The Flightpath To Autonomy

Goes Through OPV

IFATCA Geneva 2024-03-22

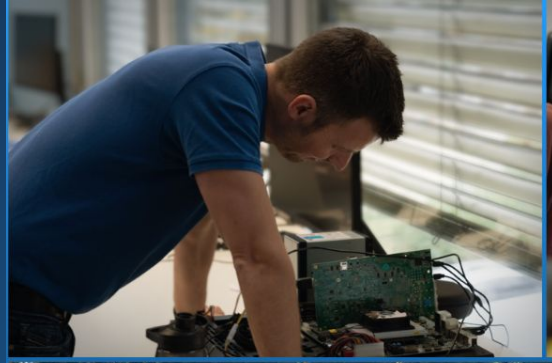
Dr. Luuk van Dijk
CEO & Founder • Daedalean

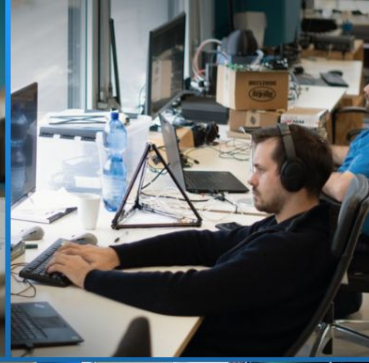
We are Daedalean

150+	18	17
staff	PhDs	pilots

Google
SpaceX
Airbus
Intel
Airbus Helicopters
Pilatus
kopter
Lufthansa Aviation Training
DLR German Aerospace Center
Rolls-Royce
Honeywell
CERN
FLARM
BCG
wingtra

Carnegie Mellon University
Imperial College London
University of Cambridge
University of Oxford
ETH zürich
Stanford University
Universiteit van Amsterdam
TU Delft
RWTH Aachen University
Universidad Politécnica de Madrid








In 2016, we set out to build the world's first fully autonomous flight control system...

...making flying safer, scalable and smarter by replacing and outperforming the human pilot on every measurable dimension

Source: FAA-S-8081-16B

5 **Plan**

Plan the mission, modify the mission — pre-flight and en-route

4 **Decide**

Real-time decisions on board in normal and contingency situations

3 **Communicate**

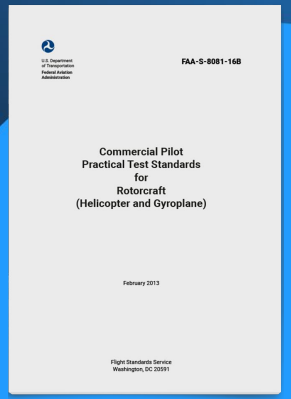
Talk to air traffic controllers; understand other pilots

2 **Navigate**

Find optimal flight path, use existing air spaces, traffic patterns

1 **Aviate**

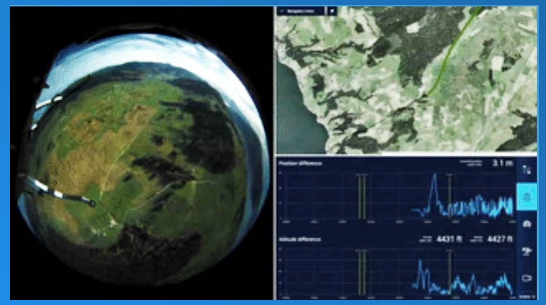
Perception; control; aircraft state monitoring. Always know where to land and avoid obstacles



VXS – Daedalean's Computer Vision suite to assist and to pilot in VMC

Making decisions and judgement calls
that are currently the exclusive domain of the human pilot

Where am I?



Visual Navigation

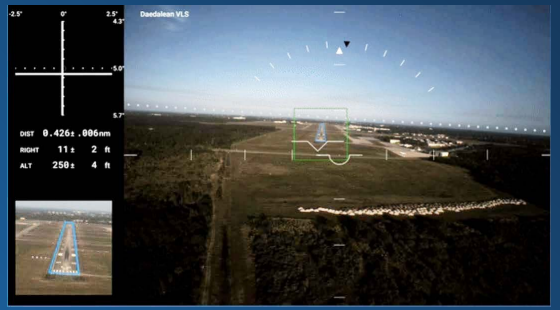
High-precision positioning
in GPS-denied situations

Where can I fly?

Visual Traffic Detection

Detection of cooperative (e.g. planes)
and non-cooperative (e.g. drones,
bird flocks) airborne hazards

Where can I land?

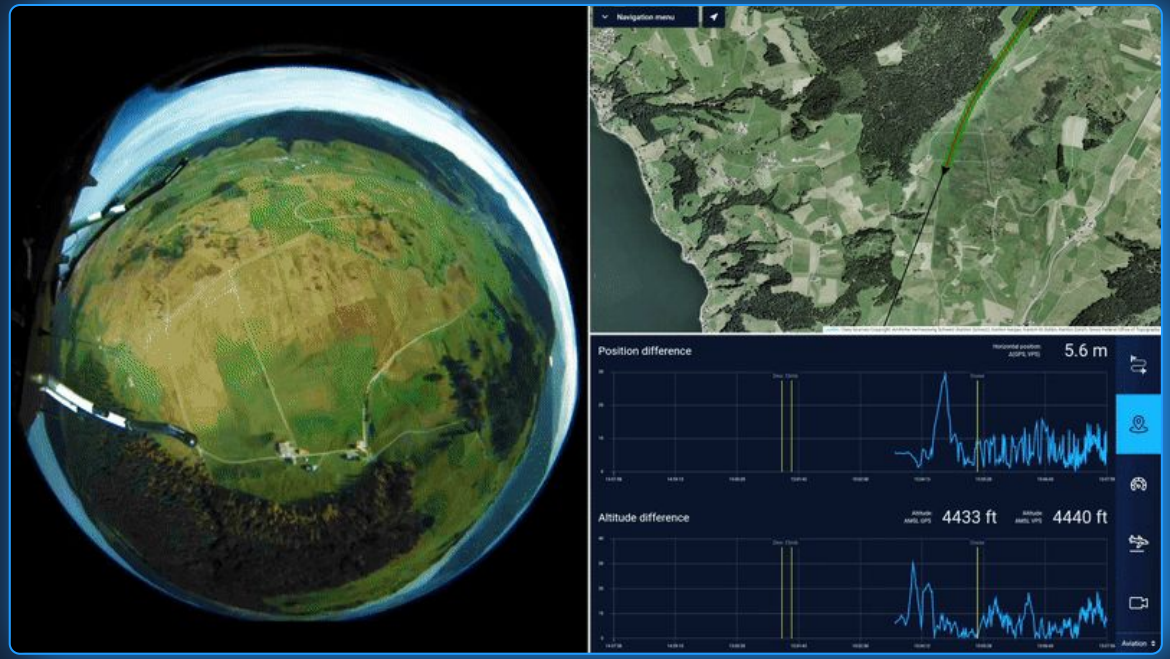


Visual Landing Guidance

Runway and helipad
landing guidance

Visual Positioning

Camera-based navigation and landing guidance



Functions

Continuously outputs position, heading, velocities, height above ground, landing guidance and corresponding uncertainties

Properties

Navigation data on par with high-end INS/GNSS and ILS is designed to integrate with existing INS-/GNSS-based navigation systems while being dissimilar

Safety certification level

DAL-C+

Visual Traffic Detection

Noticing all fixed wing, rotorcraft and drones in time

Functions

- Detects and tracks traffic
- Classifies traffic
- Identifies size, position, direction of movement, time to collision

Properties

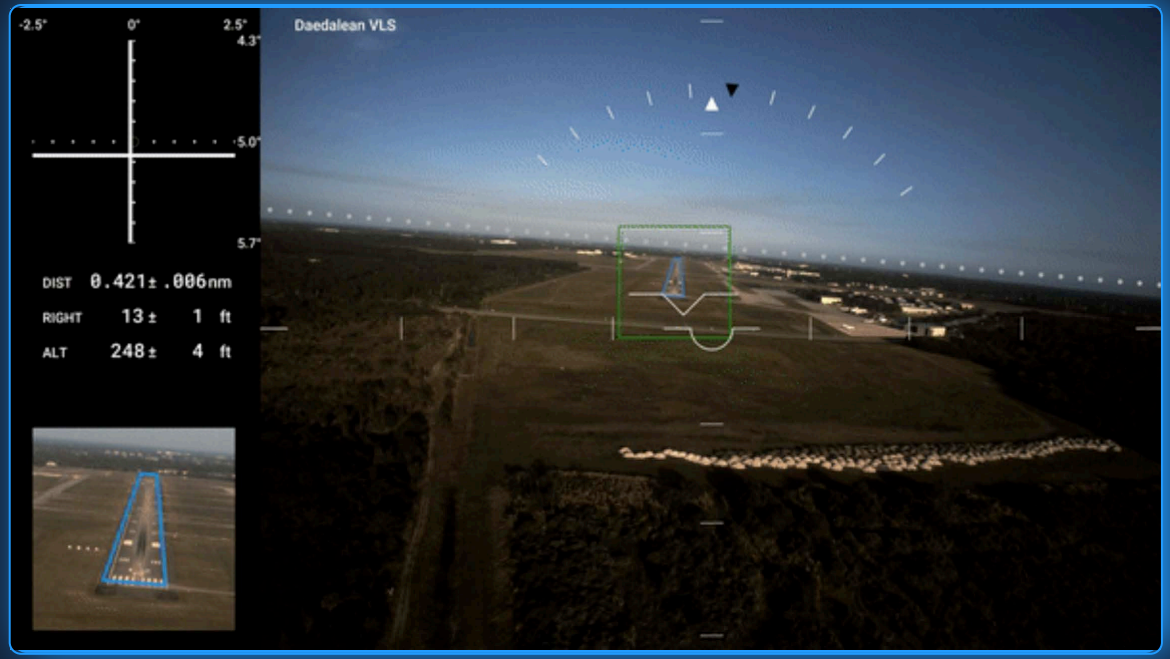
- Better accuracy than human pilots
- Detection range up to 3.5 km
- Up to 10 Hz
- Integration with existing flight deck instruments as a pilot-aid

Safety certification level

DAL-C+

Visual Landing Guidance

Onboard GNSS-independent landing guidance for VTOL and fixed-wing aircraft



Functions

- Lists runways, helipads or landing markers in view
- Provides guidance on final approach to touchdown to the selected runway, helipad or landing marker

Properties

- Continuous real-time tracking of ownship position relative to the runway, helipad or landing marker
- No equivalent instrument exists

Safety certification level

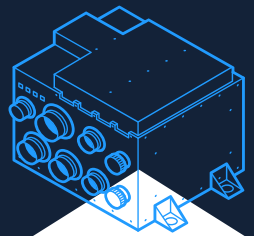
DAL-C+ target

Underlying ~~magic~~ technology

Certifiable in-house machine-learned algorithms (neural networks)

System level

Cameras



Aerospace-grade computing hardware

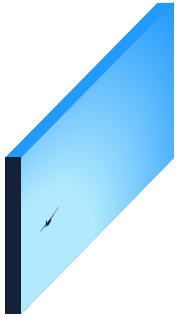
Updated path plan

for the pilot or for the FCC

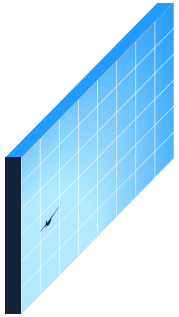
Control

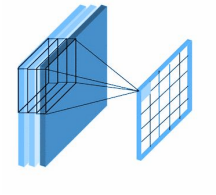
Software level

Camera

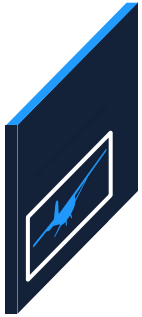


Preprocessing

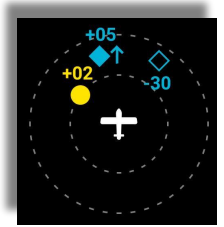




Certifiable Convolutional Neural Network



Post-processing



Certification

- DAL-C certification of Traffic Detection the first vision-based ML application
- Required creating new methodology for showing fitness for purpose and absence of unintended function

We are here
2024-03

1. A concept for Learning Assurance proposed, used by EASA in their “First usable guidance for Level 1 AI/ML application“
2. STC application for Traffic Detection
3. FAA issues Issue Paper, EASA issues a Certification Review Item
4. A specific application gets certified, referencing ML policy as means of compliance

Paving the way to certify the use of AI in safety-critical avionics

EASA and Daedalean' joint reports: [CodaNN 2020](), [CodaNN 2021]() introduce the W-shaped Learning Assurance process for validation of deep neural networks in safety-critical applications.

[The FAA and Daedalean joint report]() evaluates how the W-process fits the FAA's future certification policy.

> "System engineering has its V — now machine learning has its W

Graham Warwick
Managing Editor,
Technology with Aviation Week,
aka The Worocle

Stages Toward Autonomy

	Level 1 Assistance	Level 2 Partial automation	Level 3 Highly automated	Level 4 Fully automated	Level 5 Autonomous
Pilot role	Full responsibility	Full responsibility	Remote / onboard pilot responsible for decision making and execution	Remote pilot supervises AI decisions	Full responsibility
Levels of Aviation Autonomy Collins Aerospace	Aviate Navigate Communicate Command Manage systems System / Human	System			
Classification of AI applications EASA	Level 1 AI: assistance to human 1A: Human augmentation	1B: Human cognitive assistance in decision and action selection	Level 2 AI: human/machine collaboration 2: Human and AI-based system collaboration	Level 3 AI: more autonomous machine 3A: AI-based system performs decisions and actions, overridable by the human	3B: AI-based system performs non-overridable decisions and actions
Technical roadmap DAEDALEAN	Situational Intelligence™ Sensing and semantic understanding Assistance in situational awareness	Assistance in forecasting risks and offering mitigation	Risk management Full guidance	Actuation Self-separation of aircraft in the air	Full autonomy
Aviation certification level	DAL-C			DAL-B to DAL-A	
Interface	To crew (Human-Machine interface)			Directly to aircraft	

Find more at: ieeexplore.ieee.org/document/8569280

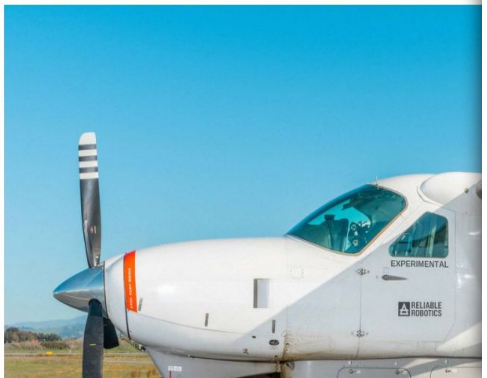
Source: easa.europe.eu/ai

Automate or autonom-ate?

This Startup Wants to Fill the Skies With Cargo-Filled Robot Planes

● Reliable Robotics has been flying Cessnas through a mixture of autonomy and remote control. FedEx, for one, is a believer.

By Ashlee Vance +Get Alerts



Autonomous aviation startup Xwing hits $400M valuation after latest funding round

Aria Alamalhodaei @breadfrom / 6:00 PM GMT+2 • April 15, 2021

Comment

The safety pilot has his hands off the controls during an Xwing demonstration flight. ***Image Credits:*** *Xwing*

Xwing has scored another win two months after it completed its first gate-to-gate autonomous demonstration flight of a commercial cargo aircraft. The company said Thu
it has raised $40 million at a post-money valuation of $400 million.

The company is setting its sights on expansion — not only tripling its engineering team,
eventually running regular fully unmanned commercial cargo flights.

THE VERGE TECH REVIEWS SCIENCE CREATORS ENTERTAINMENT VIDEO MORE

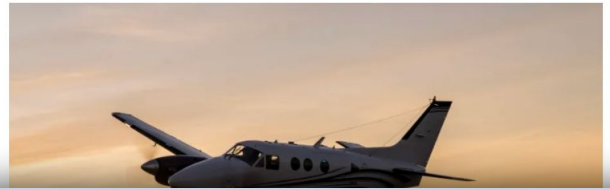
TECH TRANSPORTATION AVIATION

Merlin Labs wants to fill the sky with pilotless planes carrying cargo and passengers

Autonomous flight startup announces $25 million funding round

By Andrew J. Hawkins | @andyjayhawk | May 26, 2021, 12:00pm EDT

SHARE



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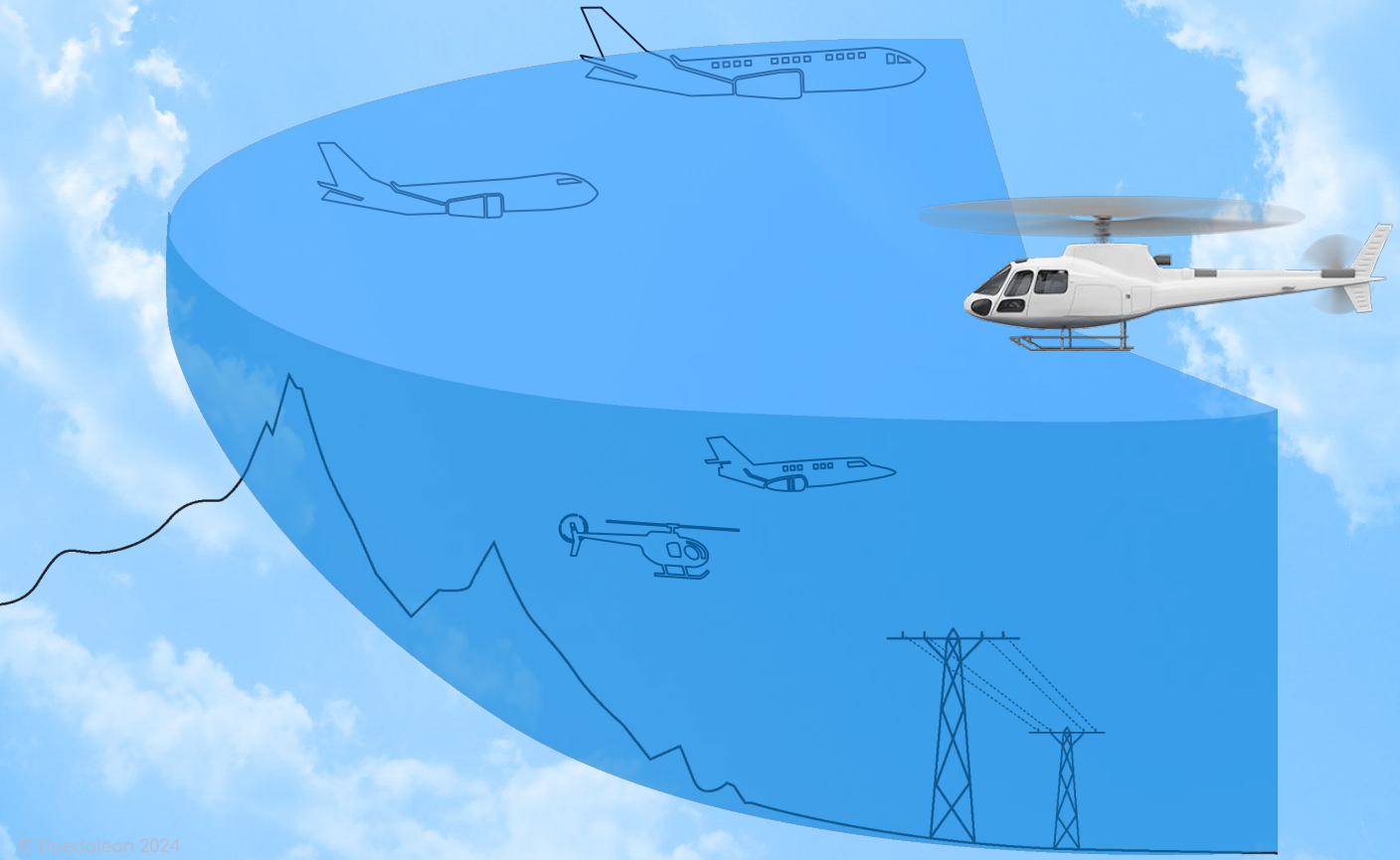
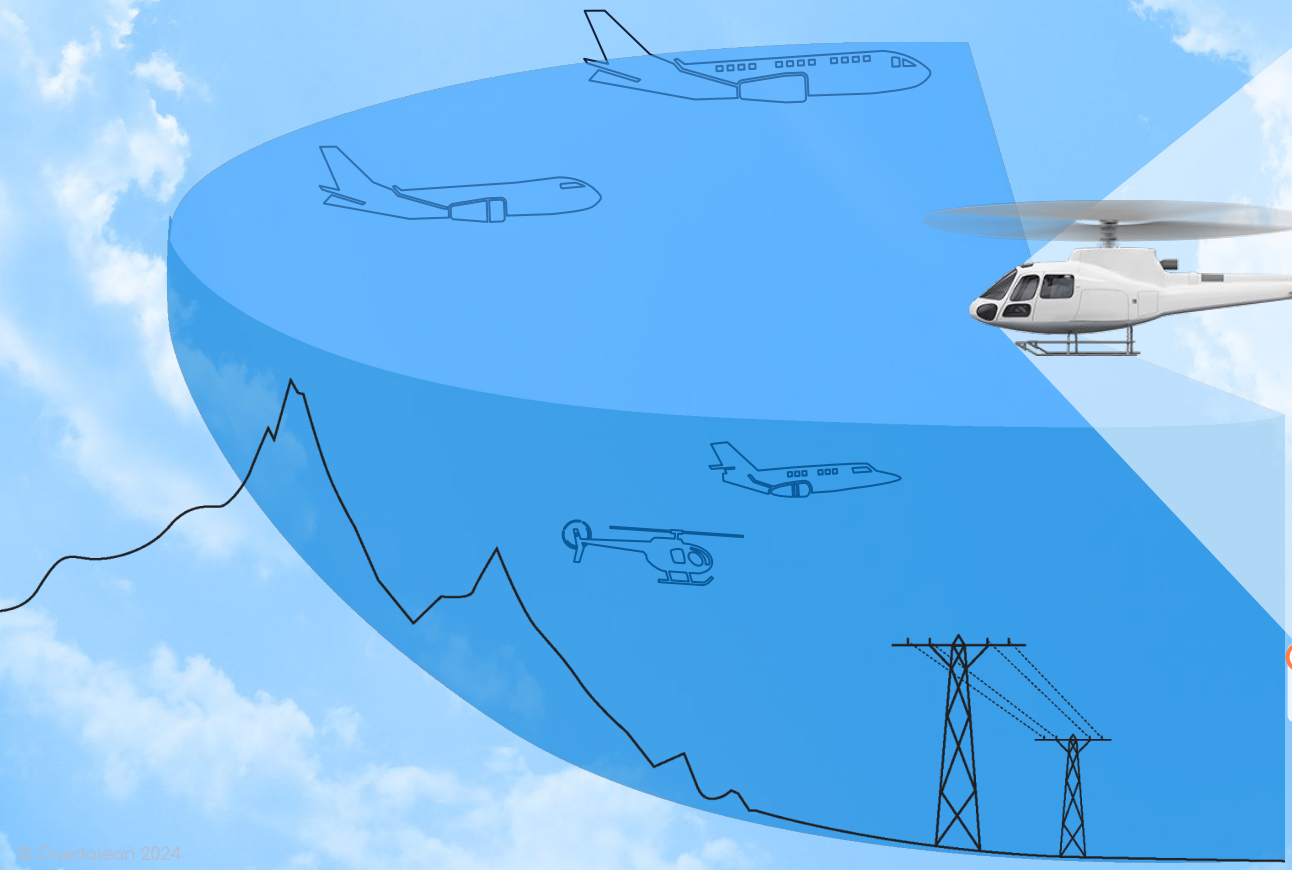
Autonomous flight technology for unmanned aircraft.

Our software integrates sensors and maps with onboard flight control systems to allow regional aircraft to navigate, take off and land safer than ever before.

What it is that a human pilot actually does?



What should a computer do?



Gathering and fusioning information from all possible sources

Semantic Understanding

Risk Management

Hazard Avoidance Safe Guidance

Actuation

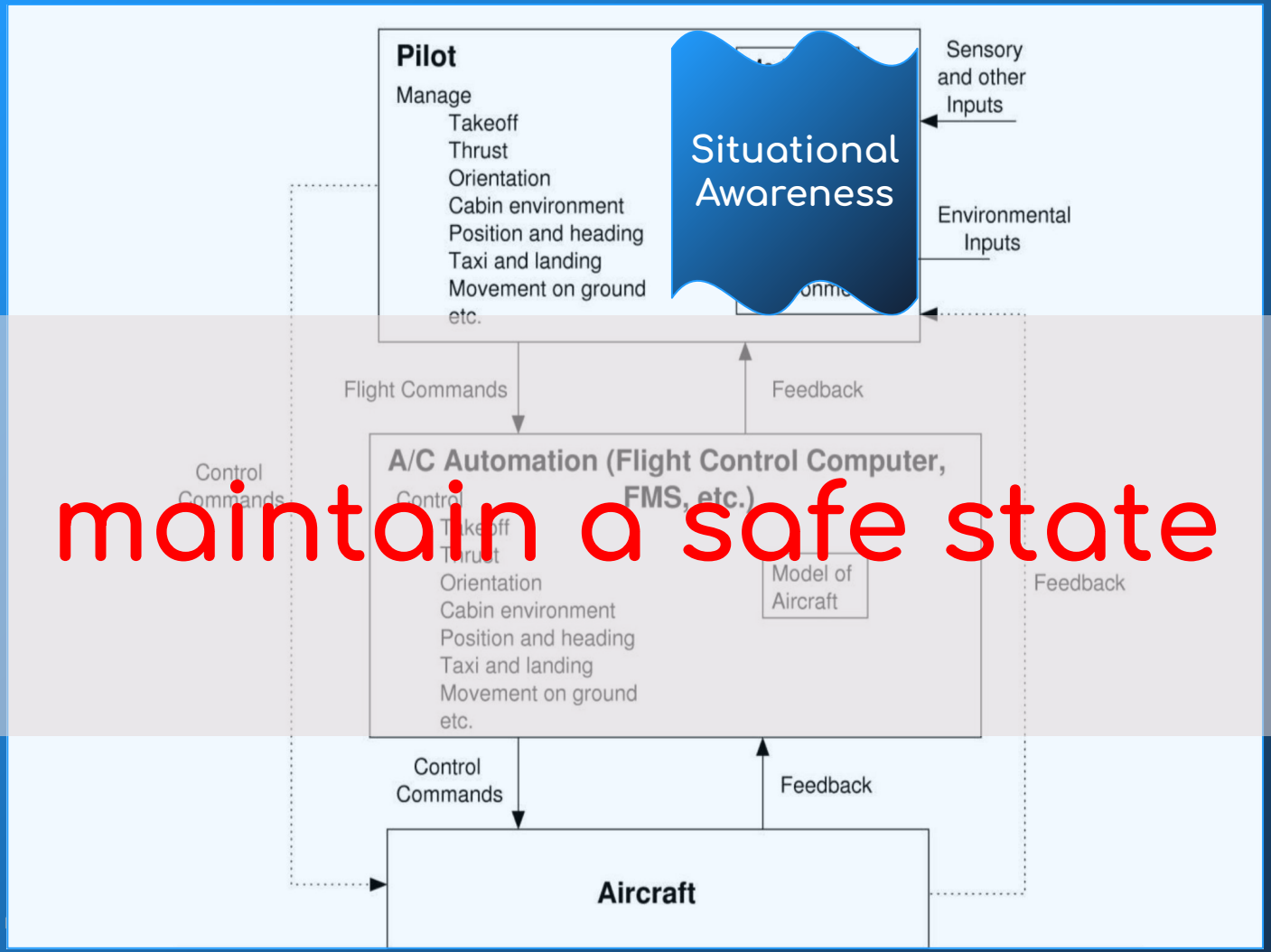
Key capabilities at key phases of flight

1. Detect and avoid hazards (on ground and airborne)
2. Emergency landing guidance to a safe site (known and unknown)
3. Detect and avoid airborne hazards (also non-cooperative)
4. Weather awareness
5. Position and navigate (also in GNSS-denied environment)
6. Precision landing on pre-marked site
7. Safe landing on unmarked site

Take-off and initial climb

Cruise

Final approach and landing

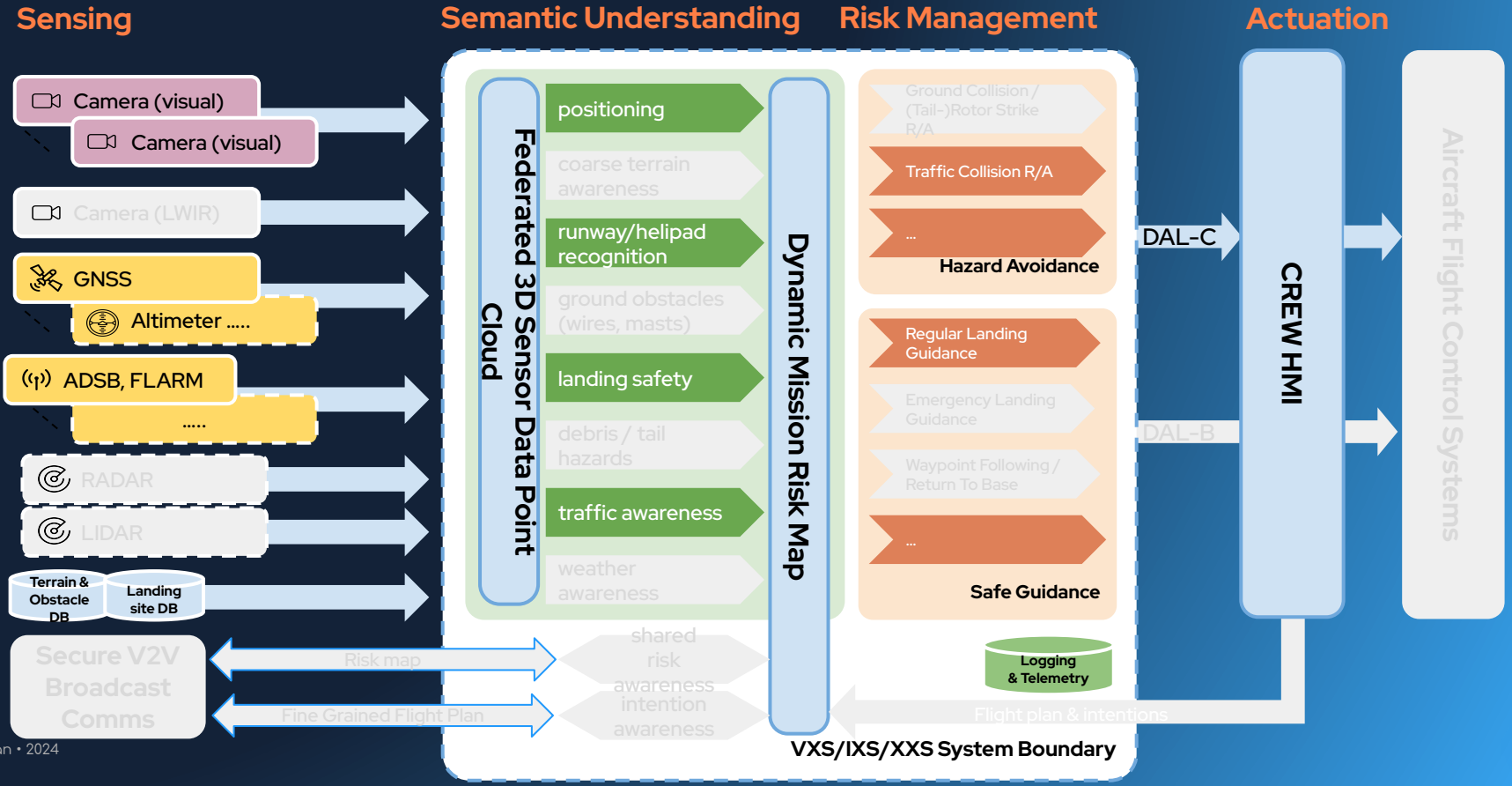


maintain a safe state

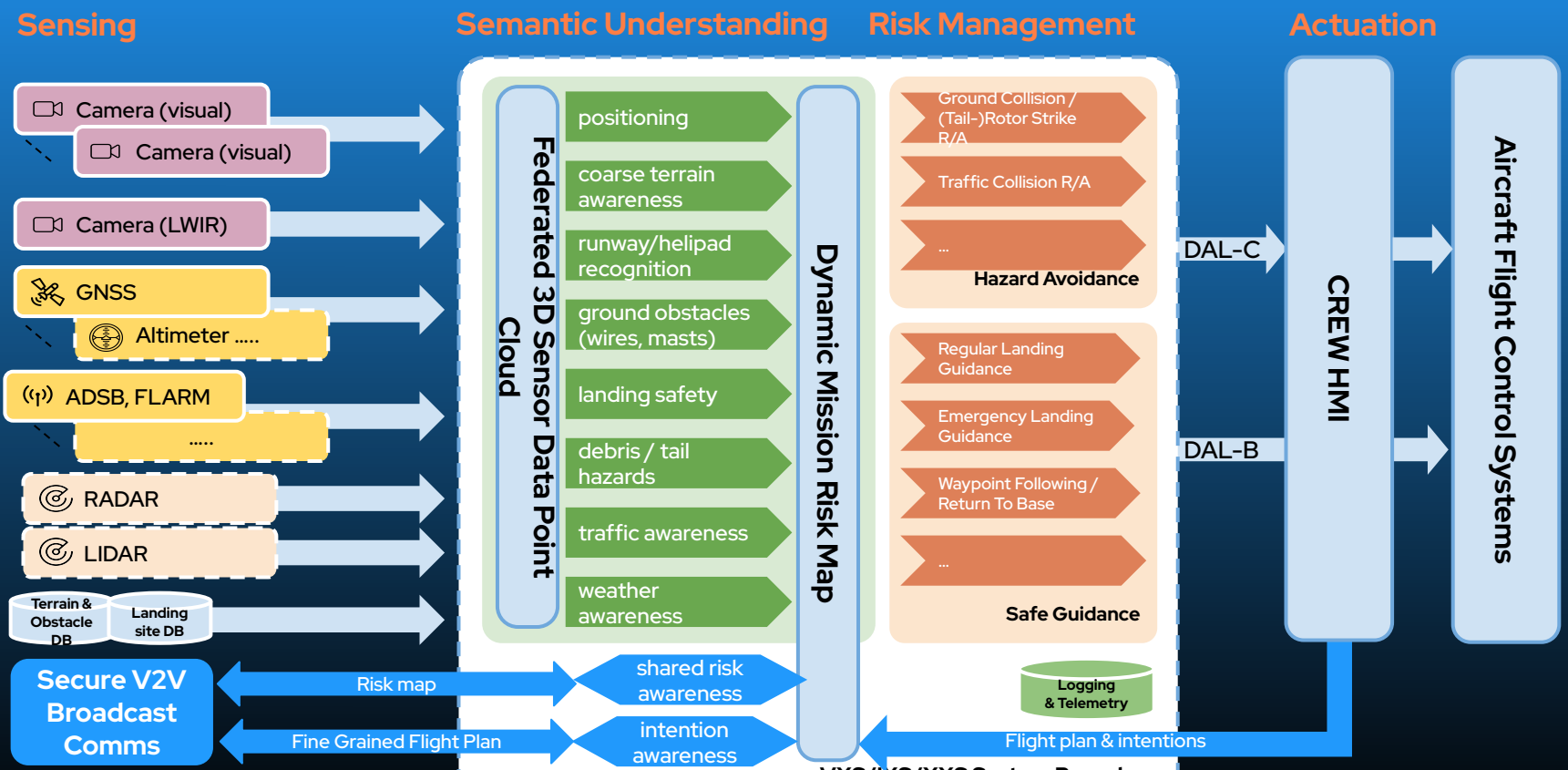
A Systems-Theoretic Approach to Safety in Software-Intensive Systems.

Nancy G. Leveson

Daedalean Situational Awareness Today



Daedalean Situational Awareness Tomorrow



Every single pilot gets a copilot

- Create the aircraft that doesn't kill anyone if you take your hands off the controls
- Make pilot interface with the flight plan, not with the aircraft
- Guiding HMI principle: reduce information overload, don't add to it

PILOTEYE

AILUMINA
VISTA