Queen Mary University of London

20 October 2026

Simulation and Training in Aerospace – Who Flies, Who Decides?

Andy Fawkes

External Lecturer

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How Many Aircraft are Made Each Year?

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Aircraft Production in 2019

Crewed Aircraft	
Airliners (Airbus & Boeing)	1,243
Business jets	809
Turboprops	525
Piston aircraft	1,324
Helicopters	819
Military (Estimate)	1,200
Total	**≈ 6,000**

Uncrewed Aircraft	
Military drones, world spend	≈ $7bn
MQ-9 Reaper, built in total	≈ 400
Reaper cost each	≈ $34m
Civil drones registered in USA	> 1m
Share made by DJI	77%

Sources: GAMA; Airbus; Boeing; Lockheed Martin; Teal Group (military drones); FAA via The Drive (drone register); Drone Industry Insights (DJI share). Military aircraft total is an estimate.

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Aircraft Production Now

Crewed Aircraft (2025)	
Airliners (Airbus & Boeing)	1,393
Business jets	854
Turboprops	594
Piston aircraft	1,782
Helicopters	938
Military (Estimate)	1,500
Total	**≈ 7,000**

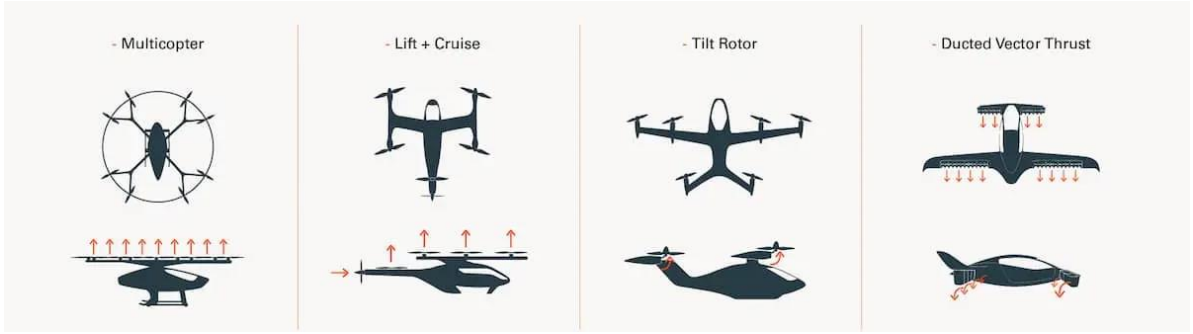
Uncrewed Aircraft	
Ukraine, 2024	≈ 1.7 million
Ukraine, 2026	≈ 10 million
Ukraine, planned	20 million
Russia, FPV planned 2026	> 7 million
FPV drone cost	Few $100's

Sources: GAMA; Forecast International; Lockheed Martin; Aerospace Global News; Interfax-Ukraine; Ukrinform; Kyiv Post. Military aircraft total is an estimate. Russian figure is a Ukrainian estimate.

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Aircraft Production Diversity

	Civil	Military
Crewed	Airbus A350 (Europe) · COMAC C919 (China) · Embraer E2 (Brazil) · Joby eVTOL (US, piloted)	F-35 (US) · J-20 (China) · Su-35 (Russia) · Rafale (France)
Uncrewed	DJI camera drone (China) · Zipline delivery drone (US, used in Africa) · DJI Agras crop sprayer (China) · EHang EH216 (China, pilotless passenger)	FPV drone (Ukraine) · Shahed/Geran (Iran, Russia) · Bayraktar TB2 (Turkey) · MQ-28 Ghost Bat (Australia)



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The Presenter

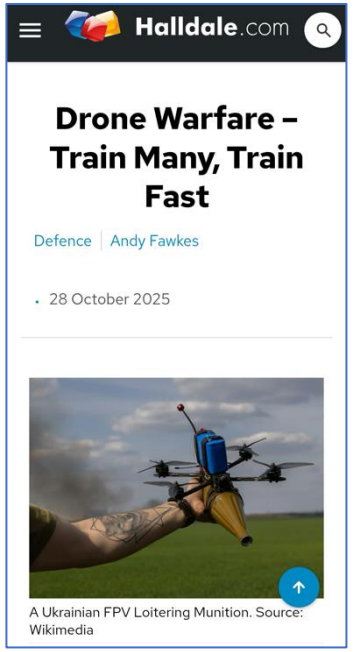
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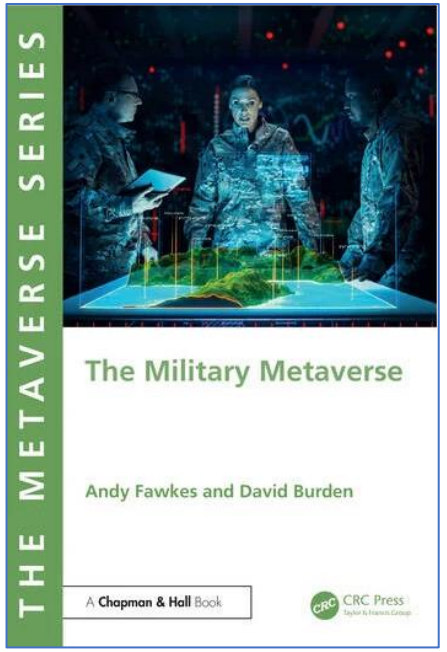
Previously

Ministry of Defence

Bohemia Interactive SIMULATIONS

Now



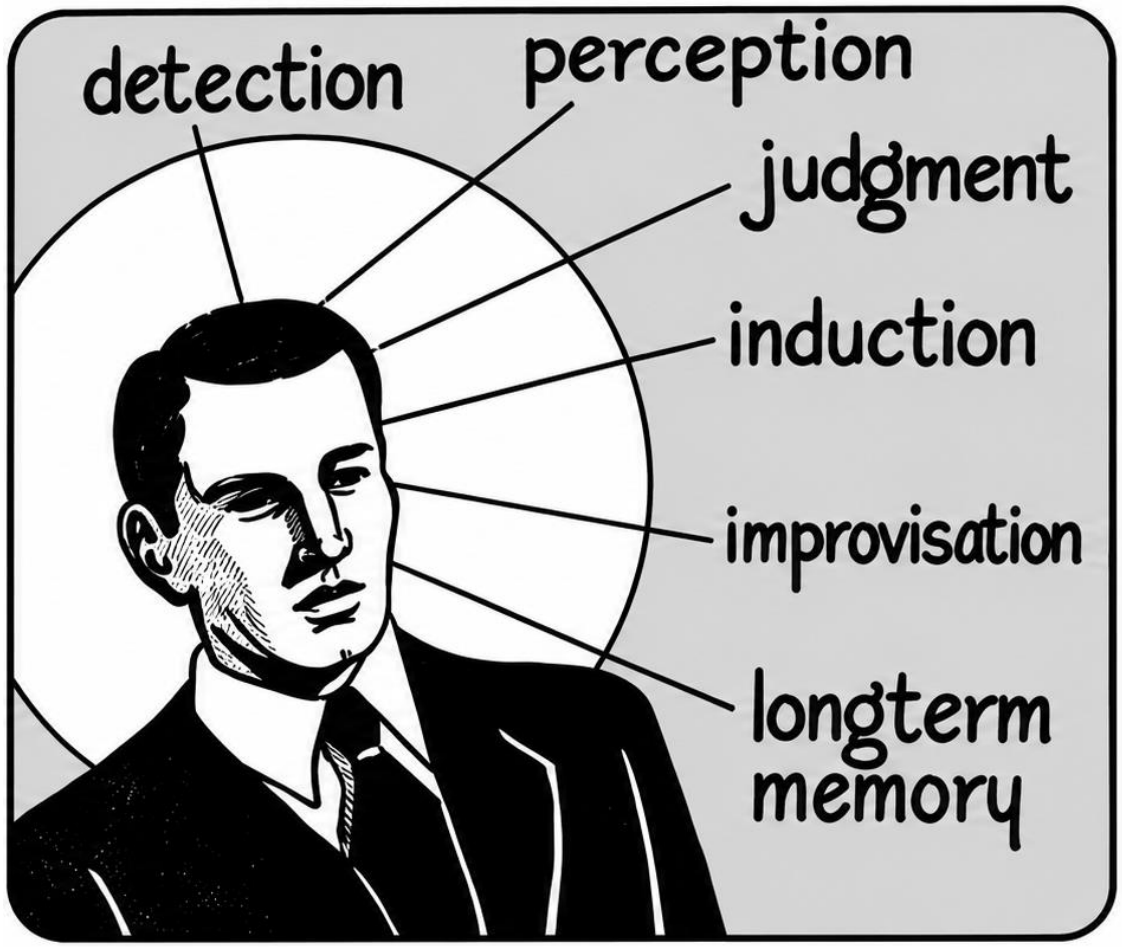


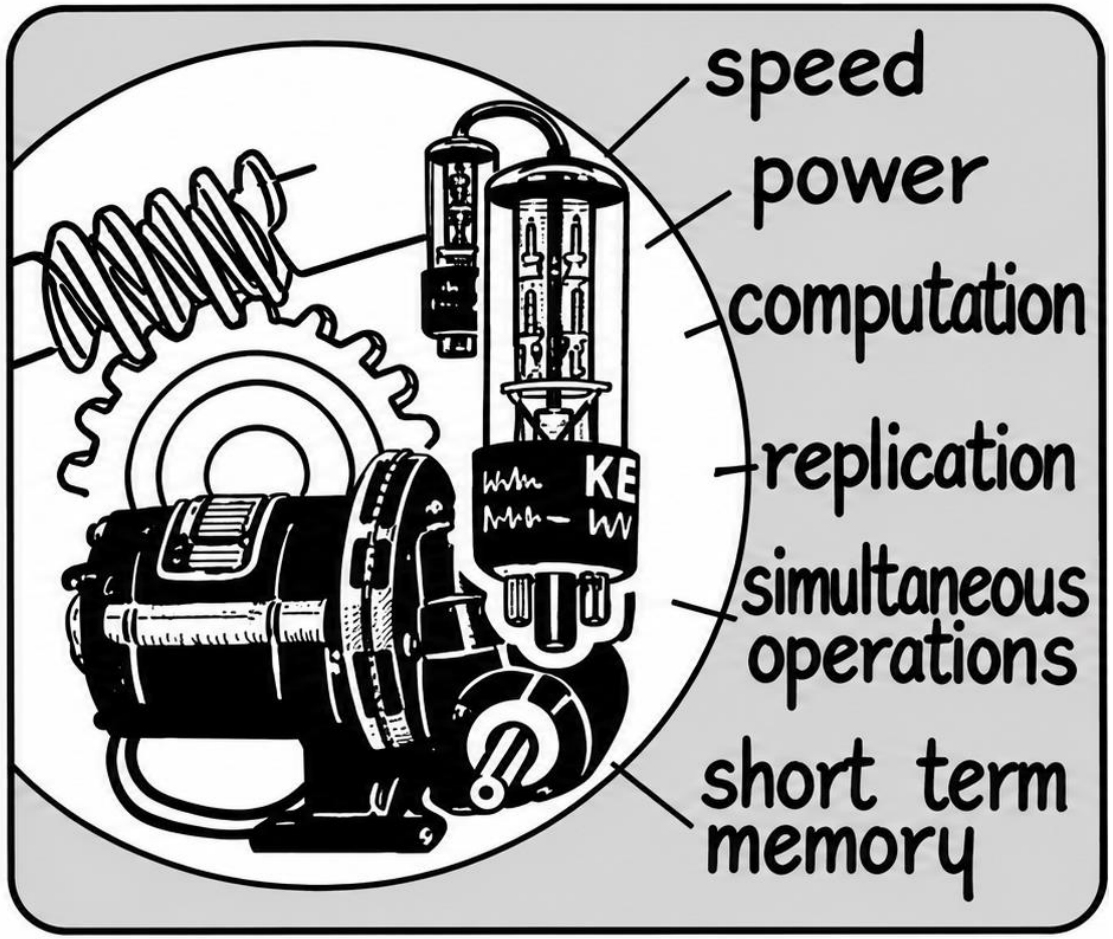
ROYAL AERONAUTICAL SOCIETY

Institution of MECHANICAL ENGINEERS
Improving the world through engineering

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What should humans do, and what should machines do? (1951)





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Pilots of the Future?



- What will they do?
- Who will they be?
- Where will they be?
- How will they train?
- Will we need them?

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Barriers to Entry for Innovation are Lowering



https://www.youtube.com/watch?v=Ndftcft6XhU



www.youtube.com/watch?v=KwRSAfoW5uo

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Outline

1. Aircraft/Machines
2. Flight Simulation
3. People
4. Careers

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1 of 4

Machines

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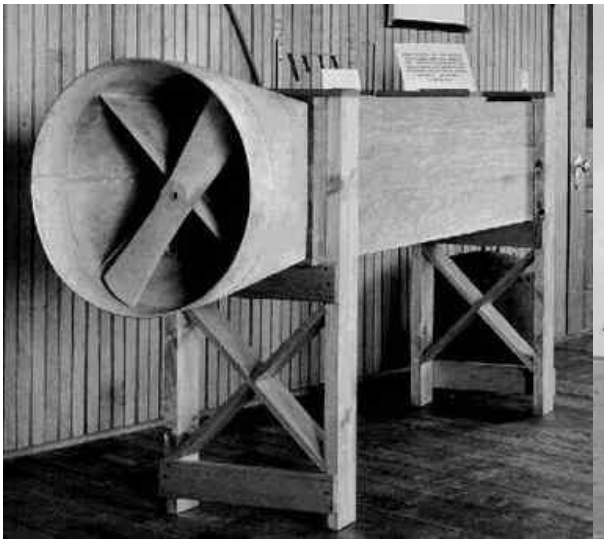
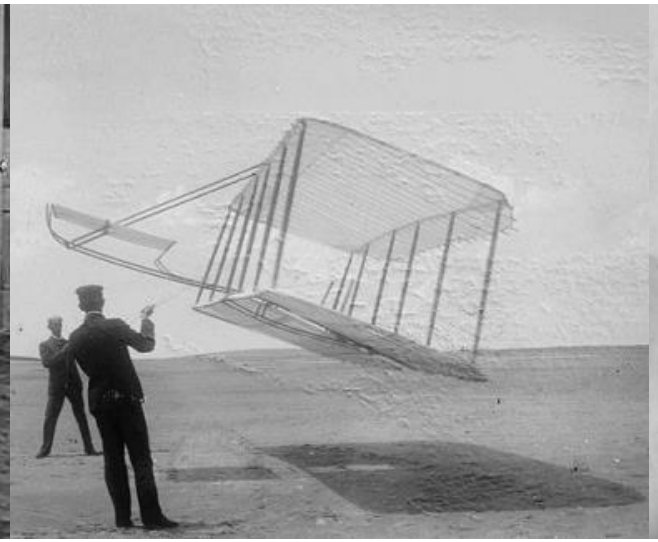
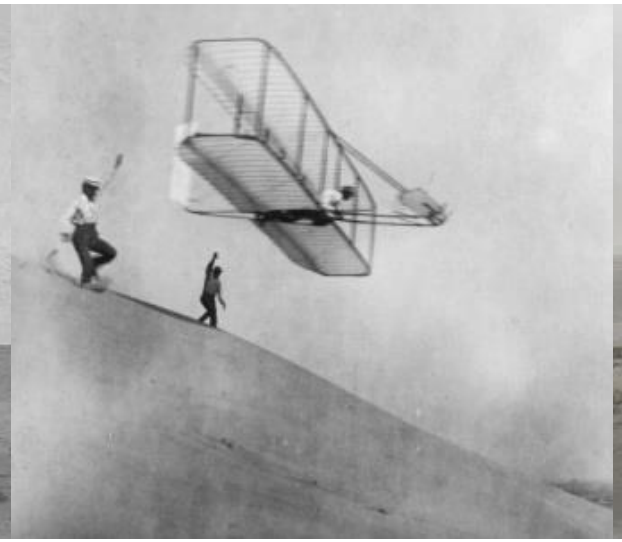
Humans & Flight - 1903



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1903 – Wright Brothers

- Test
- Train
- Fly


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eVTOL

Joby
2026



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New Uses



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New Factories

Ukraine
"General Cherry"
company



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AI



- Choosing targets
- Hitting targets
- Lowering the skill needed

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Swarms



- Human Remote control
- Cameras
- + $3,500 MESH Modem Relays forming a chain
- + AI for some targeting

www.rferl.org/a/russia-ukraine-jet-powered-drones-shahed-geran/33841747.html



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Who Owns the Technology Future?

- Military & Aerospace?
- Commerce & Entertainment?

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Opportunity and Challenge

Opportunity	Challenge
New kinds of aircraft: e.g. eVTOL, delivery, inspection	Rules, airspace and public trust must catch up
Capability at low cost: a $50 autonomy module can make a novice drone operator many times more effective	The same cheap technology is available to anyone
Development in weeks and months, not decades	Testing. Training and safety evidence must keep pace

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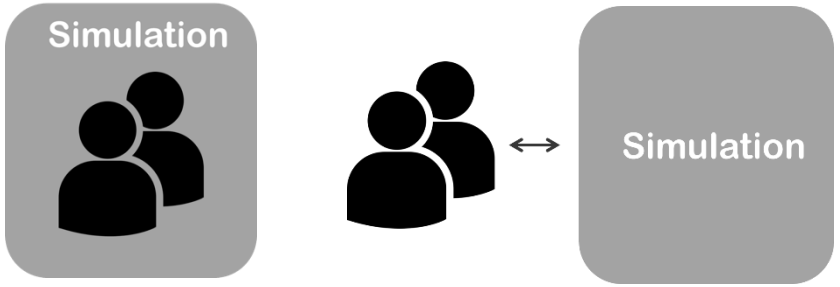
2 of 4

Flight Simulation

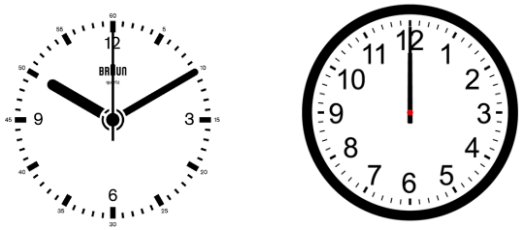
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What is a Simulation?

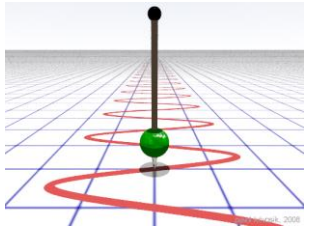
- Humans Inside or Outside



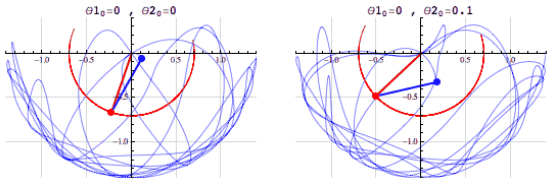
- Runs in Real or Non-Real Time



- Some Systems have Order



- Some Systems are Chaotic



- Some are Random



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Human(s) Outside the Simulation



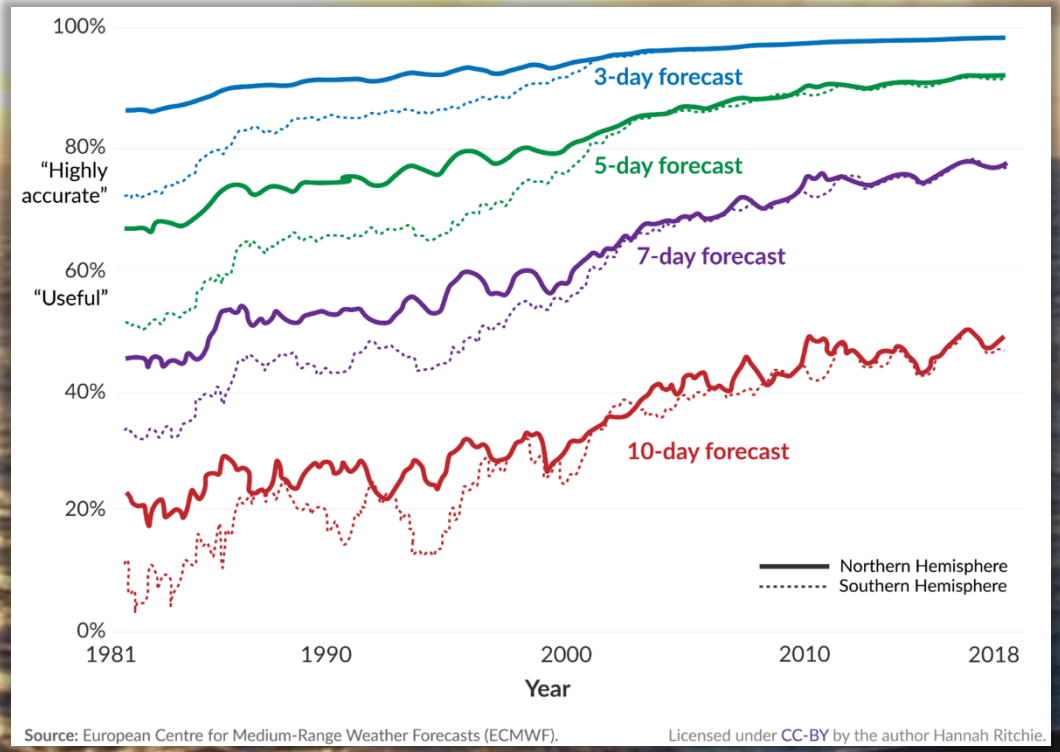


Simulation

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"Met Office's 4-day forecast is as accurate as its 1-day forecast was 30 years ago"

Met Office (15 Nov 2023)



Source: European Centre for Medium-Range Weather Forecasts (ECMWF).

Licensed under CC-BY by the author Hannah Ritchie.

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Human(s) Inside the Simulation



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Flight Simulator

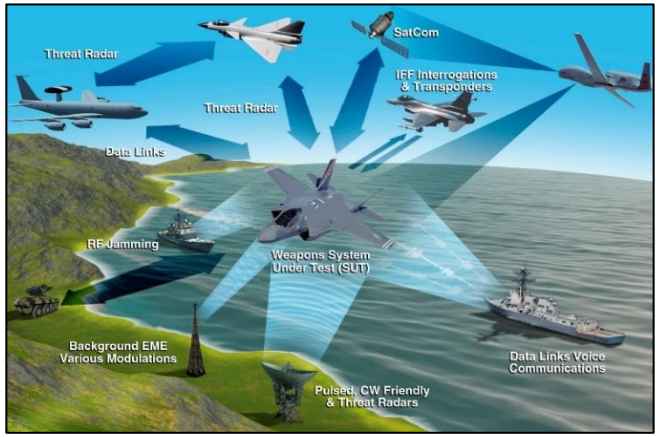


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Why Flight Simulation?













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Simulation Past and Present

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1910s

Leon Levavasseur’s Antoinette Barrel – France 1910

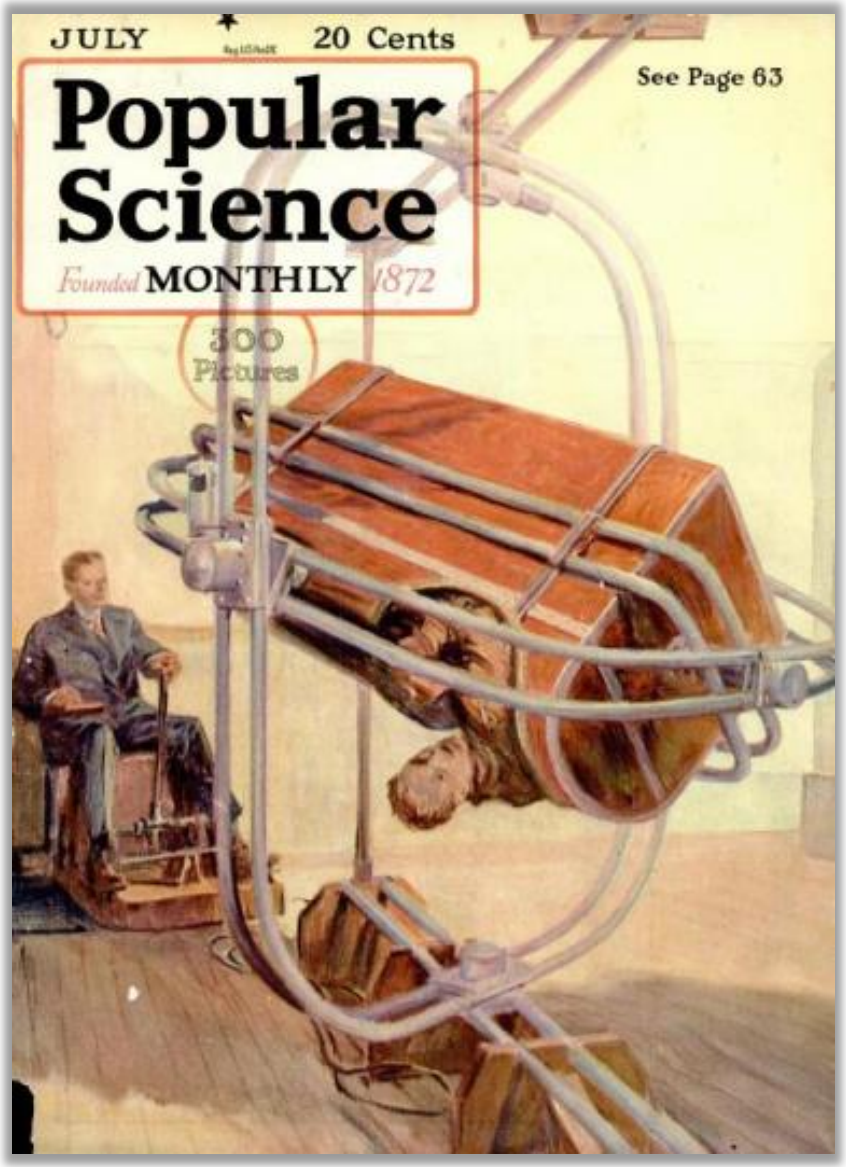




Wikipedia

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Popular Science – July 1919



Ruggles Orientator

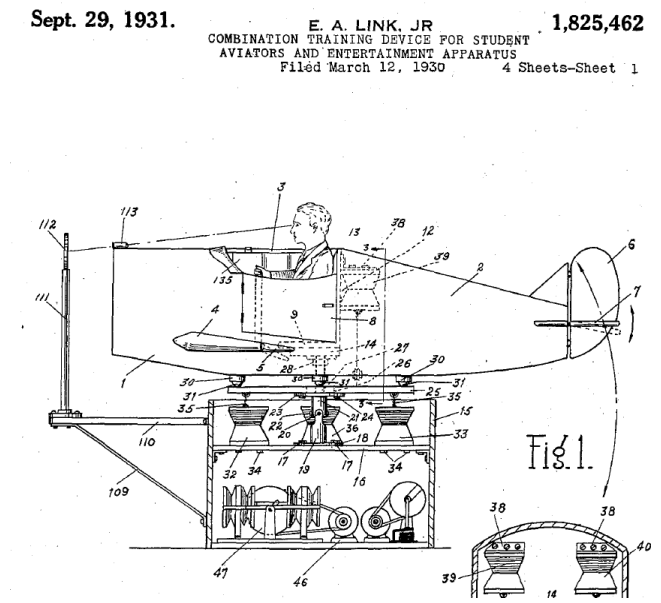
“90% of the flying casualties during the war were caused not by bullets, or badly built machines, but by "the failure of the man”

Maj.-Gen. George W. Squier

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1920s/30s – Edwin A Link

- Trainer based on Automatic Piano technology
- 1931 Patent “Combination Training Device for Student Aviators and entertainment Apparatus”


Sept. 29, 1931. E. A. LINK, JR 1,825,462
COMBINATION TRAINING DEVICE FOR STUDENT AVIATORS AND ENTERTAINMENT APPARATUS
Filed March 12, 1930 4 Sheets-Sheet 1
Fig. 1.

- The Link Trainer came into widespread use during WWII
- 10,000 trainers used to improve safety and shorten training time for over 500,000 pilots



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WW2 Link Trainer



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Queen Bee Drone – 1930s/40s



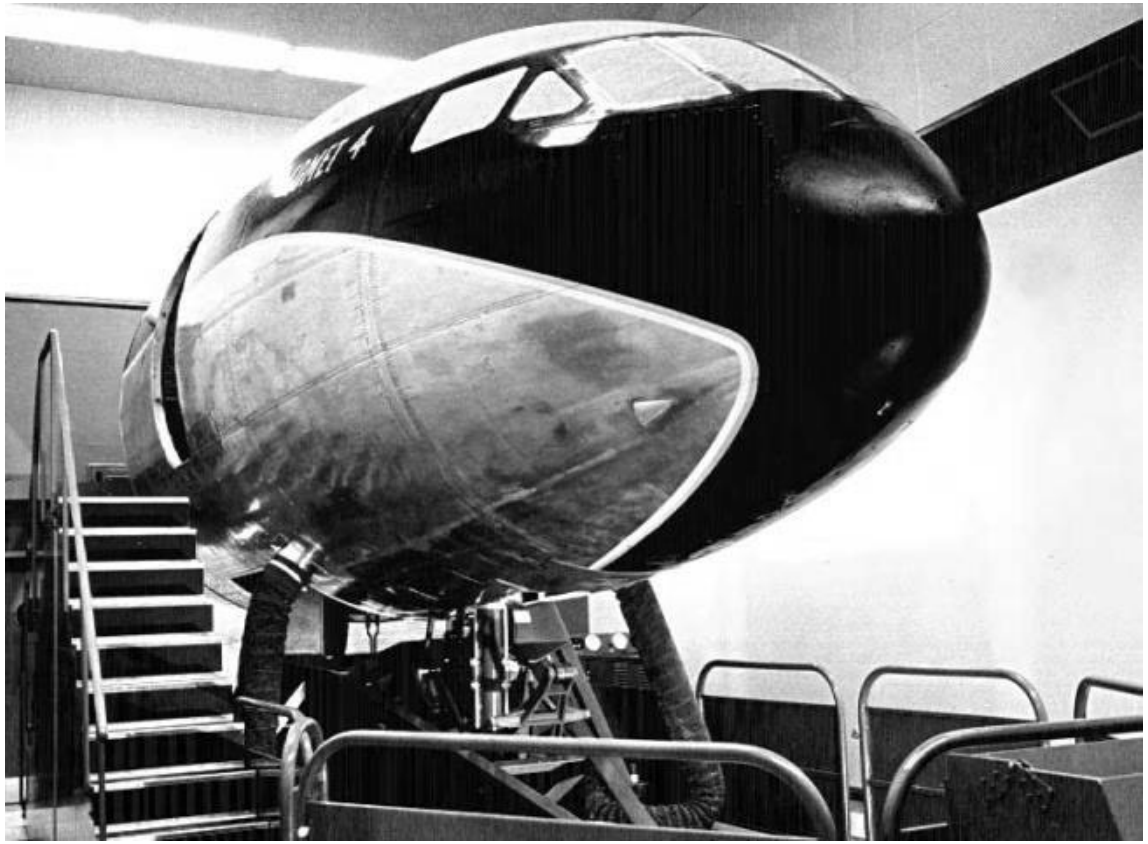




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1950s

- Analogue to Digital Computing
- More complete Aircraft Data
- Motion Simulators



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Spacewar!

1962

- Generally considered the first Shooter game
- The basic PDP-1 model cost US$120,000 ($1.25m in 2024)





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SR-71 Blackbird

Fred Forehand, Singer-Link's SR-71 PM:

"They created the mission upstairs, and the tape they produced for the simulator was the same tape used onboard in the aircraft computer."







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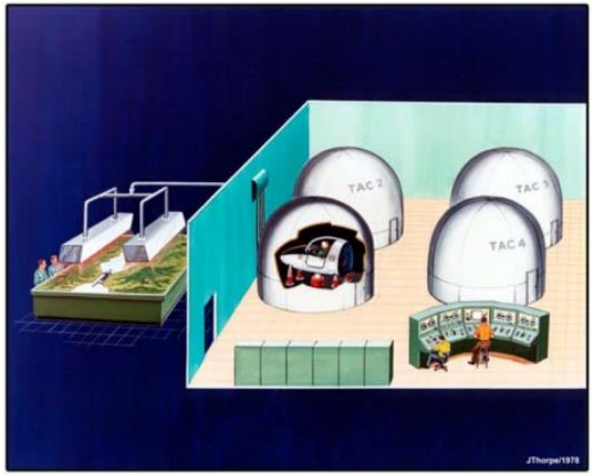
USAF Capt Jack Thorpe's White Paper (1978)



1
Enemy aggression detected by overhead sensor



2
Planning a response using the holographic electronic sand table



3
Air crews rehearse the plan and planners assess suitability



4
Mission execution with real time observation

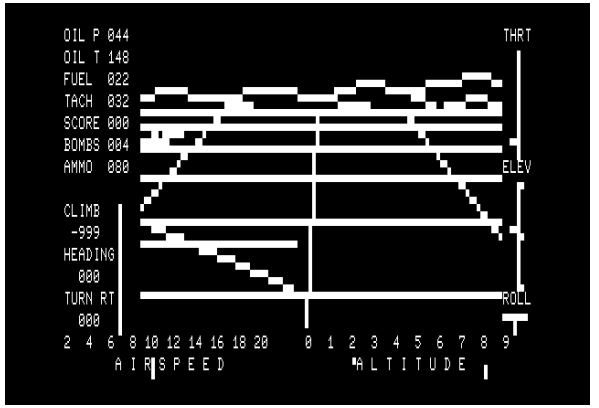
Ref. I/ITSEC 2010 "Trends in Modelling, Simulation and Gaming: Personal observations about the past 30 years and speculating about the next 10" Jack Thorpe PhD

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(Microsoft) Flight Simulator



subLOGIC Flight Simulator 1 for Apple II, 1979 (sold Jan 80)



subLOGIC Flight Simulator 1 for TRS-80, 1980





Microsoft Flight Simulator 1.00, 1982

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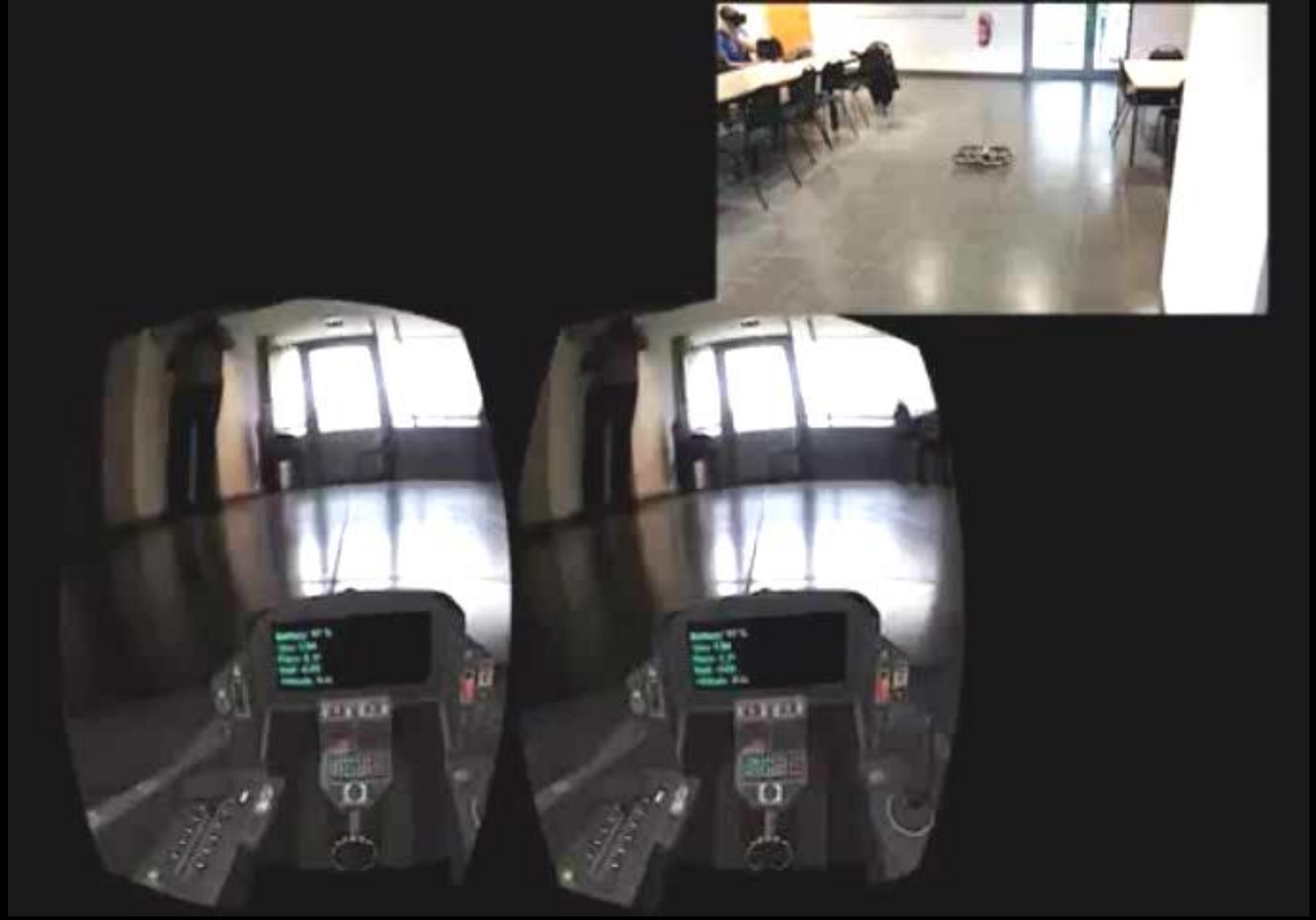
1970s/80s Flight Simulation

BBC Open University “Million Pound Man” (1980)

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Rift Drone (2014)

AR.Drone 2.0
Oculus Rift
Unity
Xbox 360 Controller
Open-Source Software
https://github.com/daraosn/oculus-drone



https://youtu.be/3WmQ1_8ytaM?si=nsmukHRH8lEMll33

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Simulation Now – Land, Sea, Air, Anywhere









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Unreal Games Engine Software in CAE Flight Simulator (now)





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Consumer Flight Simulation Now



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There's Still Crewed Aircraft Out There!

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Full Flight Simulator (FFS)

- Supports conversion to a new aircraft type
- Airline flight crews typically train two days every six months
- CAE alone delivered 61 FFS in its 2025 financial year
- About 1,800 civil FFS worldwide

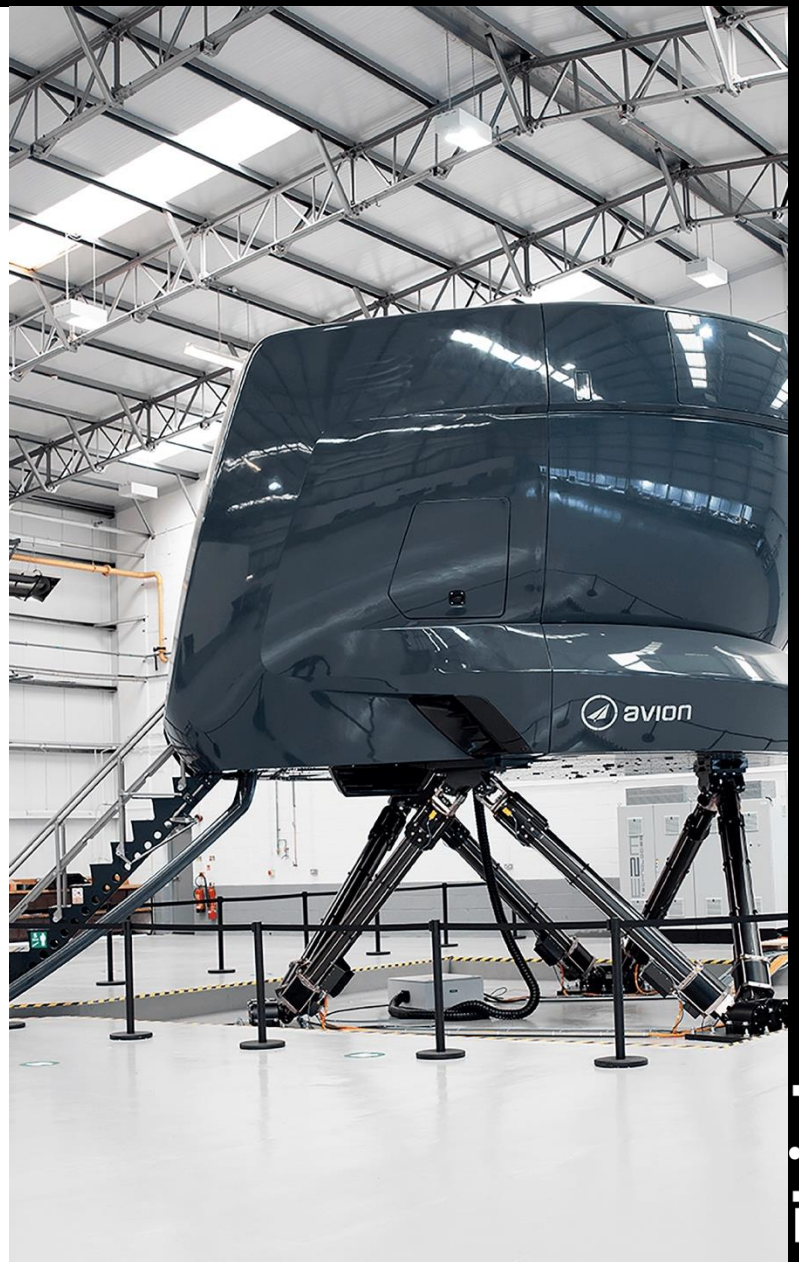




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Civil Aviation Rewrites its Simulator Rules

- New EU rules apply from **30 April 2028**
- Old labels (Level A to D) replaced by a **Capability Signature**
- **14 features** (visual, motion, sound, systems and others), each rated at one of **4 fidelity levels**
- **Task to tool:** decide what must be trained, then choose the device



EASA, Regulation (EU) 2026/781 and CS-FSTD Issue 1 (2026).

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Fast Jet Training at RAF Valley (UK)



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VR for Professional Use

EASA Qualifies World's First VR Flight Training Device



EASA calls the VRM Switzerland Virtual Reality FSTD qualification "a further step towards Agency and industry objectives to improve overall rotorcraft safety by 50% by 2028." Image credit: VRM Switzerland.

RICK ADAMS APRIL 26, 2021

VRM Switzerland has received approval from the European Union Aviation Safety Agency (EASA) for pilot training credits in a type-specific Robinson R22 virtual reality flight simulation training device, the world's first VR-driven FSTD to receive approval from an aviation regulatory authority.

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Drone Racing League (DRL)

&

Drone Racing League Simulator





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TruePlayers

Firehawk

- 25,000 Players
- Command console
  - Inject jamming, weather, faults, live.
- After action review
  - Full telemetry, 3D replay, NATO-standard report.
- Benchmarking
  - Individual and formation, one data set.



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XR

Gaming Skills



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Mail Online

Call of Duty: Defence secretary John Healy wants online gamers to join up for real to become drone pilots as he plans to ease entry requirements for 'console warriors'

By DAVID WILCOCK, DEPUTY POLITICAL EDITOR FOR MAILONLINE
PUBLISHED: 14:28, 22 September 2024 | **UPDATED:** 14:28, 22 September 2024

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51 shares
129 View comments

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Drone Pilot Training How Long Does it Take?

Broad Brush

Multiple Sources

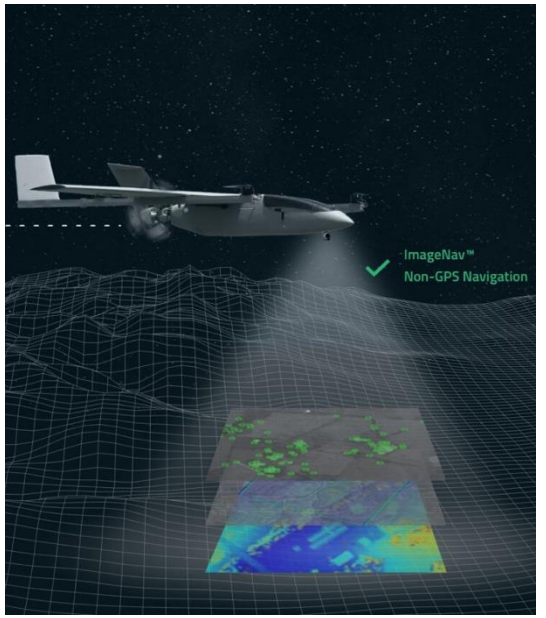
Phase	Simulation (Cumulative)	Live (Cumulative)	Total (Cumulative)	Source
Initial Familiarisation	10-15 hrs	0 hrs	**10-15 hrs**	UK RAPSTONE, US OSUT
Basic Competence	20-30 hrs	5-10 hrs	**25-40 hrs**	Multiple sources
Combat Ready	50-60 hrs	10-15 hrs	**60-75 hrs**	Irwin-Clark, Carr
Mastery (w/ self-paced)	70-80 hrs	10-15 hrs	**80-95 hrs**	Carr (9:1 sim ratio)

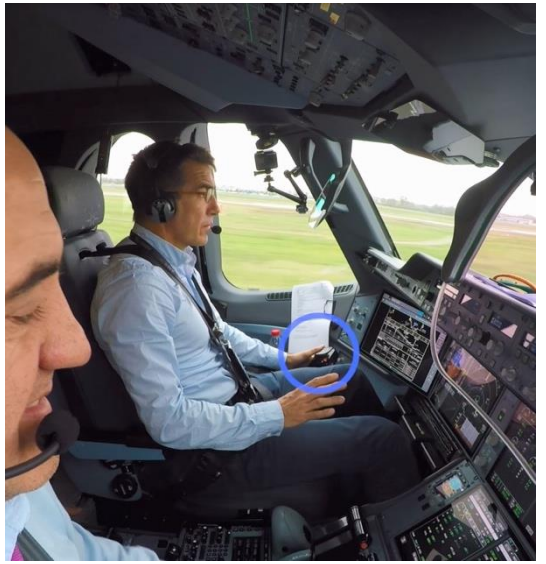
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Simulation Leaves the Ground

- **Drones:** when satellite navigation is jammed, drones find their way by matching what their camera sees with a 3D map they carry on board. Companies now sell maps of the Earth made for machines, not people.
- **Airliners:** Airbus has tested aircraft that taxi, take off and land by recognising the runway with on-board cameras.
- **Next, machines that imagine:** AI “world models” let a machine predict what will happen next, and test its options in its head before it acts.

For the machine, the simulation is its reality





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3 of 4

The People

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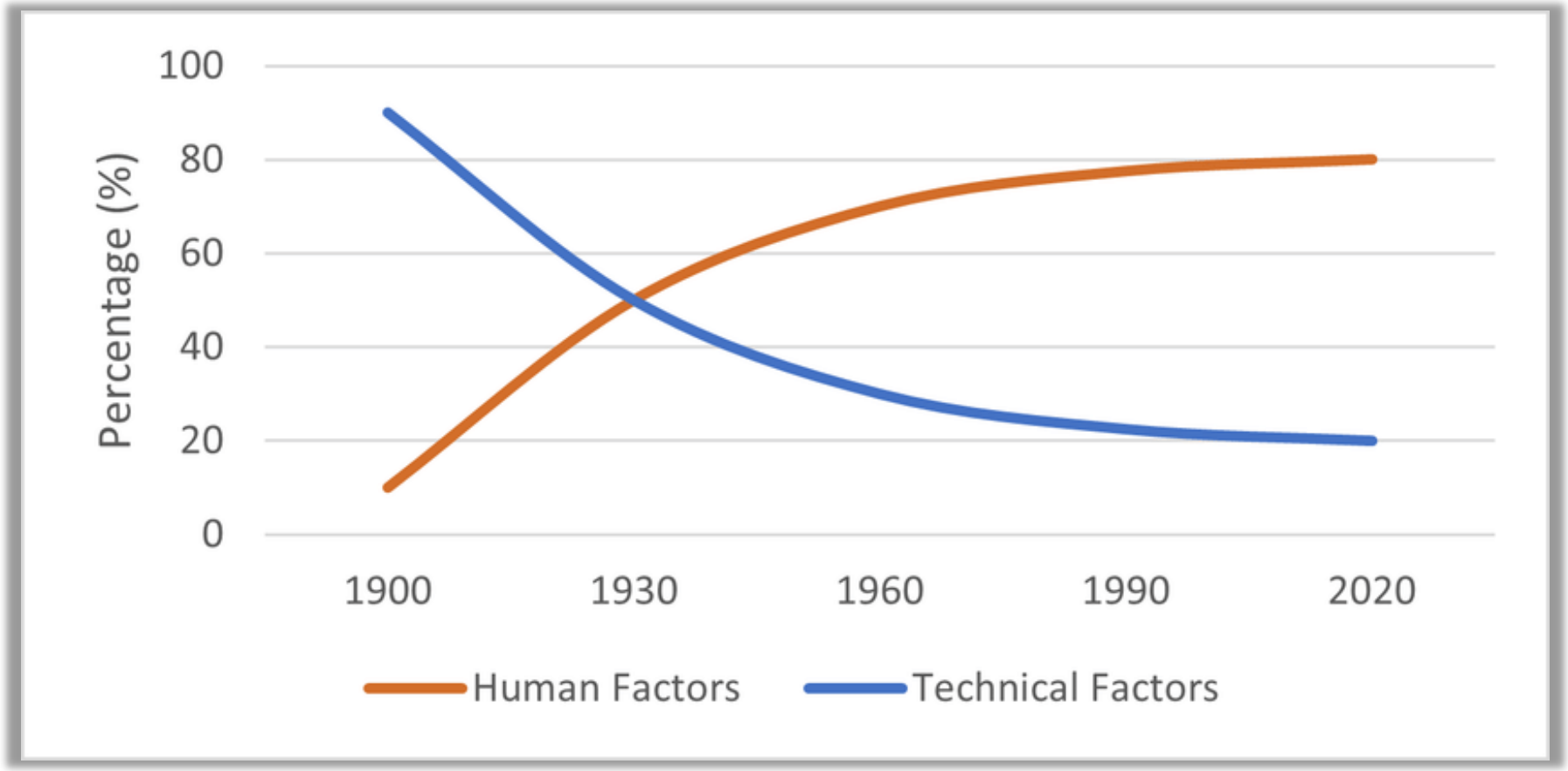
Storm Eunice – Bristol Airport – 18 Feb 22



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Humans and Aircraft

Evolution of Aviation Accident Causes



Machine Learning and Natural Language Processing for Prediction of Human Factors in Aviation Incident Reports - February 2021

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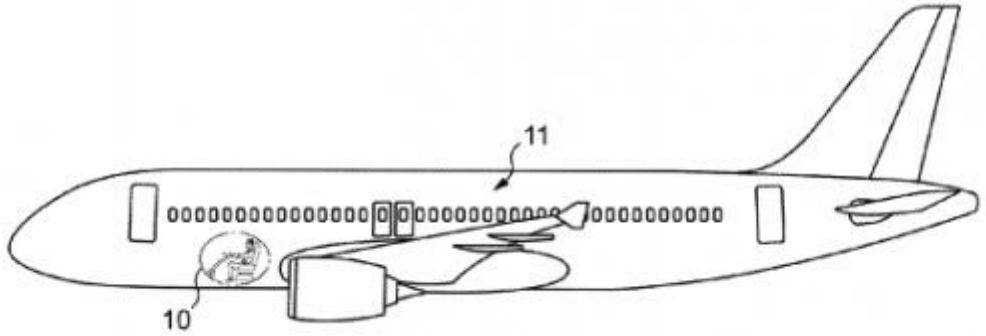
BOAC VC10 Automatic Landing (1968)

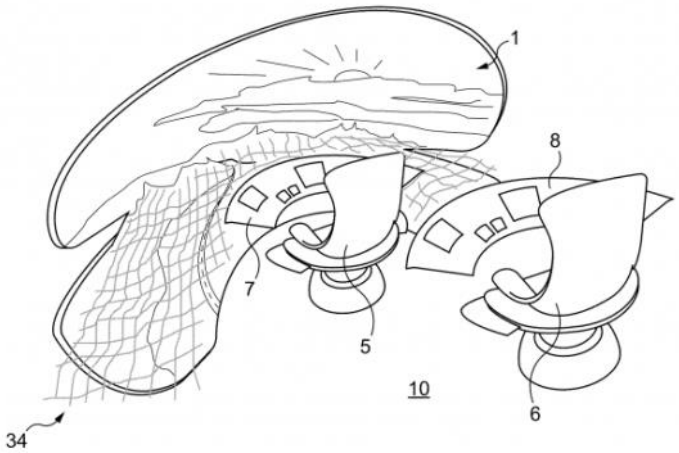


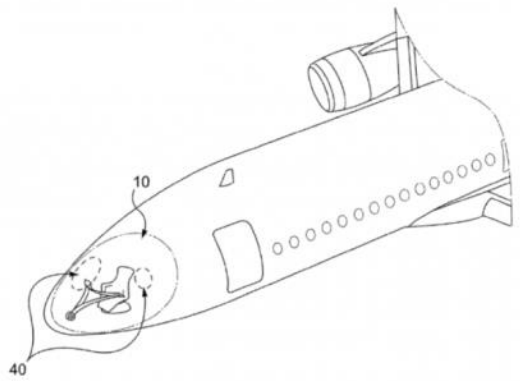
Source – Pathe

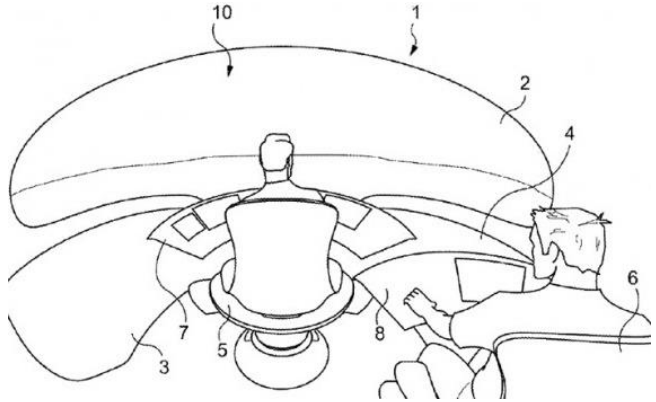
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Airbus Windowless Cockpit Patent









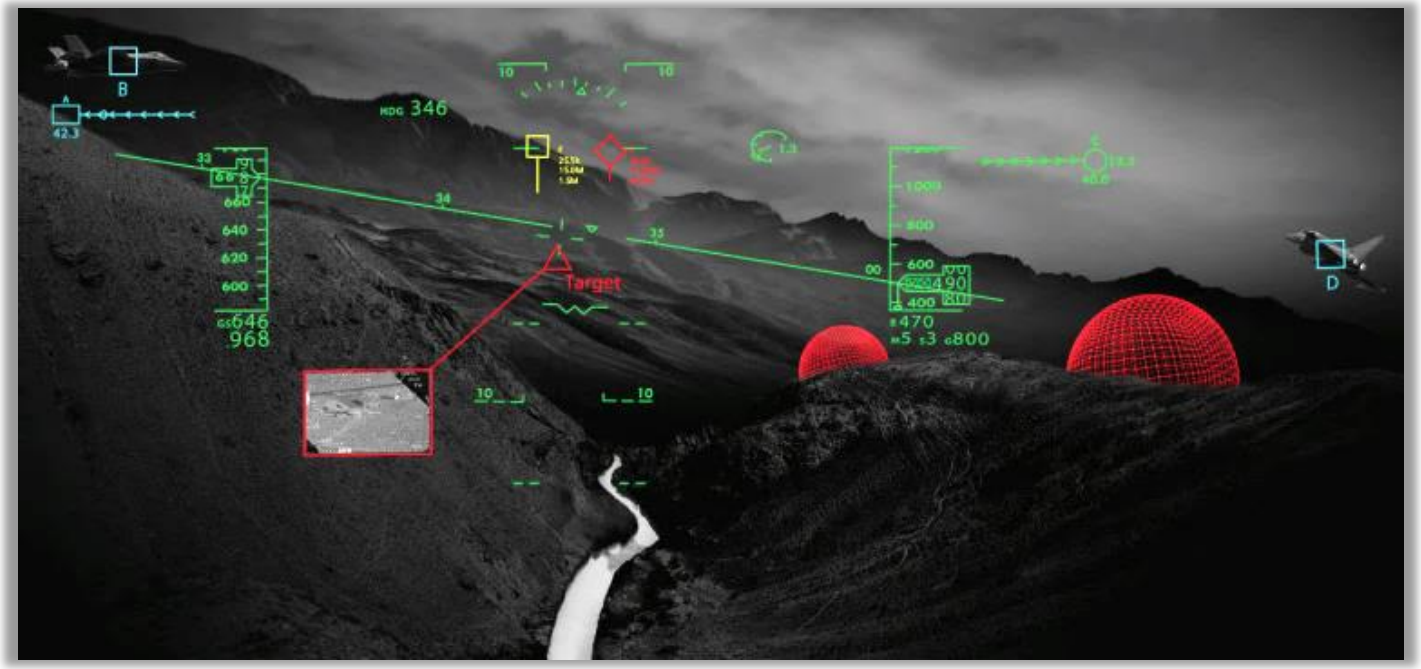
AIRBUS

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XR

BAE Systems Striker® II





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Redundant Pilots?

engadget UK



Combat AI beats US Air Force's top tactical experts

And it only requires the processing power of a Raspberry Pi.

Andrew Dalton , @dolftown
06.28.16 in Robots

A new artificial intelligence flight combat system dubbed ALPHA has taken on one of the Air Force's top tactical experts and won. Retired USAF Colonel Gene Lee -- an experienced combat instructor with "considerable fighter aircraft expertise" -- was repeatedly shot down during engagements with ALPHA in a high-fidelity air combat simulation. Lee called his computerized opponent "the most aggressive, responsive, dynamic and credible AI I've seen to date."

2016

BREAKING DEFENSE

AIR WARFARE, NETWORKS / CYBER

AI Slays Top F-16 Pilot In DARPA Dogfight Simulation

"It's a giant leap," said DARPA's Justin (call sign "Glock") Mock.

By THERESA HITCHENS on August 20, 2020 at 6:03 PM

3.6k SHARES



Heron Systems' AI pilot scores the final kill against AF F-16 instructor "Banger" in AlphaDogfight Trials

WASHINGTON: In a 5 to 0 sweep, an AI 'pilot' developed by Heron Systems beat one of the Air Force's top F-16 fighter pilots in DARPA's simulated aerial dogfight contest today.

2020

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The Pilot as the Team Leader



U.S. Marine Corps XQ-58A Valkyrie (2024)

- Loyal wingmen aka Collaborative Combat Aircraft (CCA): MQ-28 Ghost Bat (Australia) · XQ-58A, FQ-42 and FQ-44 (US) · GJ-11 (China) · Kızılelma (Turkey) · S-70 Okhotnik (Russia)
- MQ-28: 150 hours flying, more than 20,000 hours in simulation
- US Air Force: at least 500 planned by 2032

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Collaborative Combat Aircraft – A Human Challenge?



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Cautionary Tales



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Algorithms…

The Register®
Biting the hand that feeds IT

Security

Brit Watchkeeper drone fell in the sea because blocked sensor made algorithms flip out

Report scolds maker Thales for poorly understood software

By Gareth Corfield 15 Apr 2019 at 13:58 120 SHARE ▼



A Thales Watchkeeper drone. File pic, Crown copyright

A British Army Watchkeeper drone stalled itself and crashed into the sea on a bad weather flight test, military investigators have said – though most of the wreckage was never found.

Investigators concluded that one of its pitot probes used for reading the aircraft's speed and angle of attack (AOA) became blocked, causing the Watchkeeper's onboard flight control logic to enter an erratic series of climbs and dives until it stalled itself and flopped into the sea. They criticised the craft's maker, Thales, for not fully understanding how its algorithms responded to loss of accurate sensor data.

Air Marshal Susan Gray, director-general of the Defence Safety Authority, criticised the Ministry of Defence and Thales for their "incomplete level of detailed technical understanding" regarding the drone and its systems.

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Air France Flight 447 (2009)





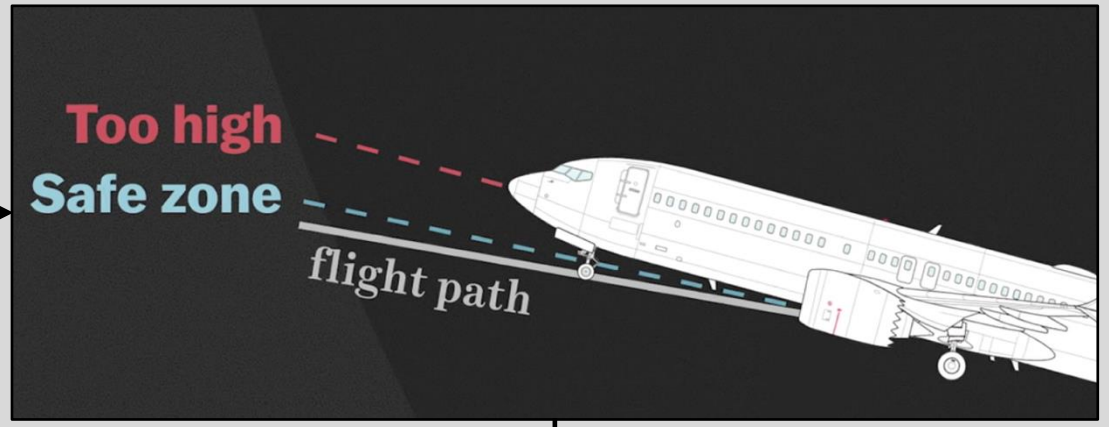


Wikipedia

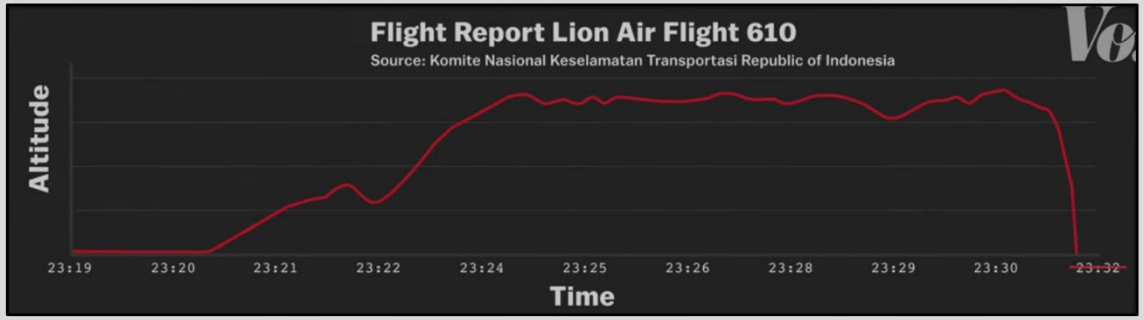
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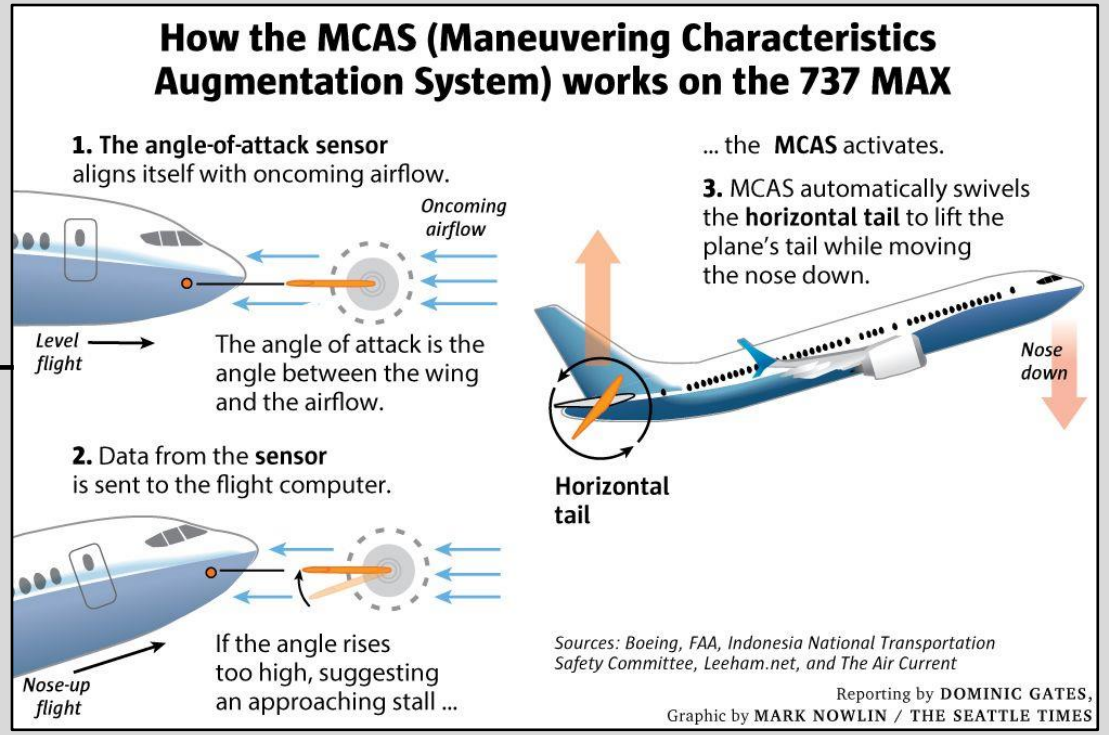
Boeing 737 MAX











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Monitoring Systems

The Register®

{* INTERNET OF THINGS *}

Army Watchkeeper drone flopped into tree because crew were gazing backwards

Live footage of runway and grass verge more compelling than actual flight instruments

Thu 29 Aug 2019 // 10:11 UTC 98 GOT TIPS?

Gareth Corfield BIO EMAIL TWITTER SHARE

The latest British Army Watchkeeper drone crash happened because its crew became fixated on live footage from an onboard camera instead of their instruments, a Ministry of Defence report has revealed.

An internal Defence Accident Investigation Branch (DAIB) report detailed why the semi-autonomous aircraft, tail number WK050 and flown on the day by two Royal Artillery operators, crashed in June 2018.

The report, dated February 2019, was published online by the MoD after the BBC made a Freedom of Information request for it, leading to news reports over the past few weeks.

WK050 flopped into a tree just beyond the runway of Aberporth airport on the Welsh coast after its Army operators, under the supervision of contractors from a Thales joint venture company, cut its throttle immediately after the drone had landed and lifted off again.

"Had no action been taken, the [Watchkeeper] would have completed its automatic go-around from which it could have been commanded to conduct a further approach," said the DAIB in its Safety Investigation Report, which was written by a major and a Warrant Officer 1 (WO1).





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In the Loop …

"If I'm in the loop mentally I can respond more quickly than if I have to watch an automatic system and take over and then get my mind into the loop.

So, I was more comfortable in flying a manual descent than an automatic descent… my mental computer is already running at full speed.“

David Scott
Apollo 15 Commander (1971)

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… and Human Teams?

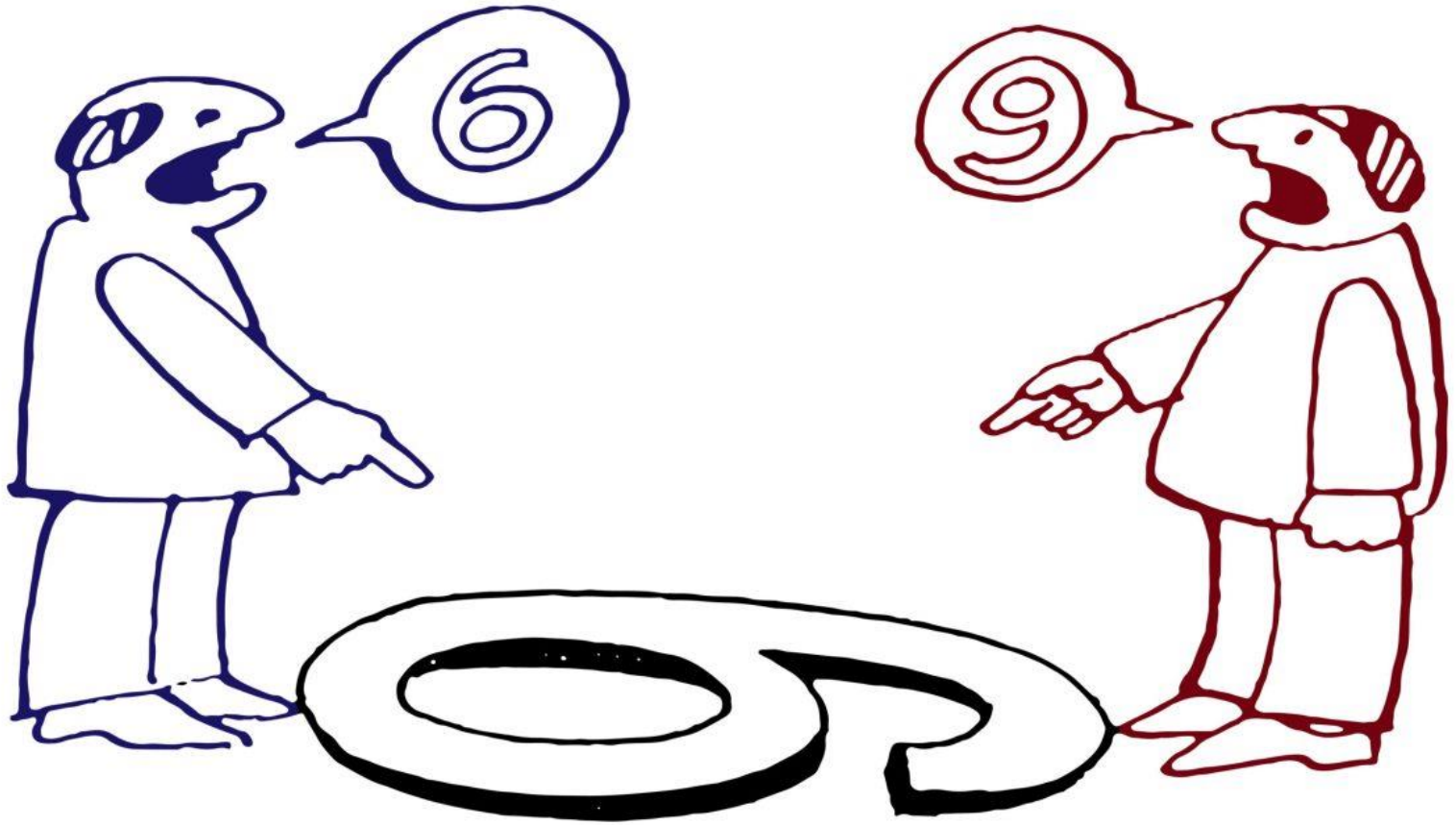
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The High and the Mighty (1954)



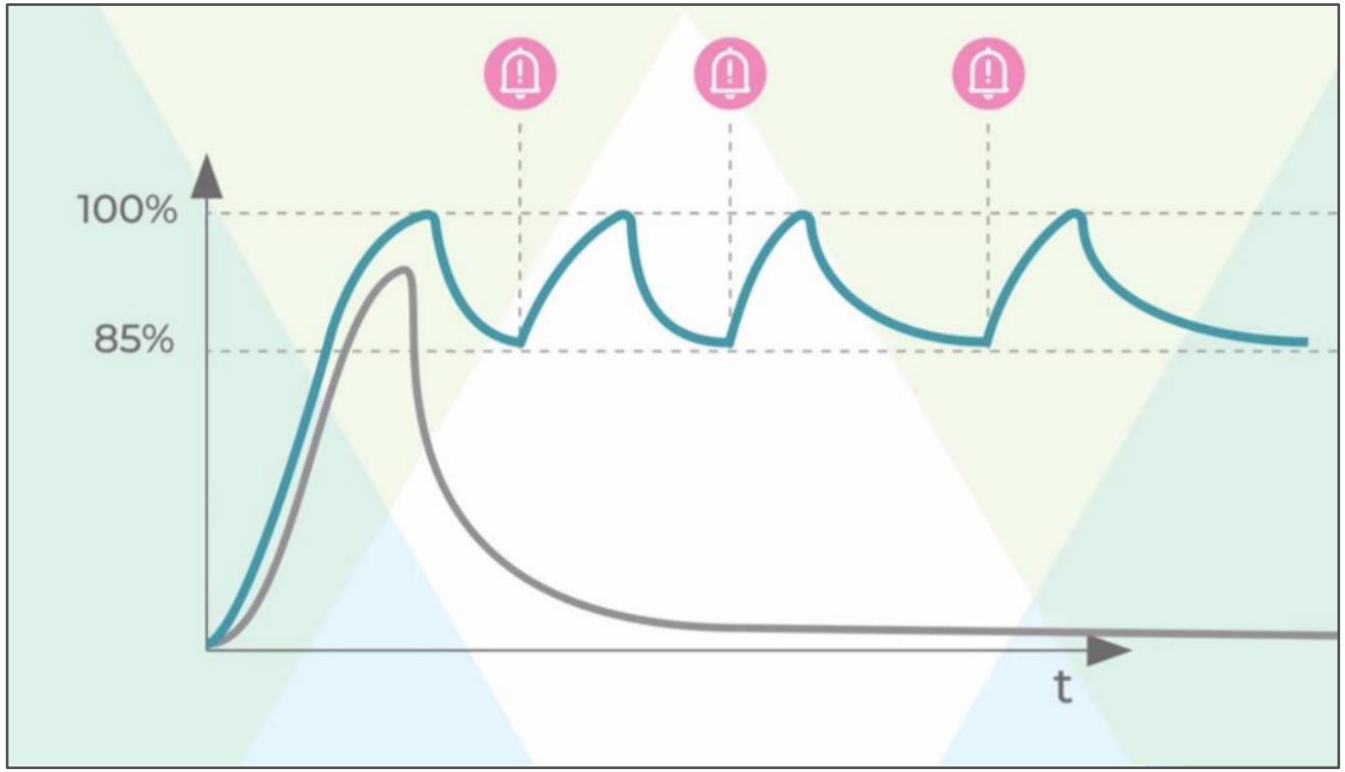
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Differences of Perception



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Skill Fade



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Humans need to Practice, Practice, Practice!

Individually, in Teams *and With Machines*



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People
-
Engineers

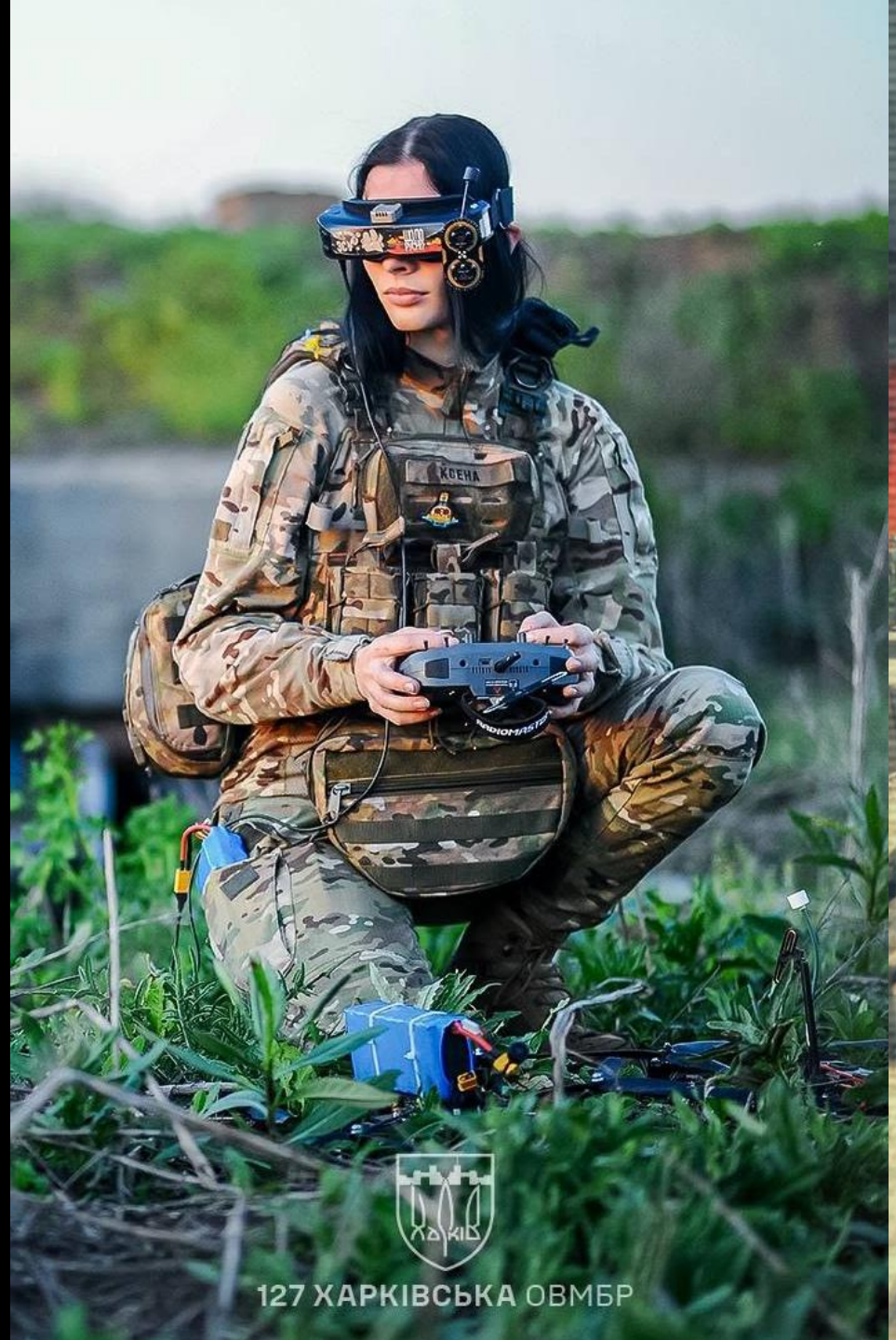
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When War Looks Like a Game

Drone operator "Ksena" (2026)

-

FPV War Kamikaze Drone



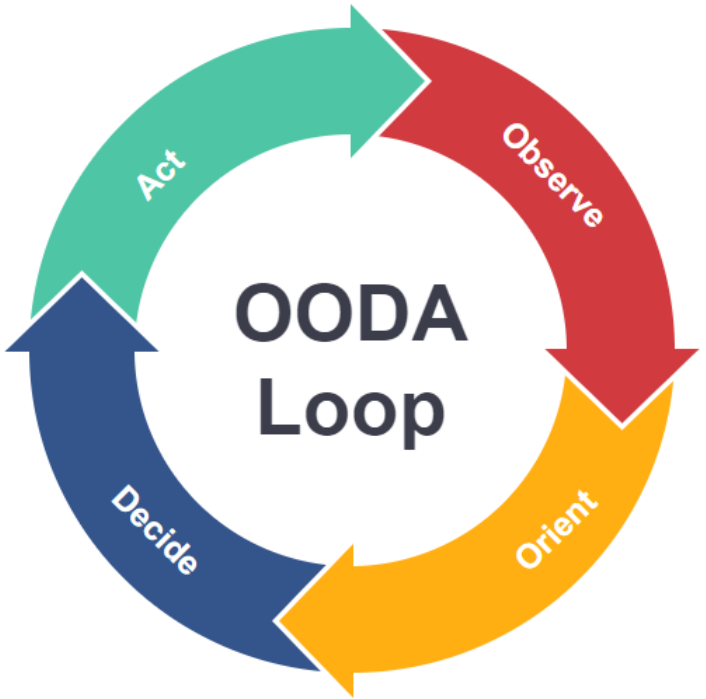


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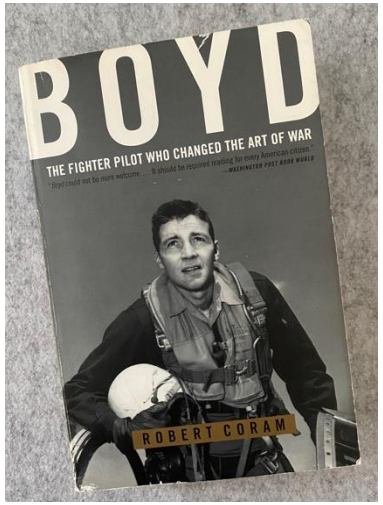
Inside our OODA loop

- **For 50 years:** simulators, displays and training helped pilots get through the loop faster than the enemy

- **Now:** AI can observe, orient, decide and act faster than any human can follow



What happens when the machine is inside every human's loop?



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Who Decides the Rules?



UN General Assembly, December 2024: 166 votes for action on autonomous weapons, 3 against. No binding treaty

Civil	Military
rules set openly by regulators, before the aircraft flies	rules increasingly built into software and training data

When engineers design the algorithms, the data and the simulations, they are writing the rules the machine will follow: what to notice, what to ignore and when to act.

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4/4

Thoughts on Careers



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Why Be An Engineer



It’s not boring - no two days are the same

Making a difference to the world

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It is an Exciting & Important Time of Change in Aerospace

- AI & Data Analytics
- Autonomous Flight
- Digital Twins and Digitisation
- Drones/Uncrewed
- Electrification
- Space
- Sustainability

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Professional Engineer

- Chartered Engineer
  - Emphasis on Technology Development
  - Masters Level
- Incorporated Engineer
  - Emphasis on Technology Application
  - Bachelors Level



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Professional Engineer Competences (UK SPEC)



A. Knowledge and understanding:
The ability to apply both general and specialist engineering knowledge to complex problems.

B. Design, development, and solving engineering problems:
The competence to use theoretical and practical methods to analyze and solve engineering challenges.

C. Responsibility, management, and leadership:
Demonstrating the ability to manage projects, teams, and resources, as well as showing technical and commercial leadership.

D. Communication and interpersonal skills:
The ability to communicate effectively with both technical and non-technical stakeholders.

E. Professional commitment:
A personal commitment to a Code of Conduct, professional standards, recognizing obligations to society, the environment, and the profession. This includes a commitment to continued professional development (CPD).

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Code of Conduct

(IMechE)

- **Practise competently:**
  - Maintain knowledge and skills, record continuing professional development (CPD), work strictly within your area of competence, disclose limitations, quantify and limit risk, and maintain adequate professional indemnity insurance.
- **Act with integrity:**
  - Avoid deception, bribery, and corruption; respect confidentiality; review engineering evidence honestly without bias; declare conflicts of interest; record gifts or hospitality; and do not improperly implicate the Institution in correspondence.
- **Promote sustainability:**
  - Comply with health, safety, and environmental protection laws; recognize socio-economic and environmental factors; avoid deliberate waste or exploitation of natural resources; and balance present needs with those of future generations.
- **Exercise engineering leadership:**
  - Contribute objectively to public discussions on engineering matters, take positive action when encountering unmanaged risk or malpractice, respect others, and actively support equality, diversity, and inclusion (EDI) while addressing conscious or unconscious bias.

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Some Professional Organisations

ROYAL AERONAUTICAL SOCIETY

Institution of MECHANICAL ENGINEERS

Improving the world through engineering

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Thoughts on Careers

- Be Kind
- Don’t worry too much…
  - It’s mostly beyond our control
  - Go to the next interesting job





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A Pivotal Moment in Aerospace?

Excitement & Responsibility

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Questions?

LinkedIn
andyfawkes

simuation.news
uncrewedsystems.news



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