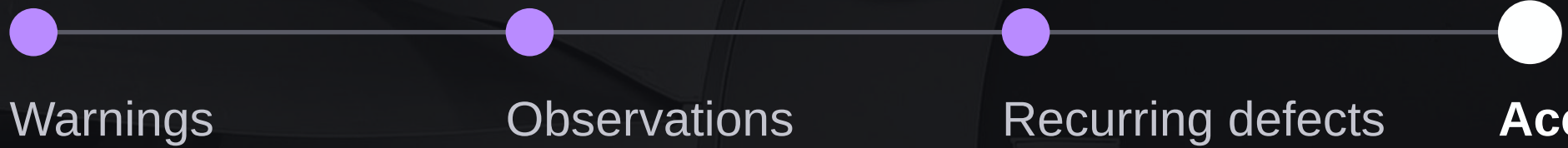
AI SHOULD ADVISE

HUMAN SHOULD DECIDE

“The responsibility for systems to meet their requirements rests with the system designer and AI developer, not the AI itself.”

FAA, Roadmap for AI Safety Assurance, 2024

THE ACCIDENT IS RARELY THE FIRST WARNING



“WHAT COULD WE HAVE PREVENTED IF WE KNEW EARLIER?”


MAINTENANCE TRAINING
MACHINE NUMER: S/N 212793
737
COURSE LEARNINGS
LOCATION ZONE
710
CEC 9313

THANK YOU

REFERENCES

Regulatory

FAA. Roadmap for Artificial Intelligence Safety Assurance, Version I. U.S. Department of Transportation, 2024. faa.gov/media/82891

EASA. Artificial Intelligence Roadmap 1.0, 2020; Roadmap 2.0, 2023. easa.europa.eu/en/domains/research-innovation/ai

EASA. AI Concept Paper Issue 2 — Guidance for Level 1 & 2 Machine Learning Applications, March 2024.

Operator and OEM

Delta Air Lines. Reliability programmes and data analysis — presentation to IATA. (Maintenance-related cancellations and prediction success rate, operator-reported.)

Airbus. Skywise Predictive Maintenance / Delta TechOps programme reporting, 2018–2019.

Boeing Global Services. Insight Accelerator product description.

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Nowlan, F.S. and Heap, H.F. Reliability-Centered Maintenance. United Airlines for the Office of the Assistant Secretary of Defense, 29 Dec 1978. Report AD-A066579. (Source of the 11% / 89% age-reliability finding, UAL 1968 dataset, Exhibit 2.13.)

NASA. Reliability-Centered Maintenance Guide for Facilities and Collateral Equipment, 2008.

F-35 Joint Program Office / U.S. DoD. Releases on the ALIS-to-ODIN transition, 2020–2022.

Commercial Market Forecasts (Tier 3)

Six commercial market-research publications, 2025–2026 editions, reporting 2025 aircraft predictive-maintenance market values between approximately USD 3.9bn and USD 12.3bn. Cited collectively as a range; none independently verifiable.

McKinsey & Company. Estimates of maintenance cost reduction from predictive maintenance (consulting estimate, cited as such).